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THE RELATIONSHIP BETWEEN HIGH SCHOOL STUDENTS' COGNITIVE STYLE AND SPATIAL ABILITY IN ANKARA CANKAYA

A MASTER'S THESIS

BY

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THE PROGRAM OF CURRICULUM AND INSTRUCTION
İHSAN DOĞRAMACI BILKENT UNIVERSITY
ANKARA

JANUARY 2021

2021

To my family with love…

The Relationship Between High School Students' Cognitive Style and Spatial Ability in Ankara Cankaya

The Graduate School of Education

of

İhsan Doğramacı Bilkent University

by

Merve Akkaya

In Partial Fulfilment of the Requirements for the Degree of

Master of Arts

in

Curriculum and Instruction

Ankara

January 2021

İHSAN DOĞRAMACI BILKENT UNIVERSITY
GRADUATE SCHOOL OF EDUCATION

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Merve Akkaya

Dec 2020

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

Assoc. Prof. Dr. Erdat Çataloğlu (Supervisor)

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

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ABSTRACT

The Relationship Between High School Students' Cognitive Style and Spatial Ability in Ankara Cankaya

Merve Akkaya

M.A. in Curriculum and Instruction
Supervisor: Assoc. Prof. Dr. Erdat Çataloğlu

January 2021

In this study the relation between students' cognitive style and spatial visualization ability was investigated in Ankara, Çankaya. Gender, schools and grade level/age were independent variables of descriptive study. Sample of this research were 393 anatolian high school students from four different schools. Group Embedded Figures Test (Witkin *et al*., 1971) and Turkish version of Purdue Spatial Visualization Test (Guay, 1976) were used to assess students' cognitive style and spatial ability. Sevimli (2009) adapted Purdue Spatial Visualization Test into Turkish. Group Embedded Figures Test' second and third part included in scoring and each part contains nine questions. Five minutes were given for students to answer questions in each part. Purdue Spatial Visualization Test contained three parts. Each parts contain 12 questions. Time were given for the whole test. Descriptive statistical analysis were conducted to investigate the students' cognitive style and spatial visualization ability with respect to independent variables. Independent samples *t*-test was conducted whether gender difference had statistically significant effect on cognitive style and spatial ability. One-way ANOVA test was used to determine whether the mean difference in school and grade level were statistically significant or not. Correlation coefficient between students' cognitive style and spatial ability was computed. According to results, students' cognitive style and spatial visualization ability were independent from students' gender. There were statistically significant difference in students' cognitive style and spatial visualization ability with respect to students' schools and grade level/age. There was a statistically significant and positive correlation between students' cognitive style and spatial visualization ability.

Keywords: Spatial ability, spatial visualization ability, cognitive style

ÖZET

Ankara'nın Çankaya İlçesindeki Lise Öğrencilerinin Bilişsel Stilleri ve Uzamsal Görselleme Becerileri Arasındaki İlişki

Merve Akkaya

Yüksek Lisans, Eğitim Programları ve Öğretim

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Ocak 2021

Çalışmanın amacı Ankara Çankaya bölgesinde bulunan lise öğrencilerinin bilişsel stilleri ve uzamsal görselleştirme becerileri arasındaki ilişkiyi araştırmaktır. Cinsiyet, okullar ve yaş/sınıf çalışmadaki değişkenlerdir. Betimleyici araştırma yönteminin kullanıldığı bu çalışmada, dört farklı Anadolu lisesi ve 393 lise öğrencisi örneklem olarak seçilmiştir. Öğrencilerin bilişsel stillerini saptamak amacı ile ''Group Embedded Figures Test'' ve öğrencilerin uzamsal görselleştirme becerilerini saptamak amacı ile 'Purdue Spatial Visualization Test'' in Sevimli (2009) tarafından uyarlanan Türkçe versiyonu kullanılmıştır. Gömülü figür testi üç kısımdan oluşmaktadır. İkinci ve üçüncü kısım puanlamaya dahil olan dokuzar sorudan oluşur. Her iki bölüm için de süre beşer dakikadır. Uzamsal görsellem testi üç ayrı bölümden oluşur ve her bölüm için ayrı süre verilmez. Her bölümde 12 soru bulunmaktadır ve toplamda 36 soru vardır. Tek doğru cevaba sahip olan bu test çoktan seçmelidir. Öğrencilerin cinsiyet, yaş ve okul değişkenlerine göre bilişsel stilleri ve uzamsal görselleştirme becerisini belirlemek için betimleyici istatiksel analiz yöntemi kullanılmıştır. Bu çalışmada cinsiyetin istatiksel olarak anlamlı bir farklılık oluşturup oluşturmadığını analiz etmek için bağımsız örneklem *t*-testi kullanılmıştır. Öğrencilerin bulunduğu okulun ve sınıf seviyelerinin istatiksel olarak anlamlı bir farklılık oluşturup oluşturmadığını analiz etmek için tek yönlü varyans analizi kullanılmıştır. Son olarak öğrencilerin bilişsel stilleri ve uzamsal görselleştirme becerileri arasındaki ilişkiyi analiz etmek için korelasyon katsayısı hesaplanmıştır. Analizlerin sonucunda cinsiyet, öğrencilerin bilişsel stilleri ve uzamsal görselleştirme becerileri üzerinde istatiksel olarak anlamlı bir farklılık oluşturmamaktadır. Öğrencilerin bilişsel stilleri ve uzamsal görselleştirme becerileri okul ve sınıf düzeyi/yaş değişkenine bağlıdır. Öğrencilerin bilişsel stilleri ve uzamsal görselleştirme becerileri arasında anlamlı ve pozitif bir korelasyon bulunmuştur.

Anahtar Kelimeler: Uzamsal beceri, uzamsal görselleştirme becerisi, bilişsel beceri

ACKNOWLEDGEMENTS

First and foremost I would like to thank my supervisor Assoc. Prof. Erdat Çataloğlu for his support, knowledge and guidance during my study. His guidance helped me to complete this study without losing my enthusiasm.

I wish to thank all members of Bilkent University Graduate School of Education CITE program for their contributions to this study. I owe my hearty thanks to Ece Güneysu, Ecem Doğdu, Özlem Keser, Ecem Yalım and Hatice Gönül for helping me all the possible ways and for being amazing friends. I am indebted to my colleague Fatma Çiçek for her support during the process of saving my hard disk. She was worried with me like it was her study.

I also thank to committee members of my thesis defense for their valuable feedback and suggestions.

My deepest thanks goes to my family for their unconditional support, endless love and care at each stage of my life. They were my constant source of inspiration.

Lastly and mostly, I would like to thank Emre Demir who holds a special place in my heart. He always support me even if I lose my motivation. His love and support were very special for me to achieve goals in my life.

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CHAPTER 1: INTRODUCTION

Introduction

In this research, the relationship between two mental constructs, that is students' cognitive style and their spatial ability was investigated on Turkish high school physics students. Students - or people in general - have different cognitive styles. The majority of people fall into two distinct categories of cognitive styles namely, field dependent and field independent. When students are required to solve problems while learning a new subject, these two leaning styles become an important part during this process. The spatial ability construct is another important cognitive process utilized during learning, especially in tasks where spatial information such as location, scale, space, shapes and so on is needed to be used. Both of these constructs are related to the successful teaching and learning of abstract concepts required in school subject fields such as physics.

In the light of this very brief information, then, by gaining an understanding through the investigation of a possible relation between students' cognitive style and spatial ability it might be possible for teachers, science educators and researchers alike, to further understand the complexity of the underlying factors that prevent or enhance the teaching and learning of successful physics.

Background

Individual differences play an important role in the way of living a life. Some of the differences between individuals determines their reactions in different situations. For

example, if a car accident happened in front of group of people, some of them just start crying while some others might try to help the accident victims. In the above scenario, the situation was the same for the group of people. However, their behaviors and reactions were different. The reason being is that individuals have different personality, characteristic, intelligence, motivation, and attribution. Obviously, these different characteristics distinguish individuals from one another. Therefore, it comes to no surprise that research has been conducted on the various reasons for different characteristics of individuals. Chen and Miller (2007) tried to unveil this phenomenon and they came to a conclusion that there were factors actually that shape and can explain to an extend individual differences. According to them, the social context as a complex factor was very important one to shape and explain these differences. Social context was defined as the environment constituting the neighborhood, family and its effects, and the social community the individuals were surrounded with.

Individuals most likely think differently and might have their own methods in solving problems during daily live activities. Why should not this approach be true for school life as well. Students deal with different problems in their school life. When students face problems, they most likely think about or approach the problems in different ways, and they try to find solutions by using or utilizing different problem solving techniques. Sullivan (2009) emphasized this fact by explaining that when individuals start to learn, not only their motivation, personality, attributions for their success and failures played an important role to learn but also their cognitive abilities.

These commonsensical approach on individual differences has manifested itself in academic research. Nowadays diversity and inclusion play a key role in education. Terms such as, individual difference, self-paced learning, multiple intelligence, expert vs novice, cognitive styles and so on are all areas of research interest. The relationship between individual differences and cognitive style are very important to achieve the goal of learning effectively. According to Williamson (2018), learners can have different cognitive styles and this result with individual differences among learners. In addition, it was verified that when engineers and scientist were compared to individual from different professions, scientists and engineers had different cognitive style profiles and personality traits.

On his worked on individual's cognitive style differences, Sternberg (1997) showed that some students use an analytic and systematic approaches to learning, while others have a more intuitive and global approach. Witkin, a pioneer in this research field, refers to this phenomenon as field dependent and field independent cognitive style (Witkin, 1974; Witkin & Goodenough, 1981).

Witkin's outcomes on his seminal research (Witkin, 1974; Witkin & Goodenough, 1981) showed that there were two type of individuals, the first group of individuals are classified as those to accept externally provided structure. This group of individuals are those that are individuals that accept externally provided structure and stay connected to them.

Individuals who are responsive to external reinforcement think and solve problems within these frameworks. These types of individuals are called field dependent. On

the other hand, field independent individuals restructure perceived information into a different structure. External structures are not important for field independent individuals to process their experiences. This type of individuals construct their own framework and they develop their own methodology to solve problems. In order to explain it clearly, Witkin and Goodenough's (1981) Rod and Frame Test (RFT) can be given as an example. RFT was applied to the participants to explore characteristics of field dependent (FD) and field independent (FI) individuals. In this test, there were luminous square frame and luminous rod in a dark room. The frame could rotate clockwise (CW) and anticlockwise (ACW) and the rod too, which was placed in the center of the frame could rotate independently from the frame CW and ACW independently from frame. For both, the pivot was the same center. While the frame around the rod remains in its initial position of tilt, participants' tasks were adjusting the rod to a vertical position with respect to ground. According to result of RFT, although field independent individuals ignore the position of frame and align the rod in vertical position, field dependent individuals were affected by the position of the frame and they failed to align the rod vertically by as much as 30 degrees. It can be seen from below Figure 1.

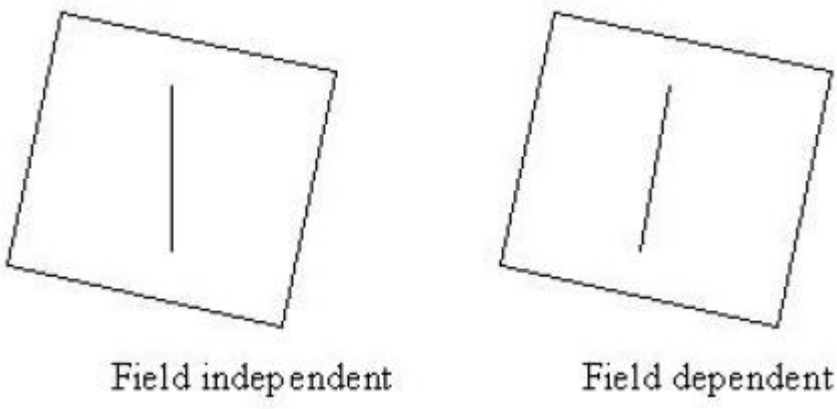

Figure 1. Rod alignment of field dependent and independent individuals

As mentioned above, the characteristics of field dependent and field independent individuals were explained by Witkin. According to him, FD learners have more intuitive and global approaches. Therefore, they tend to think in more broad and passive ways. However, FI learners have analytic and systematic ways of thinking. They perceive and process information methodically. Subsequently, FD and FI learners show different characteristics when they solve problems.

Although individual differences can be affected by the two distinct cognitive styles pointed out above, other cognitive factors such as spatial ability could play an important role in teaching and learning physics. As it is for cognitive styles students show different spatial abilities and this in turn can affect their understanding in their physics lessons (courses). Therefore, both students' cognitive style and their spatial ability are important for achieving goals in their lessons.

Anastasi (1976) defined spatial ability as a skill which is used to perceive fixed geometric relations and it is also used to apply mental transformations such as rotation and reconfiguration to existing geometric objects and their proximal relations.

These characteristics of learning will affect students understanding in different lessons especially in physics. In physics education, it is important for teachers to explore students' approaches of learning to provide them with effective lessons. Moreover, the spatial abilities of students are very important for physics lesson. For example, when dealing with vectors, students have to know dimensions and dimensional calculations.

According to research, Einstein's theory of relativity, Faraday's electromagnetic field theory, Newton's law of motion and Maxwell's laws comprised spatial reasoning (Miller, 1986; Nersessian, 1995; Shepard, 1996). There was a list from United States Employment Service about the occupations which require a high level of spatial ability and physics was also added in this list (Dictionary of Occupational Titles, 1991). It also showed that spatial ability had significant effect on learning and teaching of physics.

Mayer and Sims (1994) investigated that students with high spatial ability do not have difficulty in understanding diagrams and they can easily construct an imagery object in working memory. However, students with low spatial ability have difficulty to understand diagrams. Therefore, teachers need to consider students' spatial abilities when they prepare their lessons with graphical representations or diagrams.

The following sections explains the context and need for exploring further the relationship between student's cognitive styles and their spatial abilities as it relates to physics education.

Therefore, it is important to know if there is a relation between students' spatial ability and field dependence/independence to prepare effective and meaningful lesson for students

Problem

Physics is an area that relays heavily on problem solving skills. Most of the physics teachers spend a considerable amount of time for solving problems in a typical

physics lecture. A high achieving student is usually the one that shows advanced skills in solving problems. Different studies were conducted about the relationship between cognitive style and students' achievement in physics lessons (Ziane, 1996). According to Ziane's research FD physics students obtained lower scores in solving physics problems than the students who had FI cognitive style.

Kinematic problems in physics lesson was another area that students had difficulty in solving problems. Kozhevnikov, Motes and Hegarty (2006) investigated the relationship between spatial ability and problem-solving skills in kinematic problems which include prediction of the motion of two-dimensional object, translating from one reference frame to another. According to result of the study, students who had high spatial visualization ability can integrate several motion parameters and they had the ability of reorganization of the spatial problem into another coordinated. However, the low spatial ability student group could only consider a single motion parameter at a time. Moreover, their interpretation of kinematics related graphs were picture like representation. This research showed that cognitive style and spatial ability had a significant effect on problem solving in physics.

It is important for physics teacher to understand if their students' ways of thinking are field dependent or independent. In addition, the level of students' spatial ability was significant for them when solving problems. The literature lacks information about how to help teachers assess and address these differences. Teachers have difficulty to explain topics and they use insufficient materials in their lessons with respect to students' cognitive styles and their spatial ability. Moreover, especially in physics education, students need to think in three dimensions. However, generally

teaching methods and materials are not suitable for students' abilities and styles. The current study investigated whether students' cognitive style affects their spatial visualization ability. It has significant effect to know students cognitive style and their spatial visualization ability to improve teaching methods for students. Therefore, it is important to find out the relationship between students' cognitive style and their spatial visualization ability.

Purpose

The purpose of this study was to explore the relationship between students' cognitive style and their spatial visualization ability. The Group Embedded Figure Test (GEFT) was used to measure students' cognitive style and the Purdue Spatial Visualization Test (PSVT) was used to measure students' spatial ability.

Research questions

This study addresses the following research questions:

1. Is there a statistically significant relationship between students' cognitive style and their spatial visualization ability in some selected high schools in Ankara?
2. Are there any statistically significant difference between students' cognitive style by gender?
3. Are there any statistically significant difference between students' spatial visualization ability by gender?
4. Are there any statistically significant difference between students' cognitive style by schools?

5. Are there any statistically significant difference between students' spatial visualization ability by schools?
6. Are there any statistically significant difference between students' cognitive style by grade?
7. Are there any statistically significant difference between students' spatial visualization ability by grade?

Significance

This study has three significant contributions. First result of this study showed how students' cognitive style and spatial abilities are related. This relation is important for teachers and also students. Teachers can change their teaching style by using this relationship. They can find different methods to explain topics or they can use different materials to increase students' understanding. Secondly, students can choose different methods according to their cognitive style and spatial ability when they study individually. According to the results, teachers can use more spatial visuals depend on their students' cognitive style. Finally, teachers can prepare activities and materials according to the relationship between students' cognitive style and spatial ability to improve their understanding. This study may increase the effectiveness of lessons.

Limitations

In this research participants are some high school students in Ankara region. Therefore, it will not be generalized to all high school students at different regions in Turkey.

Definition of key terms

Field dependent: acceptation of externally imposed frameworks and staying connected to these frameworks while dealing with problems, thinking or remembering (Witkin, 1974).

Field independent: reconstruction of information into a different framework by do not considering external structures (Witkin, 1974).

Spatial visualization ability: way of thinking in two or three dimensional (Linn & Petersen, 1985).

Ethical considerations

Permission from Ministry of National Education (MoNE) was be obtained for this study. In addition to the permission from MoNE, permissions for using GEFT and PSVT were obtained for this research. Also, utilization permission should be required to apply tests in schools. Moreover, parent notification and permission letter were prepared for this study.

CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

In the first chapter, background of my research topic, problem and purpose were given. According to the information in the first chapter, the relationship between students' cognitive style and spatial visualization ability was investigated. Also, difference between cognitive style and spatial ability by gender, schools and grade level analyzed.

This chapter is about the literature review to examine theoretical framework. This framework helped to answer research questions which was given in Chapter 1. The aim of this chapter to investigate main concepts of this research. These were:

- Studies conducted with GEFT and PSVT.
- Cognitive style as it relates to gender
- Spatial ability as it relates to gender
- Studies about the possible relations of cognitive style with grade level or age.
- Studies about the possible relations of spatial visualization ability with grade level or age.

The studies conducted with GEFT

GEFT is widely applied and well-known test to measure field dependence/ independence of students. In this section, the studies which is conducted by using GEFT was investigated.

Miller (2007) explored the relationship between creativity and cognitive style. In the research cognitive style was measured by using GEFT. Participants of the research was 90 (60 female and 30 male) undergraduate students from Midwestern University and their age range is between 12-32 (*M*=19.74). In the research two tests were used. One of them was used to assess creative performance of the students. It was collage making test. Another one is GEFT to assess students' cognitive style. Result of this study showed that, when the students score on creativity was high, students' GEFT score also high. Therefore, if the students were more field independent, these students were more creative than field dependent students.

It has been debated whether field dependence- independence construct represents intellectual style construct or whether it represents variation in an individual's spatial preference patterns. Zang (2004) explored the relationship between thinking style construct and field dependence/independence construct. There were 200 (154 female, 46 male) volunteer participants in the research. Participants were from Shangai and 97 of them majoring in Mathematics and 103 of them majoring in the Chinese Language. The range of the students' age from 18 to 23. There were juniors (58), sophomores (67) freshman (75) students. In this research modified version of the GEFT was used, since the research was conducted on Chinese students. Modification of GEFT done in 3 steps. Then, they did a pilot research by using modified version of GEFT among Chinese university students. GEFT and Thinking Style Inventory (Sternberg & Wagner, 1992) were two inventories of the research. In addition to these, students' academic achievement was investigated. Zhang examined students' scores on field dependence-independence scale and their thinking style scales. Also, she compared students' achievement scores in Mathematics and Chinese Language

to their scores on the field dependence-independence scales. As a result of this study, she found that field dependence and field independence construct are related to students' spatial ability.

Cakan (2003) conducted a research on undergraduate Turkish students about the psychometric data on group embedded figures tests. She investigated the effects of socioeconomic status and sex on the students' cognitive style performance. GEFT is used to assess field dependence/independence of students. According to Cakan, one of the advantages of GEFT was requirement of minimum language skills. Since, test was nonverbal test, it includes shapes mostly. Research conducted with 534 undergraduate students from two university in Turkey. Participants were from department of teacher education. Age of the participants were from 19 to 21. Students were in their second year of the education faculty when the research was conducted. Result of the study showed that 135 students were field-dependent, and 182 students were field independent. Also, scores of 217 students were in between the cut of values of upper 27% and lower 27%. According to the result of this research, GEFT is an adequate test instrument for Turkish adults. In addition, students had higher score in the second part of the GEFT than the third part. She compared the mean scores of American and Turkish undergraduates, mean scores of Turkish students were lower than American students. It was due to the relationship between culture and field dependence/independence. She concluded that according to research conducted by different researcher (Alvi et al., 1986; Kush, 1996; Nedd & Gruenfeld, 1976; Witkin & Berry, 1965), individuals from nonwestern cultures were found more field dependent than individuals from western culture. Her research in agreement with this argument.

Murphy (1997) conducted a research about the measurement characteristics of the GEFT and it provided contribution to normative and psychometric data. Test was administered to undergraduate students from Bachelor of Applied Arts in Information Management. There were 63 participants in the research. Participants completed demographic survey and then GEFT was administered to students. There were 40 female participants and 23 male participants. Female participants' ages were in between 18-48 and the male participants' age range were from 19 to 43. Participants were full time (83%) and part time (17%) undergraduates. As a result, difference between mean scores of students from information management students and original sample (Witkin et al., 1971) were nonsignificant. Therefore, it agreed with the Witkin et al. research.

The studies conducted with PSVT

PSVT is used to determine the spatial visualization skills of the participant in many studies. In this section, the studies which is conducted with PSVT was explored.

In the study conducted by Turgut, Yenilmez and Balbag (2017), spatial thinking ability of 431 prospective middle school science and mathematics teachers was explored. In this research the effect of department, gender and academic performance on the spatial ability also investigated. The range of participants' age were 18-25. There were 206 (170 female and 36 male) prospective teachers from science department and 225 (170 female and 55 male) prospective teachers from mathematics education department. PSVT was used as an instrument for the study. There were three sections in PSVT and the researcher count the number of correct answers in each section. Total scores for the spatial visualization ability included the

collection of development and the rotation constructs' scores. For the measurement of spatial orientation level, scores from views construct included directly. Result of this research indicated that spatial thinking ability of prospective teachers were low. In addition, department and academic performance had an effect on spatial visualization ability.

Baki, Kosa and Guven (2011) conducted a research about the effects of using dynamic geometry software and physical manipulatives on the spatial visualization skills. They used PSVT as an instrument to determine the spatial visualization skills of pre-service mathematics teachers for pre-test and post-test. There were 96 participants in the research. They divided participants as computer group (34), manipulative group (32) and traditional group (30). According to their research, they found that there was no statistically significant difference in the mean scores of the participants for experimental and control group before training. Before treatment total mean scores of the students for PSVT was found to be approximately 18 (*SD* =5.43). After the treatment, there were no statistically significant difference between pre-test and post-test results of the traditional group (*M*=19.37, *SD*=4.29). However, after the treatment, according to the result of the analysis they conducted, there were positive effect of treatment for computer group (*M*=23.06, *SD*=4.72) and manipulative group (*M*=21.53, *SD*=5.66). Result of this study showed that although there was positive effect of manipulative based instruction on the students' spatial visualization skill, traditional-based instruction did not have any effect on spatial visualization skill.

Güven and Kosa (2008) conducted a research about the effect of computer-based activities on the development of prospective mathematics teachers' spatial abilities. The participants of the study were 40 (18 female and 22 male) prospective mathematics teachers. Instrument of this study was PSVT and it was used as pre-test and post-test. Students had eight-week training about Cabri 3D software after pre-test. Descriptive analysis was done before and after intervention. Before the intervention mean score of the participants was 15.7 and after the intervention mean score of the participants was 21.4. Result of this study showed that there was a significant difference on participants' spatial abilities after the intervention. According to research, teachers can use different methods to increase students' spatial visualization abilities.

The studies about gender differences in cognitive style

There were different research about the effect of gender differences to the performance of students for GEFT. Most of the studies found that there were no effect of gender difference to the performance of students on GEFT.

Cakan (2003) conducted a research about psychometric data of the group embedded figures test for Turkish undergraduate students as explained in the studies about GEFT. In the research she also investigated effects of gender differences on GEFT. There were 354 female and 179 male participants in the research. Researcher used independent sample *t*-test to investigate the gender differences on GEFT. According to result of the study, there were no statistically significant difference between mean scores of female (M=8.4, SD=4.0) and male (M=9.1, SD=4.4) participants. Researcher noted that this result was in agreement with the previous findings.

In Murphy et al. (1997) research, gender differences on GEFT were also investigated. There were 89 participants fort his research. There were 60 female and 29 male students from accounting, marketing and management department of the university. According to result of the study mean scores of female and male participants was near to each other. While mean score of female participants were 12.0 (*SD*=4.32), male students' mean score was 13.0 (*SD*=5.38). At the end of the research there were no statistically significant difference between mean scores of female and male participants.

There was another research about the differences in sex and curricula on learning the group embedded figures test and it was conducted by Lusk and Wright (1981). This research conducted for 409 participants. Tests were conducted at different classes by selecting courses offered from university. Chemistry, Physics 201, Mathematics 4, Educational Psychology, General Physics, Introduction to General Psychology were examples of this classes. According to result of the research differences in enhancement within the curriculum groups are not related to gender. Also, there were no evidence of male participants were better than female participants in their performance or improvement of their scores.

The studies about gender differences in spatial ability

Gender differences in PSVT were examined and it was a major concern of the studies related to PSVT. There were studies about gender differences in the history. Some of these studies found no significant difference between female and male participants' mean score of PSVT. However, some of them found significant effect of gender difference in PSVT.

Tzuriel and Egozi (2010) conducted a research with young children to explore the gender differences in spatial ability. There were 116 participants (58 female and 58 male). All the participants were first grade students. There were experimental and control groups for the study. Spatial Relation (Thurstone & Thurstone, 1965) subset and Windows Test were used in the research as an instrument. Windows test were based on mental rotation subset of Cognitive Modifiability Battery (CMB) (Tzuriel, 1995, 2000; Tzuriel & Egozi, 2006). For both tests, before the intervention, males had higher mean score than female participants However, it showed that after the intervention, gender differences between the mean scores of female and male participants can be cancelled out or moderated.

There were another research about the gender differences and the effect of digital pentominoes game on spatial ability. Yang and Chen (2010) conducted a research with fifth grade students. It was an empirical study and there were 34 participants in the research. Spatial Intelligence Scale and pentominoes puzzles were used as an instrument in this study. Result of this study showed that after students took digital pentominoes game, students spatial abilities improved. Also, the gender difference can be reduced by support of digital pentominoes game. In addition, they found that low spatial ability groups had the gender differences.

There were some studies about the effect of gender for spatial visualization ability. Some of the studies show no difference between female and male participants. However, in some of the studies differences occur in favor of male.

Studies in favor of male participants

Through the history there were different research to examine the difference of scores between female and male participants. In some studies (Bouchard & McGee, 1977; Harris, 1978; McGee, 1979; Sanders, Soares & D'Aquila, 1982) scores of male participants were higher than the scores of female participants.

There were different theories about the gender difference for spatial ability. Harris (1978) proposed a genetic x-linked model to explain the gender difference in spatial ability. According to him, it was recessive trait and it carried on X-chromosome. This was about the role of biological factors. Another theory is about the brain lateralization. According to research (Buffery & Gray, 1972; Levy, 1976) male had greater degree of lateralization and it was advantage in spatial ability. In addition, timing of puberty was another effect of gender difference in spatial ability. According to Waber (1976, 1977) male matures earlier than female and they had better performance than female participants.

Instructional and environmental factors were another reason for gender differences in spatial ability. According to Ferguson et al. (2008), environment and experience have an impact to spatial abilities of students. Physical environment has a positive effect to increase male participants' spatial ability since they exposed it more than female participants. Therefore, according to them, male participants had higher spatial ability.

In addition rather than biological factors, academic factors and construction based toys played an important role to develop spatial abilities. Gold et al. (2018)

conducted a research to investigate effect of academic training, childhood toys and motivation on spatial ability. In this research they found significant difference in spatial ability between female and male undergraduate students especially in mental rotation. Result of this research showed that spatial ability is related with academic trainings, extra-curricular activities. Spatial ability can be developed by using construction-based toys in childhood and activities which students involved in.

Studies with no gender difference

Although there were research about gender difference in spatial ability, some research showed no gender difference in spatial ability.

Seng and Chan (2000) explored the spatial ability and gender differences in an elementary school. In their research 127 (55 female and 72 male) elementary school pupils were participants. In this research Spatial Relation Orientation Test and the Spatial Visualization Test were used to investigate students' spatial ability. Result of this study showed that there was no gender difference between students' spatial ability. Seng and Chan (2000) emphasised that students' spatial ability can be developed by cultural factors and training sessions last ten years.

Hyde (1981) conducted a research by using meta-analysis techniques to investigate the gender difference in spatial ability which is cited by Maccoby and Jacklin (1974). Maccoby and Jacklin found the well-established gender difference in spatial ability in favor of males. Hyde (1981) conducted a research to assess the magnitude of gender difference and the result showed that gender difference in spatial ability were very small. This showed that gender had minimum influence of students' scores of

spatial ability. Fairweather (1976) explained that there were other factors for the predictor of spatial performance such as birth order, handedness or maturation rate. According to Feingold (1988) relation between gender difference and the year of the study was inversely proportional. He concluded that attitudes toward female was changed over the past several decades and it helped to reduce gender difference in cognitive abilities. Also, tests which is used to investigate the spatial ability of students were important to decide emergence age of sex difference (Voyer, Voyer & Bryden, 1995). Voyer, Voyer and Bryden found that there was gender difference for spatial ability over 18 years old. However, according to them there were no significant gender difference in spatial ability for participants which was below 18 years old.

In this section, various results were explored. According to results, age, year of the study, cultural factors had an effect of gender difference in spatial ability.

The studies about grade level/age difference in cognitive style

Age was an important factor to show different cognitive styles such as field dependent or field independent. Panek, Funk and Nelson (1980) conducted a research to investigate validity and reliability of group embedded figures test. There were 175 females and their ages from 17 to 72 years. They divided participants into seven different groups depending on their ages. When the mean scores of group 1 (aged 17 to 24, *M*=5.12, *SD*=2.79) and group 2 (aged 25 to 32, *M*=5.36, *SD*=2.41) participants were considered, mean scores were increased with age for the second part of GEFT. However after the group of 3 (aged 33 to 40, *M*=3.68, *SD*=2.84) mean scores were started to decrease. There were statistically significant difference the

mean scores of group 1 and group 3 or group 2 and group 3. It was same for the third part of GEFT. It showed that when the age of the participants increased, there were difference in cognitive style. Mean scores of the participants and the age of the participants were inversely proportional. However, according to Panek, Funk and Nelson (1980), it was true for the age above 33 years.

It has been accepted that individuals become relatively more field-independent as they mature. According to Glynn and Stoner (1987), there were positive correlation (0.65) between age and the Children's Group Embedded Test scores. For the research participants were aged from 5 to 12 years old. There was another research found age difference in Preschool Embedded Test scores between 4 and 5 years old (Hall et al., 1988; Haynes &Miller, 1987). In addition, Massari (1975) found the difference in the mean scores of Children's Group Embedded Figures test for Grade 1 and Grade 3 students.

Guillot and Collet (2004) conducted a research to analyze the relationship between field dependence/independence and complex motor skills. Participants of this research was athletes and their ages were from 16 to 35 years. They divided athletes into two group according to mean of age. One group involved ages below the mean (M=22.0) and another group involved the ages above the mean. GEFT was used as an instrument to find athletes' cognitive style. Result of this study showed that there were no significant difference for age over the whole sample. Above 22 years mean score was 11.08 with standard deviation of 4.91 and below 22 years mean score was 12.42 with standard deviation of 4.23. This result was in agreement with Tabernero and Marquez (1999). There were no significant difference for age over the whole

sample in their research. On the contrary, Baker et al. (1998) found significant difference with the males in their twenties and the males in other age groups. Males in their twenties were more field-independent than males in other age groups.

The studies about grade level/age difference in spatial ability

Many researcher concluded that when the grade level/age of the students was increased their performance on spatial ability also increased. Johnson and Meade (1987) conducted a research with students from kindergarten to grade 12. They adapted seven spatial ability test for use in children. For example, they use simple and clear instruction, interesting items in test and relatively simple test items. Tests were Flags, Hands, Blocks, Hidden Figures, Spatial Relations, Mental Rotations and Cubes. Tests were prepared according to students grade level/age. Lower battery was used for students from kindergarten to grade 4. Middle battery tests were used from grade 4 to grade 6. Upper battery tests were used from grade 7 to grade 12. Result of this study showed that when the grade level of the students' were increased their performance also increased. According to Johnson and Meade (1987) there were strong tendency for spatial ability performance of students to improve over grade.

There were studies to test age difference in spatial ability and spatial reasoning. Ben-Chaim, Lappan and Houang (1988) explored the influence of instruction on spatial visualization ability of middle school students. There were approximately 1000 students as participant in this study. As pre-test and post-test, Middle Grades Mathematics Projects (MGMP) Spatial Visualization test were applied. After the pre-test were completed, MGMP Spatial Visualization Unit was taught for three weeks. According to finding of this study, increase in grade level results with increase in

spatial visualization ability before the instructional intervention. Researcher related that with the maturity level of students. When maturity level increased, spatial ability of individual also increased. It was consisted with previous research (Fennema & Sherman, 1977, 1978; Guay & McDaniel, 1977). In addition, after the intervention gains were close to each other both female and male participants.

There was more recent research about the spatial ability of fifth to eighth graders. Michaelides (2002) conducted a research with 107 students from fifth to eighth graders. Spatial ability of mental rotation was assessed by using 19 multiple choice items. Result of this study revealed that when the students' grade level/age was increased, they scored significantly higher than the students from lower grade level for the three dimensional subset. He argued that designing instructional assessment material for special age groups can be guided by knowledge about the effect of age in spatial reasoning and it was the developmental point of view of this research.

Relationship between cognitive style and spatial ability

Almost two decades later, Macleod, Jackson and Palmer (1986) investigated whether field dependence is related to an individual's spatial ability. They selected 60 subjects from 134 undergraduate students from the University of Toronto. There were 30 male and 30 female in this research. Their ages ranged between 19 and 24. They used the Embedded Figure Test and the Rod and Frame Test for field dependence. The Spatial Relation Subsets of the Multiple Aptitude Test and the Block Design Subsets of the Wechsler Adult Intelligence Scale were used for spatial ability. As a result of this study, spatial field dependence and spatial ability exhibited a median correlation of 0.51. Generally, correlation cannot be found due to random

error and method factor in these type of researches. However, they used statistical methods to help them avoid understating intertrait correlations. In this article researchers use confirmatory factor analysis technique to eliminate biases. They found that spatial ability and field dependence are strongly correlated.

In addition, a recent study, which is conducted by Taskon, Boccia, Piccardi and Cimadevilla (2017), is about the relationship between cognitive style and spatial performance. The purpose of this study was to find the effect of cognitive style and gender on spatial recognition. There were 40 participants which are undergraduate College students from Sapienza University, Rome. Half of these participants were male and half of them were female. Firstly, the Familiarity and Spatial Cognitive Style scales were used to confirm that participants did not have any topographical orientation disorders. Then, they used the Embedded Figure Test for assessing cognitive styles of participants. In addition to these, they used the Almeria Spatial Memory Recognition Test for assessing participants' spatial recognition. ANOVA was used to analyze data. Also, Statistica 10 was used to operate analysis. In that research it is found that field dependent individuals could not deduce spatial information. Field independent individuals are more proficient than field dependent individuals in extracting information and put these information to look at different perspectives. Also, they found that there is no gender difference in individuals' performance on spatial memory tasks.

To conclude, there are different studies about individual's spatial ability and field dependence-independence. They investigated their abilities in different perspectives. Researches were conducted at different countries. Also, gender effect was studied in

previous years. Embedded Figure Test is a good instrument for measuring field dependence. These studies shed light on the current research topic. Moreover, the result of the current research may provide teachers to use different ways for their teaching according to abilities of students in physics education.

CHAPTER 3: METHOD

Introduction

The purpose of this study was to investigate the relationship between high school students' cognitive style and their spatial visualization ability. This study provided an overall view of relationship between students' cognitive style and spatial visualization ability and how was the relationship between gender and different age or different grade levels with cognitive style and spatial ability.

Research design, context, participants, instrumentation, data collection and data analysis are the six sections comprising this chapter. In the research design section, research method and related constructs were described. A rational for choosing the method is described in this section as well. The context section provides information about the schools used in this research and the participants. Participant section included the population description and sampling strategy. In the instrumentation section, validity and reliability of the instrument were clarified. Data collection procedure and the ethical issues regarded regulation of Ministry of National Education (MoNE) was explained in the data collection section. Moreover, in data analysis section, analysis of this research was explained.

Research design

The purpose of this study was to explore the relationship between students' cognitive and their spatial visualization ability. Therefore, this study is classified as a

quantitative research and it is correlation research. In this study three variables were measured by using two different tests and then statistical relations between them were assessed. Therefore, I choose correlation research design. In addition, it is a descriptive study and instrument is testing in this study. There are two different tests to measure students' cognitive style and spatial ability separately. In two different tests following research questions were addressed:

1. Is there a statistically significant relationship between students' cognitive style and their spatial visualization ability in some selected high schools in Ankara?
2. Are there any statistically significant difference between students' cognitive style by gender?
3. Are there any statistically significant difference between students' spatial visualization ability by gender?
4. Are there any statistically significant difference between students' cognitive style by schools?
5. Are there any statistically significant difference between students' spatial visualization ability by schools?
6. Are there any statistically significant difference between students' cognitive style by grade?
7. Are there any statistically significant difference between students' spatial visualization ability by grade?

Research method

This study looked at existing relations between variables. Therefore, Creswell (2014) explained that, although it was correlation research, it can be refereed as descriptive

research. According to Ayiro (2012), descriptive research method explores information about existing events, situations or conditions. Descriptive research method describes the facts and characteristics of a given population or area of interest (Isaac & Michael, 1979). It helps the determining the frequency with which something occurs or help to categorize information (Burns & Grove, 1987).

In Turkey, any research conducted in schools needs an official approval by the Ministry of Education. This will grant that the research can be conducted in schools. However, final say has the school teacher. In other words, the MoNE approval is just the initial step. After having the approval of MoNE, schools was decided to conduct research by calling the head of the schools. If they permit to apply test in their schools, day was decided with them. However, some schools do not give permission to do tests because it was exam week and teachers should prepare their schedule according to it. In the decided day, first the head of the schools was visited first and according to guidance and suitability of teachers, test applied at different grades and classrooms. However, before tests were applied, the head of the school informed parents and signed informed consent form which includes the purpose of the research and rights of this research. Also, researcher's e-mail address and the phone number included in this permission paper to answer parents' questions about the research if they have questions.

Moreover, this study took place at four different Anatolian high schools in Çankaya region. There were two different tests to examine students' cognitive style and spatial visualization ability. Students' responses were analysed to find the relationship between students' cognitive style and their spatial visualization ability.

Moreover, how students' cognitive style and spatial visualization ability can change according to their gender, age or grade levels were investigated at four different schools. The data collection was done in March 2019. Tests were done in a week and one day was allocated for each school.

Context

The study took place at four Anatolian High Schools in Ankara. In this research four different high schools were chosen to apply tests in order to have different range of students according to their success. Using different high schools can be better for having variety result. In this test School 2 was highest ranked school according to high school entrance exam. Then School 4 followed it and afterwards School 3 was coming. School 1 was the last one as compared to others when the results of high school entrance exam was considered. Also, since before 2018 students went to high school according to their success. However, students started to enter the high schools starting from the previous year according to their home address. Therefore, in this study 10 and 11 graders entered high schools according to their success and 9 graders entered high school according to their home address.

Tests were applied during the spring term of 2018-2019 school year. All students participated in tests in a class. Tests were conducted under the same condition. All participants were given 40 minutes to complete the two tests. The Group Embedded Figure Test (GEFT) took 15 minutes and Purdue Spatial Visualization Test (PSVT) took approximately 25 minutes. Information about each school were given in Table 1.

Table 1
School names and the number of participants

Schools	Number of participants
School 1	94
School 2	110
School 3	81
School 4	108

Participants

Participants of this study was Anatolian high school students in Çankaya. Participants of this research was grades 9, 10, and 11.

In this study, there were 183 students from ninth grade, 114 students from tenth grade and 96 students from eleventh grade. Totally, participants were 393 students from four different high schools. Moreover, 187 of participants were male and 206 of participants were female. In Figure 2 percentage of female and male students were given.

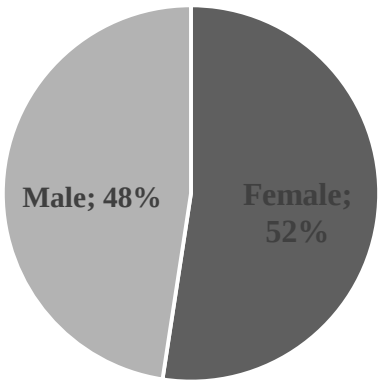

Figure 2. The percentage of female and male students

Moreover, number of students from different grades are given in table 2. In addition to this, percentages of students' grades are given in Figure 3. According to this table,

47 % of students were from grade 9 (*n* =183), 29 % of students were from grade 10 (*n*=114) and 24 % of students were from grade 11 (*n*=96).

Table 2
Grade levels and the number of participants

Grade level	Number of participants
Grade 9	183
Grade 10	114
Grade 11	96

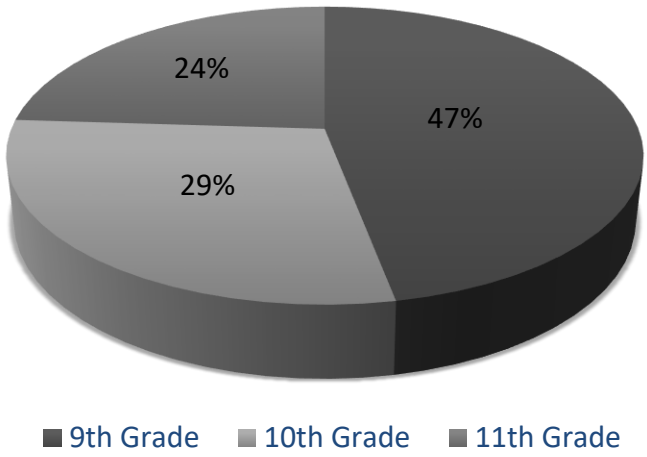

Figure 3. Percentage of students from different grades

Instrumentation

In this research two tests were used. The first test, named as Group Embedded Figure Test (GEFT), assessed cognitive styles. The second test was Purdue Spatial Visualization Test (PSVT) assessed students' spatial abilities.

In this research instrument is testing. The Group Embedded Figure Test is developed by Witkin, Oltman, and Raskin (1971), and the Purdue Spatial Visualization Tests is developed by Guay (1976). The original English version of the GEFT is given in Appendix A. This test consists of three parts and there were 25 questions. In the first part, there are seven questions and two minutes were given to students for the first part. For the second and third part, there are nine questions in each part and 5 minutes were given to students for each part. In each part, students found simple form which is hidden in a complex pattern. Simple forms were given at the end of the booklet. Turkish version of the GEFT is used in this research to apply test in schools. In Appendix B, the Turkish translated version of the test is given. Bilkent University Library had the right of the use of GEFT and had this test in the university catalogue of the library. In this test, simple forms and complex figures are given to participants. In Figure 4 example of simple form was given and it was labelled by X.

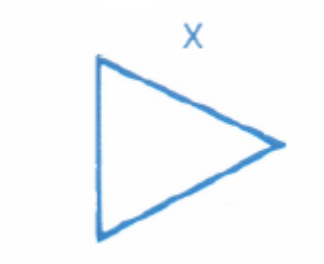

Figure 4. Simple form X

The simple of X is hidden within the more complex figure below Figure 5.

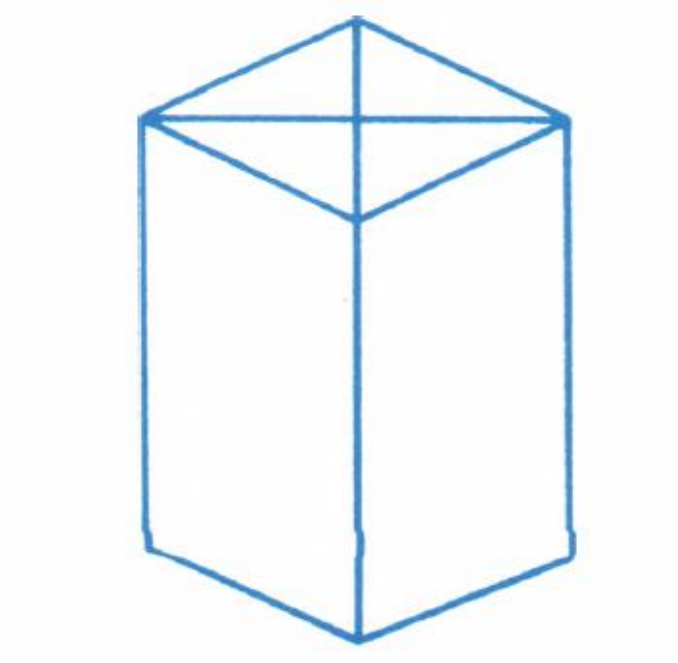

Figure 5. Complex figure from GEFT

In this test participants tried to find the simple form X in the complex figure and they traced it with pencil directly over the lines of the complex figure like Figure 6.

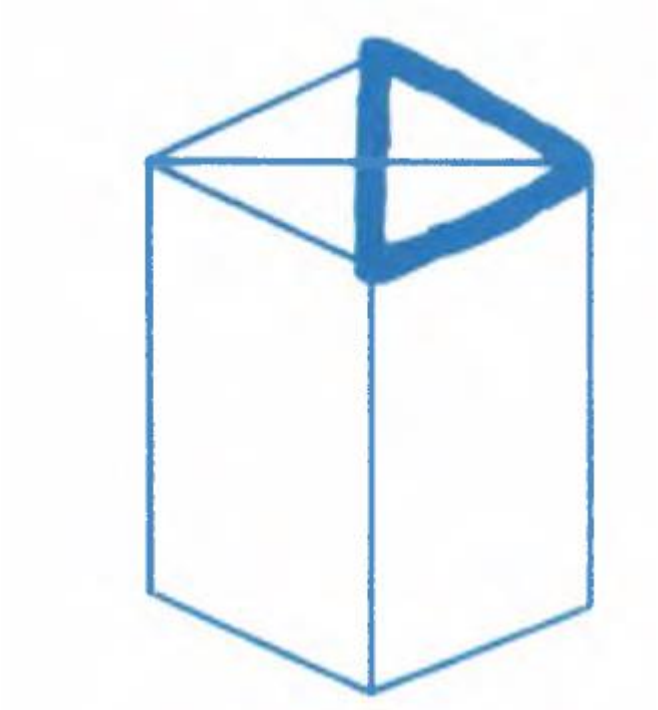

Figure 6. Simple form traced over the lines of the complex figure

Participants were asked to find the simple form in same size, same proportion and facing in the same direction.

For the second test, PSVT, Turkish translated version of the test is given in Appendix C which is translated by Sevimli (2009) for his master thesis. It was used in this study to assess students' spatial visualization ability. Permission was obtained from Sevimli to use the translated version of PSVT in this research in July 2018 via e-mail. This test consists of three parts, and in each part, there are 12 questions. The test begins with examples in the beginning of each part of the test. First part is about formation of 3D shapes. In this part students formed 3D shape by using the open form of given shapes. Example of PSVT was given in Figure 7 and Figure 8. In this test Figure 7 was given. It was the open form of the 3D shape and Figure 8 consisted of the multiple-choice shapes. In this part participants determined 3D shape by analyzing the Figure 7. Students answered these questions by using answer sheet which was distributed them. Correct answer was E from Figure 8.

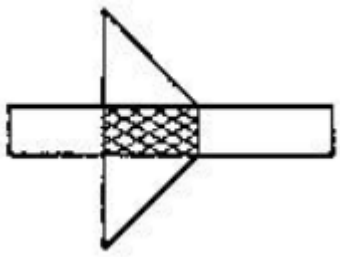

Figure 7. Open form of the 3D shape

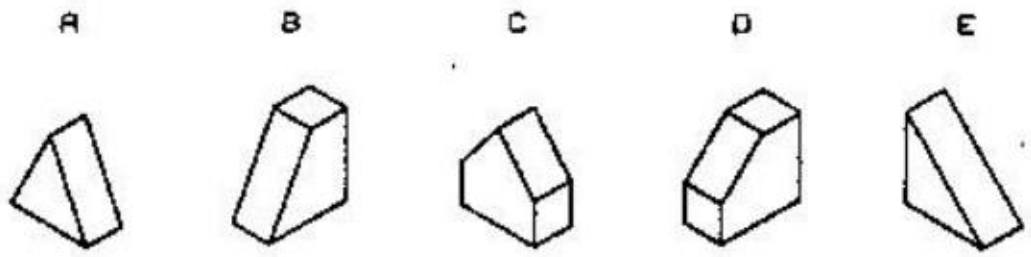

Figure 8. Multiple choice to determine 3D shape of Figure 7

Second part is about the rotation of 3D shapes. In this part of the test, example of the rotation is given for one shape. Then, participant should rotate given shape by rotating in the same direction as the example one. In Figure 9, rotation of an object is given.

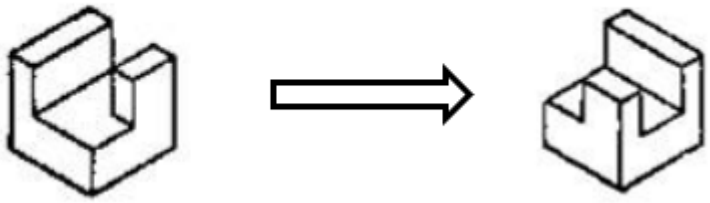

Figure 9. Rotation of object

In Figure 10 another 3D shape was given. Then in this part, participant was supposed to rotate 3D shape given in Figure 10 in the same direction as the example from Figure 9. According to this rotation, participants chose one of the choices from Figure 11. Correct answer of this example was D.

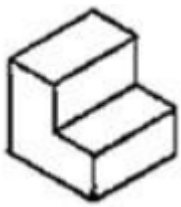

Figure 10. Example 3D shape

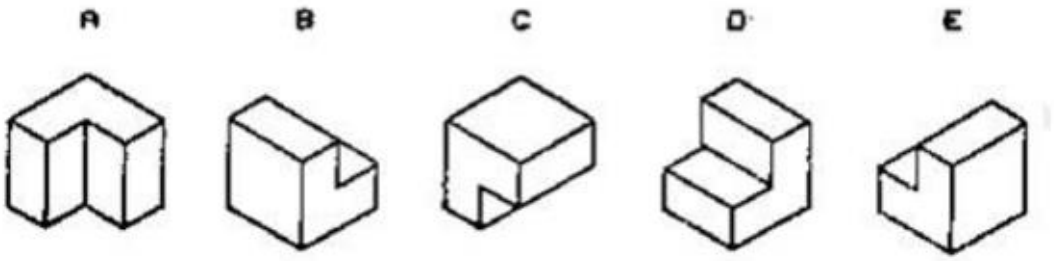

Figure 11. Choices to find the correct result after rotation

Moreover, third part is about looking the 3D shape from different perspective. Students looked 3D shape from different points of another 3D shape. In Figure 12, 3D shape was given inside the 3D box. Also, the black dot was given on the right side of the box.

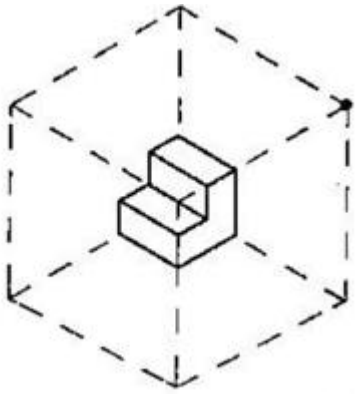

Figure 12. 3D shape and 3D box with black dot

In this part, participants supposed to look the 3D shape in the box by using the perspective of the black dot. In Figure 13, multiple choices are given and one of them was the correct answer. Correct answer of this example was E.

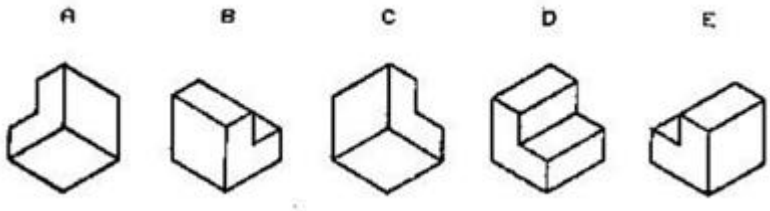

Figure 13. Multiple choices of the perspective question

Moreover, a panel study conducted with students from Curriculum and Instruction with Teaching Certificate master students from Bilkent University. GEFT and PSVT was administered to 10 master students to check for possible misunderstanding during GEFT and PSVT. This study was the validation of GEFT and PSVT. Moreover, reliability analysis was conducted by using Statical Package for Social Science (SPSS).

Method of data collection

Before tests were applied in schools, permission from Ministry of National Education (MoNE) were obtained by submitting a research proposal to MoNE. In this proposal, problem, purpose, research question, significance, limitations, participants, instruments, data collection methods, permission from tests developers to use their tests in this study, list of the schools were submitted to MoNE. After having the permission from MoNE for the 2018-2019 academic year, researcher contacted to the principals of the selected schools to get another permission from them. It is important to get permission from not only from MoNE but also from the principals or the vice principals of the schools since they have right to not allow to do tests in their schools. Therefore, the principals or the vice principals of the schools are called to get another permission from them. After getting permission from both MoNE and the principals of the four different schools, tests were applied in four different schools by the researcher.

After getting permission from principals of the schools, four different days was planned to apply tests at schools. Question booklets, the answer sheets and pencils are prepared for participants. Tests were applied with the guidance of teachers.

Introduction of the researcher and the introduction of the tests were the steps of applying tests. Students are informed about tests. GEFT was started with the explanation part and then the first section. Students asked their questions after the explanation part and the first section if there were misunderstanding since the first part of the GEFT was pilot part. Also for PSVT, students asked questions after examining the examples before tests started.

Methods of data analysis

After data were gathered from participants, statistical analysis was done by using SPSS and data were investigated by using descriptive statistical methods. Mean, median, mode, skewness, kurtosis, range, standard deviation and frequency was computed by using descriptive statistical methods. Also, descriptive statistical methods were applied based on gender, grade level and school type. In addition, independent sample *t*-test and ANOVA was conducted in this research.

In this chapter, the research method and how it applied was explained. The timeline and participants were explained. Context, instrumentation, data collection and data analysis methods are provided in this chapter. In the next chapter the results of data analysis were detailed.

CHAPTER 4: RESULTS

Introduction

In this chapter detailed information about the statistical results of this study were given. Descriptive analysis was done in order to obtain an overall information about the statistical results. One way ANOVA, independent sample *t*-test and correlation were used as well. Firstly, results of the descriptive analysis of students' score with respect to gender, three different grade and four different school were reported. Secondly, independent sample t-test was used to find the possible statistically significant difference between male and female students according to their total scores on GEFT and PSVT. Thirdly, one-way ANOVA was conducted to calculate possible statistically significant differences between schools for GEFT and PSVT. Finally, correlation was conducted to reveal whether there was any statistically significant correlation between students' total scores on GEFT and PSVT.

Firstly, descriptive analysis of the students' score of GEFT and PSVT gave brief summary about students' score with respect to gender, grade and school. In this analysis, number of students, mean score, median, standard deviation, skewness, kurtosis, range, minimum and maximum value of the student's score were given. In addition to these, graphs were piloted in order to show number of students vs. their scores in different way. Afterwards, descriptive analysis of students' scores in two different tests were given according to gender, school and grade respectively. Further computation was conducted in order to find whether there was any difference

between students' score based on gender. While this research obtained the data from four different schools, school based students' scores were analysed. Also, participants of this study were ninth, tenth and eleventh grade students from four different schools. Therefore, descriptive analysis was conducted for the three different grades on their respective mean.

Descriptive results of students' score on GEFT and PSVT

There were two different tests used in this research. First, descriptive analysis of students' score on these tests were given according to students' correct answers to the questions on these two tests.

GEFT and PSVT were applied to 393 students from four different Anatolian high schools. In Table 3, descriptive analysis results were given. According to these results, mean score of GEFT was found as 6.14 and PSVT is found as 10.52. While skewness and kurtosis of 393 students' score on GEFT were 0.557 and -0.201, these were 0.428 and 0.532 on PSVT respectively. Standard deviation of GEFT was 3.89 and it indicated that most of the students' score on GEFT was in between 3 and 10.

Table 3
Descriptive Statistical Methods for students' scores in GEFT and PSVT

Tests	Mean	Median	SD	Skewness	Kurtosis	Range	Min	Max
GEFT	6.14	6	3.89	0.557	-0.201	18	0	18
PSVT	10.52	10	3.87	0.428	0.532	23	1	24

In addition, standard deviation of students' score on PSVT was 3.87. It showed that majority of the students' score on PSVT was between 7 and 14. According to Table 3 the range value of GEFT was 18 and the range values of PSVT was 23. Moreover,

minimum and the maximum score on GEFT was 0 and 18 respectively. The maximum and minimum scores were 1 and 24 on PSVT respectively.

Figure 14 showed that one student answered all the questions in GEFT correctly and 46 students (corresponds to 11.7% of the sample) answered four questions correctly from GEFT. In addition, 19 students (corresponds to 4.8% of the sample) was not able to score. The majority of the students' total score were in between 3 and 10 (which were 263 students, and it corresponds to 67% of the sample) for GEFT.

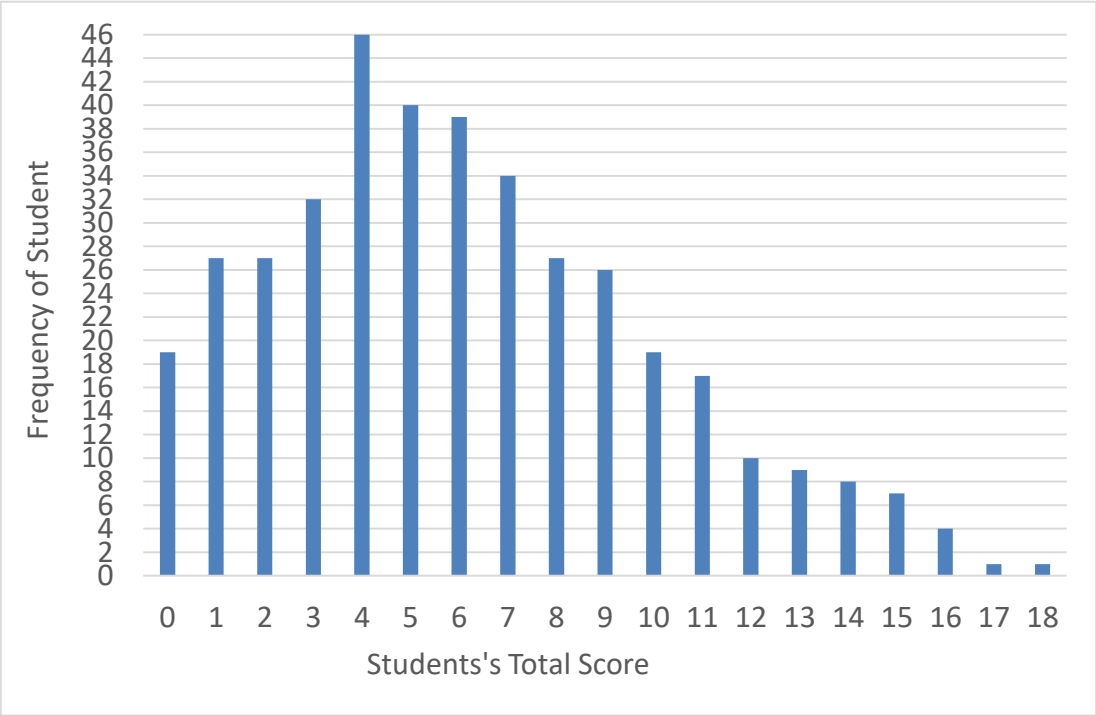

Figure 14. GEFT total score frequency distribution

Figure 15 showed that 45 students (corresponds to 11.5% of the sample) answered 9 questions correctly in PSVT. In addition, 1 student answered 24 questions in PSVT and it was the maximum score for this test. The majority of students' total score was in between 9 and 11 (which were 166 student and it corresponds to 47% of the sample) for PSVT.

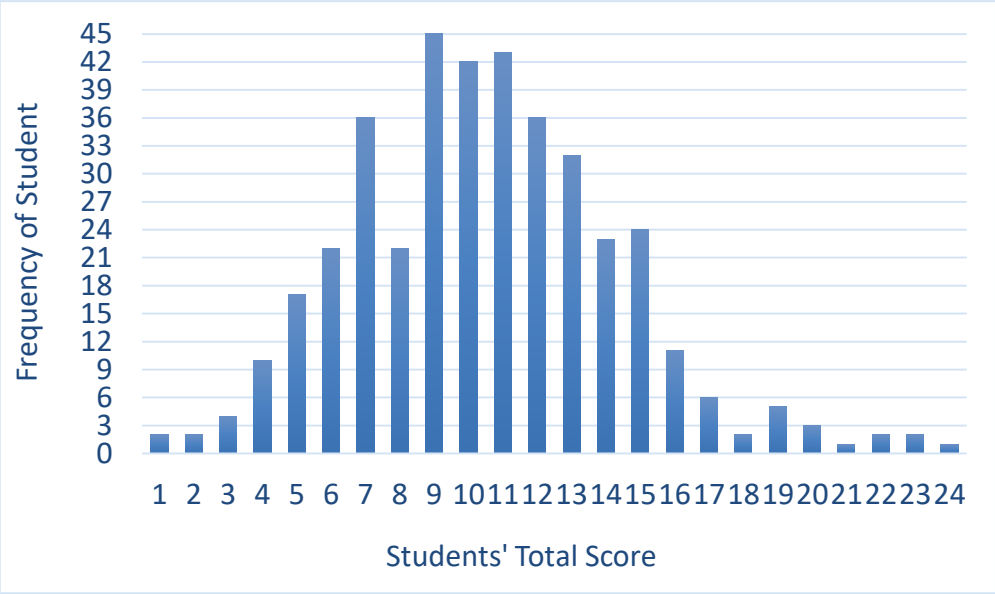

Figure 15. PSVT total score frequency distribution

By gender

When gender differences were considered for GEFT and PSVT, the following results were obtained from the descriptive analyses. Results of descriptive analysis according to gender were given in Table 4 and Table 5 for GEFT and PSVT, respectively.

In this research there were 206 female students and 187 male students. Female students consisted of 52% of the participants and male students consisted of 48% of the participants. According to Table 4, mean score of female students was 6.24 whereas mean score of the male students was 6.03 for GEFT. Median of the male and female students were different and female students' scores median score was 6 and male students' median score was 5. In addition, standard deviation for female students and male students' scores were 3.94 and 3.85, respectively. Skewness value of female students' score was 0.47 and it was 0.66 for male students according to

Table 4. Kurtosis value of female students was -0.30 and it was -0.04 for male students. It is worth pointing out that only one female student was able to correctly answer all of the questions in GEFT. The range of the female students' scores was 18, whereas the range of male students' GEFT score was one point lower, that is 17.

According to Table 5, mean score of the female and male students were 10.39 and 10.66 for PSVT, respectively. Median of the female and male students' scores were equal and it was 10 for both. This analysis showed that of the female participants' scores was 3.49 a bit tighter while the standard deviation was 4.26 for male participants. Skewness value of the female participants' scores was 0.52 and it was 0.33 for male participants' scores in PSVT. Kurtosis of the female participants' scores was 1.41 and it was -0.08 for male participants' score. Range of the female participants' score was 22 and range of the male participants' score was 23. Then, the minimum value of the male and female participants' score was equal and it was 1. The maximum value of the participants' score was 23 for female participants and 24 for male participants.

Table 4
Descriptive statistical methods for students' scores in GEFT according to gender

GEFT	N	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
Female	206	6.24	6	3.94	0.47	-0.30	18	0	18
Male	187	6.03	5	3.85	0.66	-0.04	17	0	17

Table 5
Descriptive statistical methods for students' scores in PSVT according to gender

PSVT	N	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
Female	206	10.39	10	3.49	0.52	1.41	22	1	23
Male	187	10.66	10	4.26	0.33	-0.08	23	1	24

Figure 16 and Figure 17 showed the frequency distribution of students' score by gender for GEFT and PSVT. Figure 16 showed that total number of female participants were more than total number of male participants for the scores between 5 and 8. Number of participants were same for female and male participants' score for 9. The total number of female participants were more than the total number of male participants in between the score of 10 and 18 for GEFT. In addition, number of participants for male in between 0 and 4 was more than number of female participants in this interval.

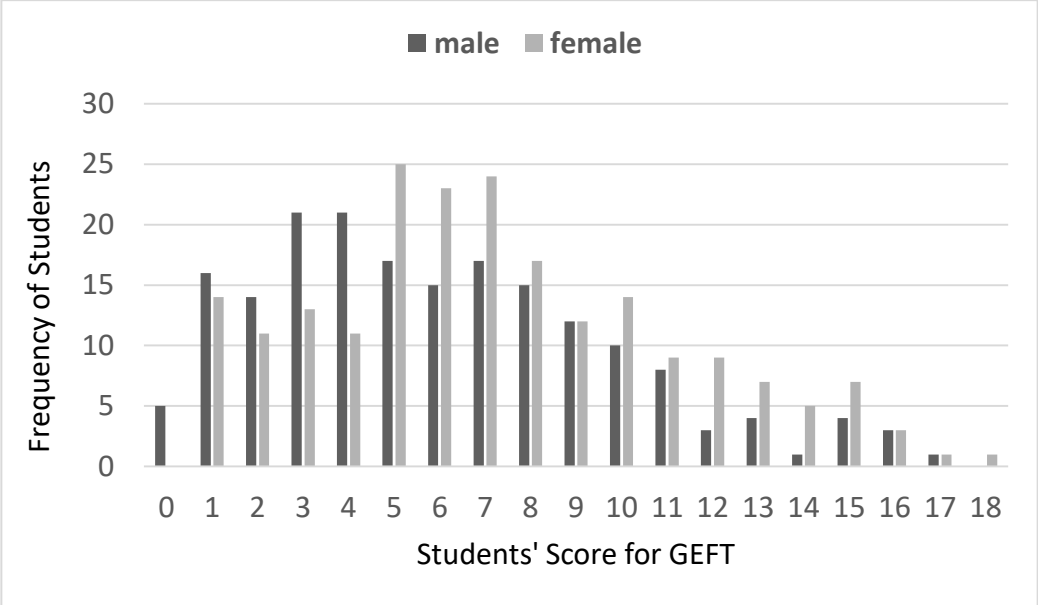

Figure 16. GEFT total score frequency distribution according to gender

Moreover, according to Figure 17, number of female participants were more than number of male participants in between the score of 8 and 14 for PSVT. Also, number of participants were same for the scores of 1 and 22 for male and female participants for PSVT. In addition, number of male participants are more than number of female participants in the score interval of 15 and 19 for PSVT.

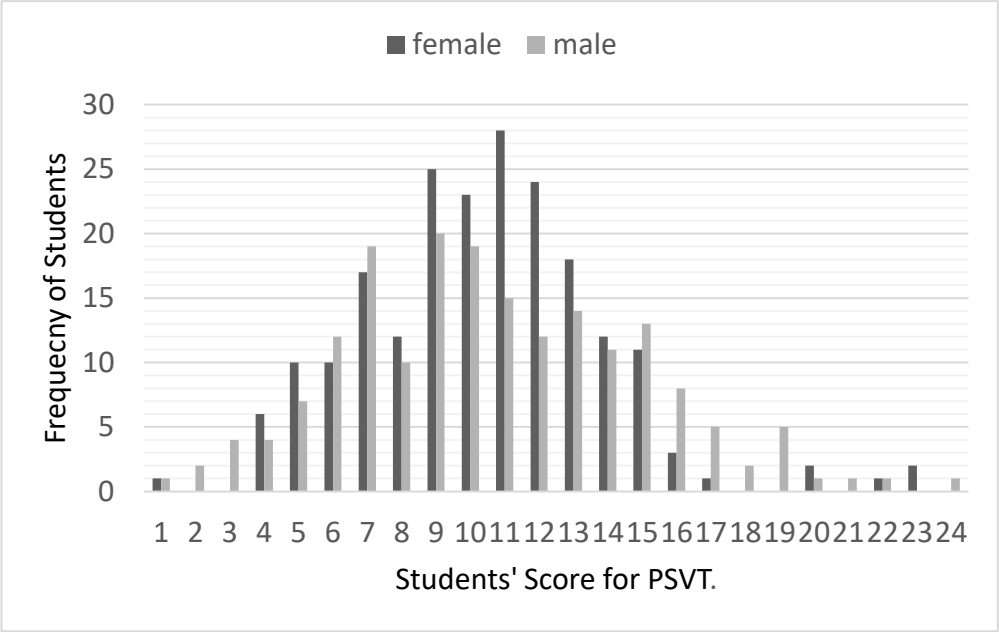

Figure 17. PSVT frequency distribution according to gender

By school

In this research data was collected from four different school and the descriptive analysis of this research according to these schools was given in Table 6.

The student data were collected from four different schools in this research. All of these four schools were Anatolian High schools. There were 94 participants from School 1 and they comprised of 24% of participants. There were 110 participants from School 2 and they comprised of 28% of the participants. School 3 had 81 participants (21 % of the participants) and School 4 had 108 participants (27 % of the participants). Therefore, School 2 had the highest number of participants and School 3 had the lowest number of participants in this research. According to Table 6, mean scores of School 1, School 2, School 3 and School 4 were 4.96, 6.74, 5.72 and 6.88 for GEFT. Mean score of School 1 was 9.32, School 2 was 11.1, School 3 was 10.7 and School 4 was 10.84 for PSVT. Median of the participants' score according to schools were 4 (School 1), 6 (School 2), 5 (School 3), 6 (School 4) for GEFT and

they were 9 (School 1), 11 (School 2), 10 (School 3), 11 (School 4). Therefore, median of the participants' scores were same for School 2 and School 4 for both tests. Moreover, Table 6 shows the standard deviation, skewness and kurtosis values for the two tests by four different schools. Participants' score range for School 1 was 15, School 2 was 18, School 3 was 12 and School 4 was 17 for GEFT. In addition, ranges of the participants' score were 22 for School 1, 21 for School 2, 18 for School 3 and 21 for School 4.

Table 6
Descriptive statistical result of students' total scores according to different schools for GEFT and PSVT

School Name	Tests	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
1	GEFT	4.96	4	3.83	0.51	-0.50	15	0	15
	PSVT	9.32	9	4.08	0.59	0.86	22	1	23
2	GEFT	6.74	6	4.03	0.67	-0.15	18	0	18
	PSVT	11.1	11	3.76	0.38	0.77	21	2	23
3	GEFT	5.72	5	3.24	0.31	-0.88	12	0	12
	PSVT	10.7	10	3.24	0.57	0.98	18	4	22
4	GEFT	6.88	6	4.02	0.54	-0.31	17	0	17
	PSVT	10.84	11	4.06	0.47	0.17	21	3	24

In addition, distributions of students' scores with respect to schools were given in Figure 18 and Figure 19 for GEFT and PSVT. According to Figure 18, 13 students' total score was one and they are from School 1. In addition, one student from School 2 correctly answered all questions from GEFT. According to Figure 19, two students' score from School 1 were zero for PSVT. In addition, one student from School 4 correctly answered 24 question from PSVT. Moreover, these values determined the range of the students' score for these two tests

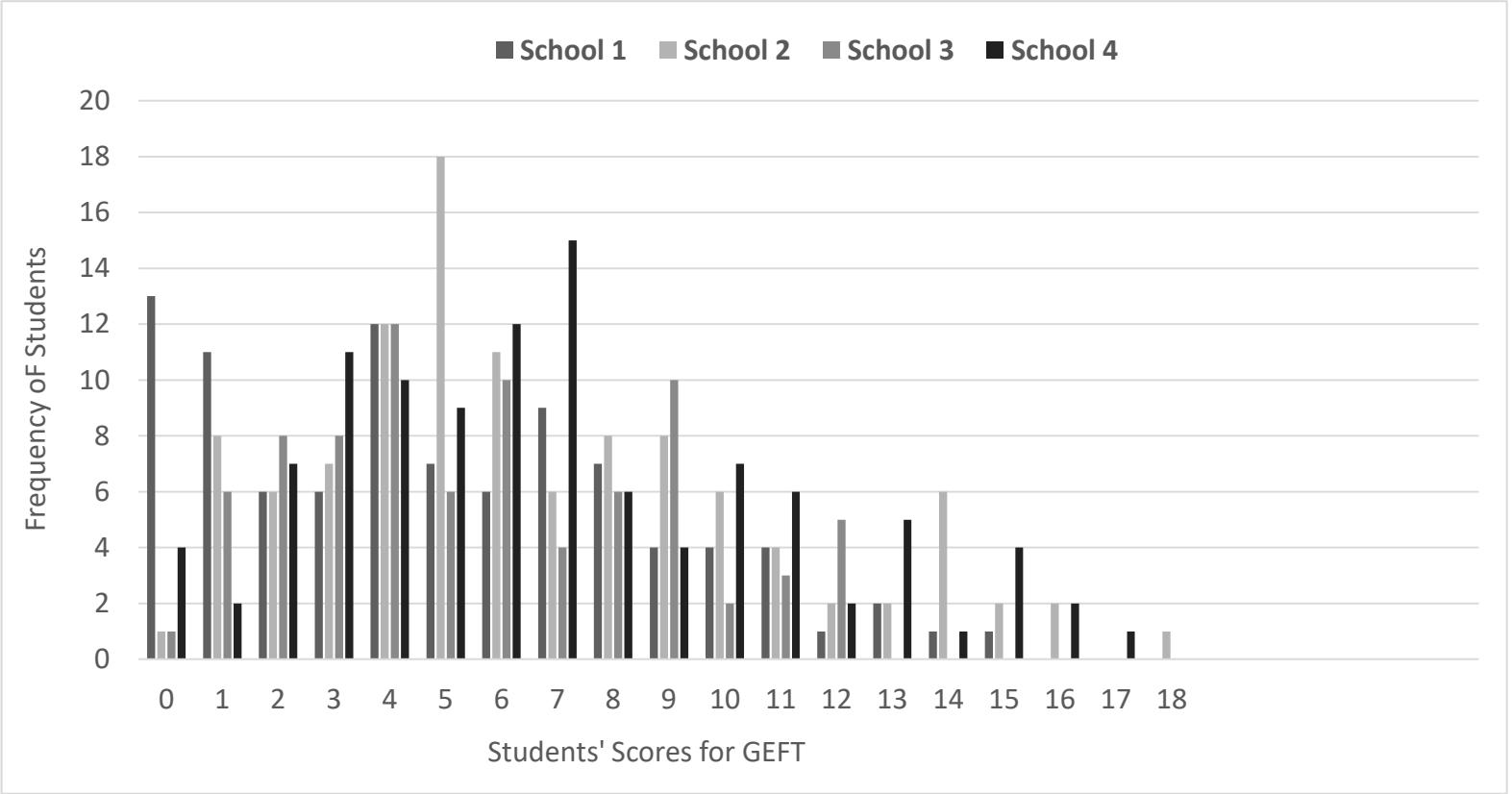

Figure 18. GEFT frequency distribution according to different schools

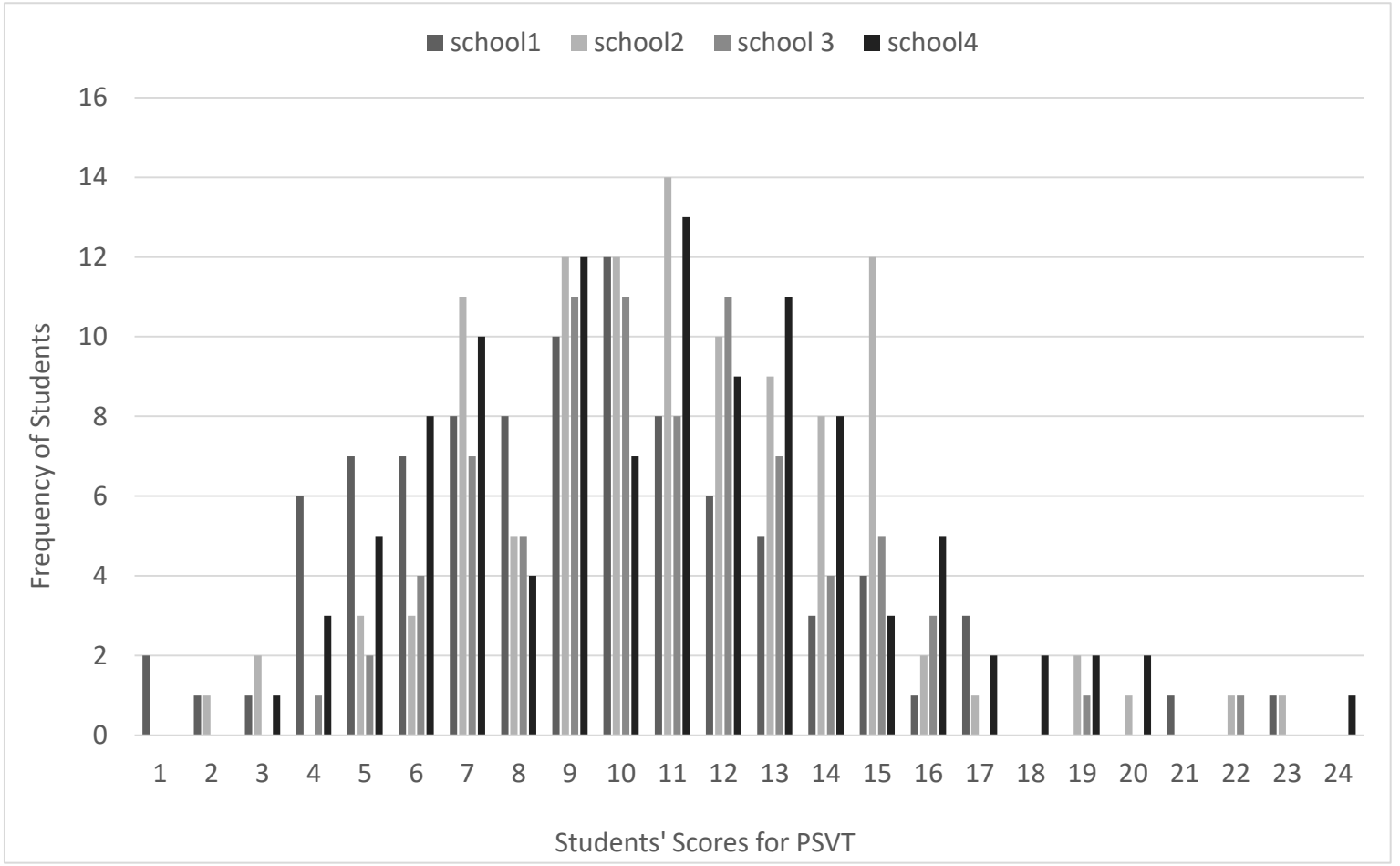

Figure 19. PSVT frequency distribution according to different schools

By grade

Participants of this research were high school students which were ninth, tenth and eleventh grade students.

According to Table 7, there were 183 students from grade 9, 114 students from grade 10 and 96 students from grade 10. Therefore, grade 9 had the highest participant number as compared to grade 10 and grade 11. Mean scores for GEFT were 5.35, 6.93 and 6.71 for grade 9, grade 10 and grade 11, respectively. When the mean scores of PSVT was considered they were 9.55, 11.6 and 11.1 for grade 9, grade 10 and grade 11, respectively. Mean scores of grade 9 was lower than the mean scores of grade 10 and grade 11. The median scores of grade 9, grade 10 and grade 11 were 5, 6 and 6 for GEFT, respectively. When the median score of PSVT was examined it was 9 (for grade 9), 11 (for grade 10) and 11 (for grade 11). Standard deviations for grade 9 (GEFT:3.67, PSVT:3.71), grade 10 (GEFT:3.95, PSVT:3.41) and grade 11 (GEFT:3.99, PSVT:4.26) were examined for different two tests. In addition, range of grade nine was 16 for GEFT (max. 16 and min. 0) and 23 for PSVT (max. 23 and min. 1), grade 10 was 18 for GEFT (max. 18 and min 0) and 19 for PSVT (max. 23 and min. 4), grade 11 was 17 for GEFT (max. 17 and min 0) and 21 for PSVT (max. 24 and min. 3). Maximum score for GEFT was done by grade 10 students and maximum score for PSVT was done by grade 11 student.

Table 7
Descriptive statistical result of students' scores on two different tests according to students' grade level

Grade	Tests	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
9th	GEFT	5.35	5	3.67	0.61	-0.19	16	0	16
	PSVT	9.55	9	3.71	0.43	0.57	22	1	23
10th	GEFT	6.93	6	3.95	0.39	-0.27	18	0	18
	PSVT	11.6	11	3.41	0.49	1.16	19	4	23
11th	GEFT	6.71	6	3.99	0.65	-0.14	17	0	17
	PSVT	11.1	11	4.26	0.50	0.20	21	3	24

Figure 20 and Figure 21 showed distribution of students' scores by grade levels. According to Figure 20, when students' total score was 4, percentage of students (14% of grade 10) from grade 10 was higher than grade 9 and grade 11 for GEFT. Moreover, when students' total score was 7, percentage of students (13.5 % of grade 11) from Grade 11 was higher than grade 9 and grade 10 for GEFT. In addition, when students' total score was 1, percentage of students (13,1 % of grade 9) from grade 9 was higher than grade 10 and grade 11 for GEFT. In summary, one can see a shift in favor of grade, that is, the older the students get, the higher their mean scores get.

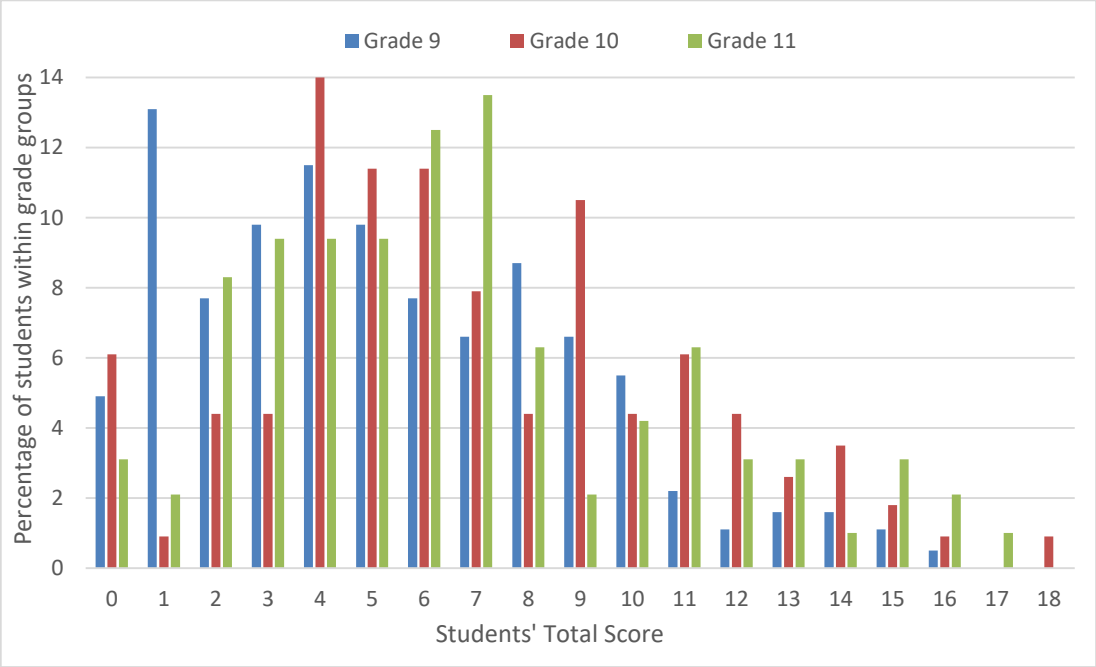

Figure 20. Distribution of students' total score according to grade level for GEFT

Also, according to Figure 21, when students' total score was 11, percentage of students from grade 10 was higher than grade 9 and grade 11 for PSVT. Moreover, there were only grade 9 students who had total score of 1 and 2. Then, only grade 11 students (2.1% of grade 11) had total score of 18 from PSVT. In addition, only grade 11 students (1 % of grade 11) and grade 10 students (0.9 % of grade 10) had

students' total score of 22 for PSVT. In summary, one can see difference between grade 9 and older grades, that is, older participants can have higher total score in PSVT.

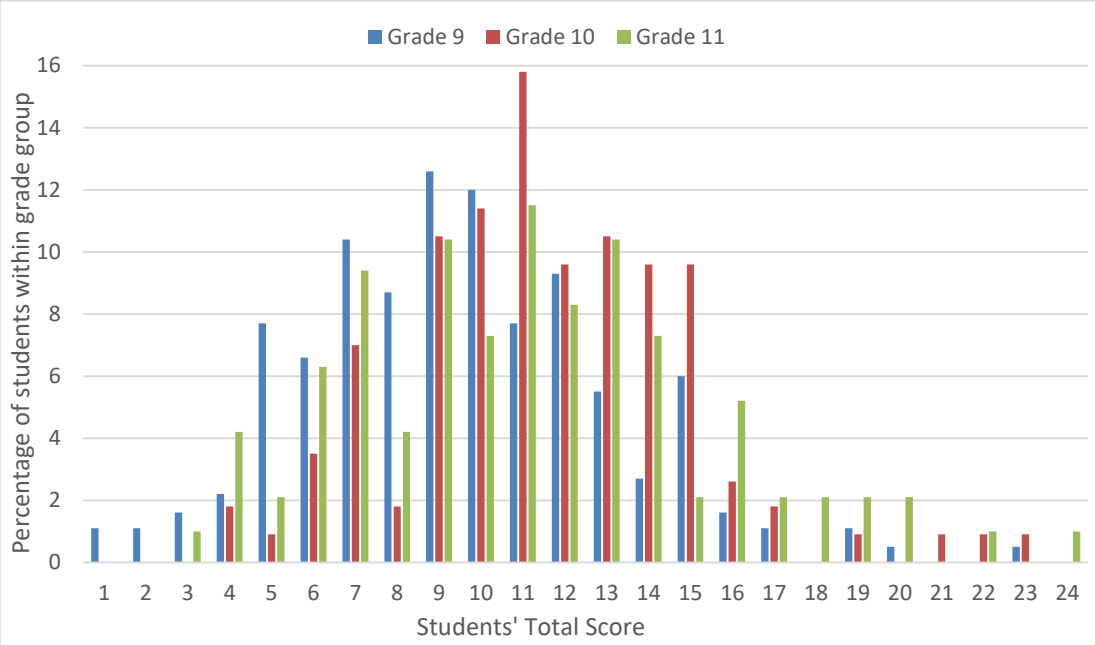

Figure 21. Distribution of students' total score according to grade level for PSVT

Item analysis

This section explored the items in GEFT and PSVT according to female and male participants. Graphical demonstrations of participants' behavior for each item in GEFT and PSVT are given below.

According to Figure 22, unanswered questions for GEFT by female and male students almost same. However, male participants left more questions unanswered for question 8 in GEFT than female students left. However, for question 3 and 7 female participants left more question unanswered than male students left. Almost there was no difference between unanswered questions by male and female participants totally for GEFT.

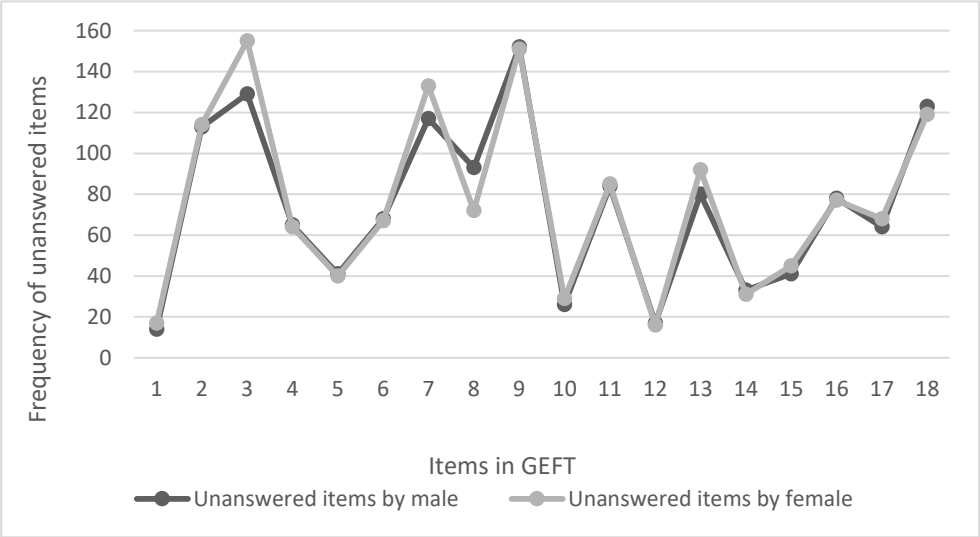

Figure 22. The count of unanswered items in GEFT

Figure 23 is the frequency of unanswered items in PSVT according to gender. Female participants left more unanswered questions between question 14 and 25. However after question 25 male participants left more questions unanswered as compared to female participants. After question 25, male participants left more unanswered questions than female participants. Conditions were same for all participants for GEFT and PSVT.

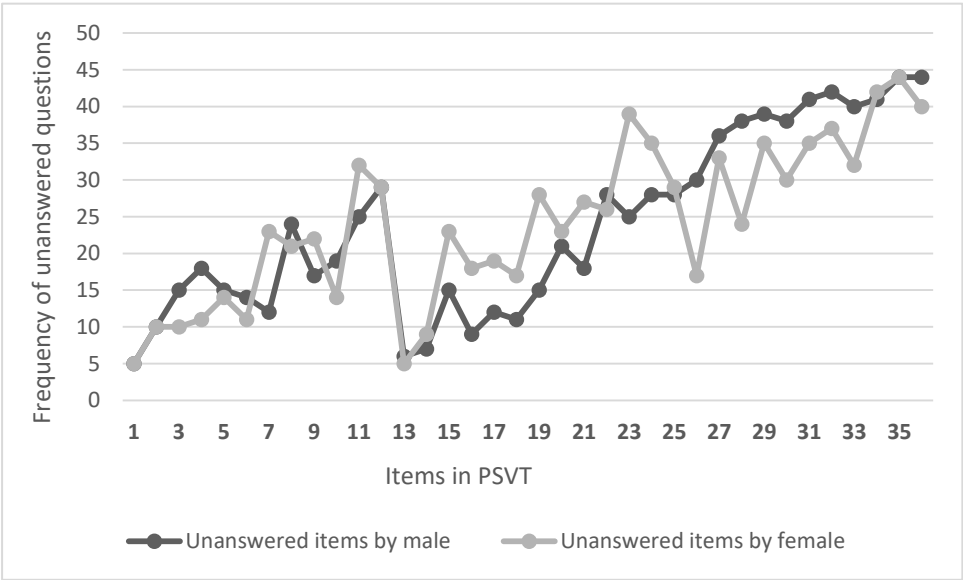

Figure 23. The count of unanswered items in PSVT

Figure 24 represents the item difficulty values for each item in GEFT according to gender. Item difficulty values was kind of psychometric measure. It was about the correct answer ration for a particular item. Totally there were 18 items for GEFT. According to Figure 24, both female and male participants found item 18 as most difficult item in GEFT. Item 9 also is found difficult for male and female participants according to Figure 24. Both male and female participants had less difficulty at item 12 as compared to other items in GEFT. One can deduce that male participants found item 8 more difficult than female participants. Difficulty of the other questions were almost same for male and female participants for GEFT.

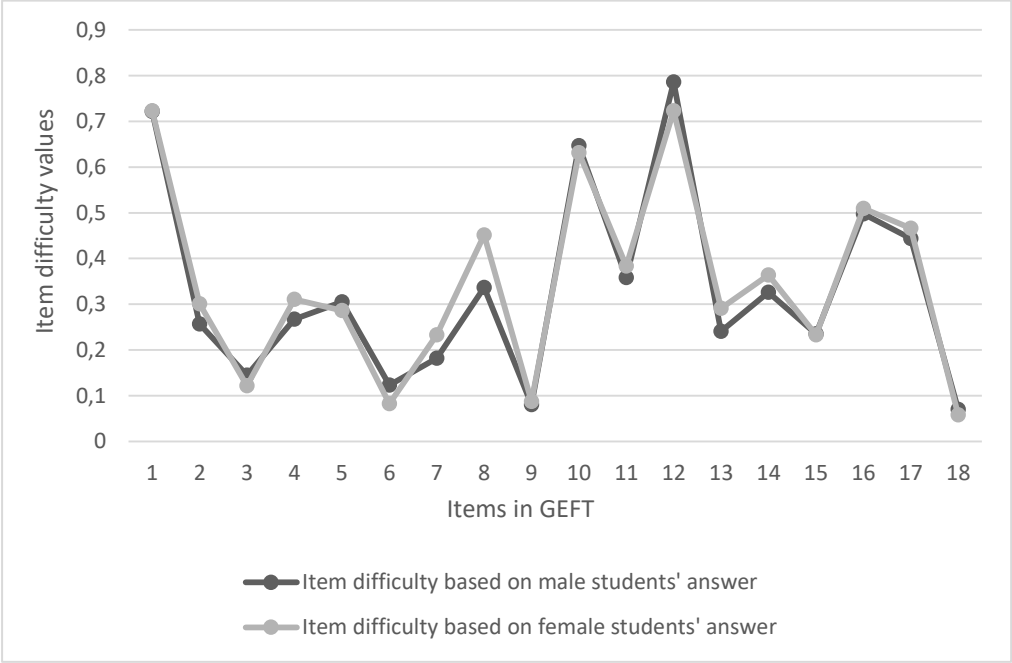

Figure 24. Item difficulty values for each item in GEFT

In Figure 25, item difficulty values are given for each item in PSVT. According to male and female participants' perception in PSVT, item 32 was the most difficult item in PSVT. Moreover, according to Figure 25, item difficulty value for item 13 in PSVT showed that most of the male and female participants had correct answer for item 13. In Figure 25, according to female participants' perception item difficulty

value for item 10 was higher than male participants' perception. It showed half of the female participant gave correct answer for the item 10, although only %30 of the male participants gave correct answer for it.

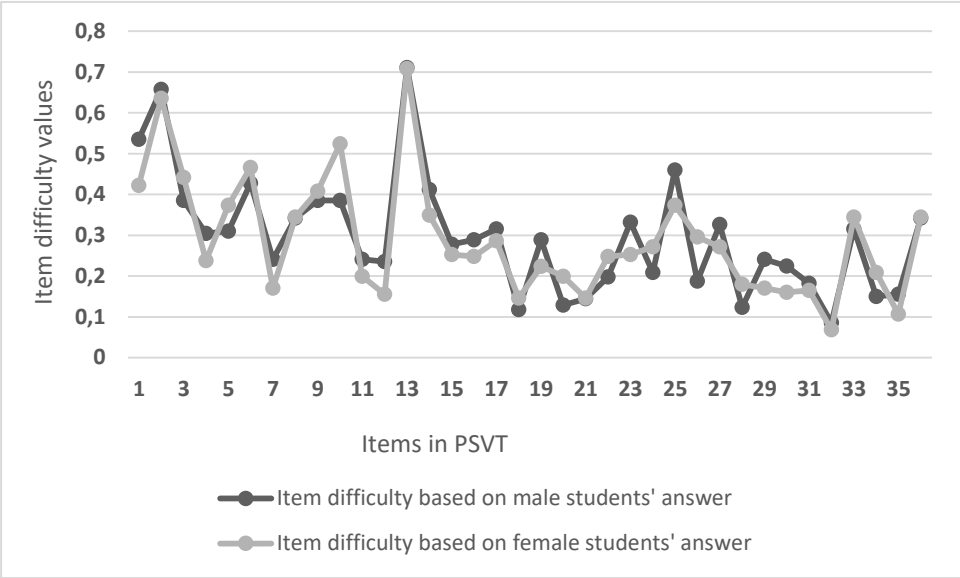

Figure 25. Item difficulty values for each item in PSVT

In Figure 26 and Figure 27, distribution of item discrimination for each item in GEFT and PSVT was given, respectively. It was psychometric measure. It was the power of an item to distinguish among participants depend on how well they have the ability being measured.

According to Figure 26, items in GEFT were differentiate in similar level for female and male participants.

According to Figure 27, Item 21 did not work well for both male and female participants. Moreover, item discrimination values for item 29, 32 and 35 was low for female and male participants.

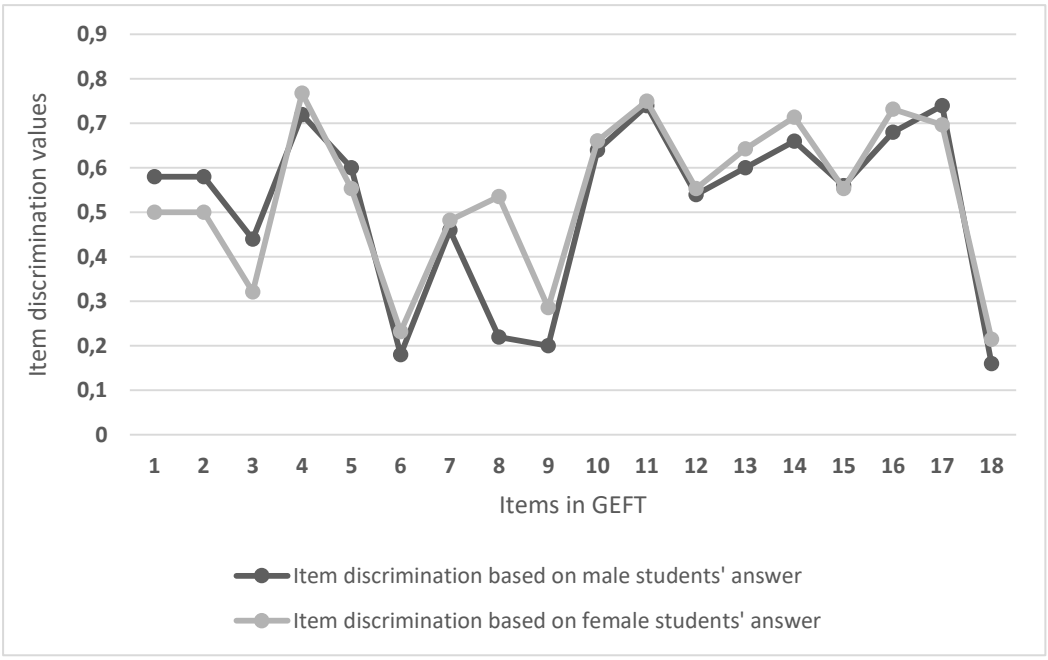

Figure 26. Item discrimination for each item in GEFT

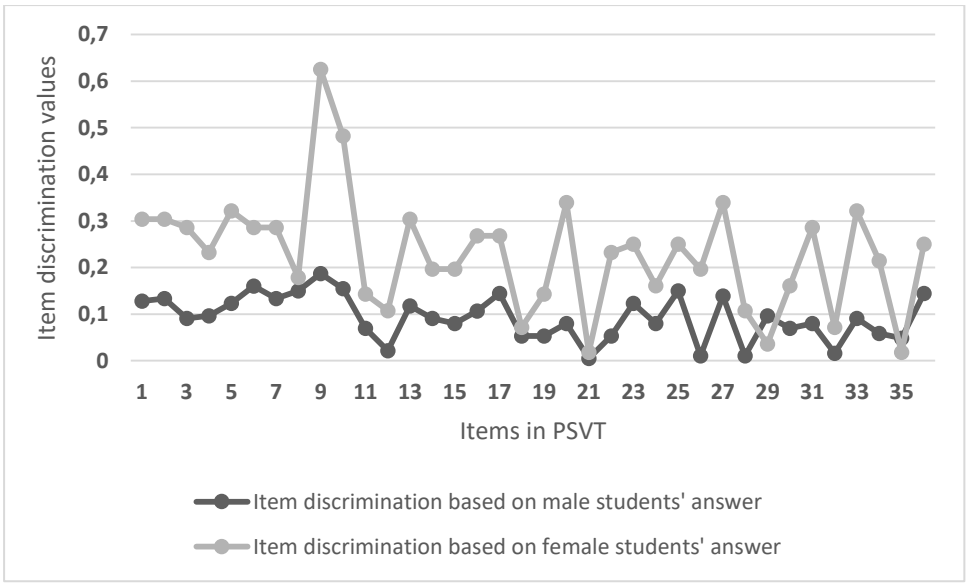

Figure 27. Item discrimination for each item in PSVT

Descriptive statistical results were given for most correctly and incorrectly answered questions from Table 8 and Table 9 for GEFT with respect to gender and grade level.

Table 8 showed that 92.5 % of the grade 10 and male students answered question three (in the second section) correctly. Grade 11 and male students followed them with the 85.4 % of correct answer of question three for GEFT. Although male participant (from grade 10 and grade 11) had the highest percent of correct answer of question three, grade 9 and male participant answer this question correctly with the 67.7 %. Female and grade 11 participants answered question three correctly with the 76.4 %. Like male and grade 9 participants, percentage of correct answers for female and grade 9 participants were lower than female grade 10 and grade 11 participants.

Table 8
Descriptive statistical results for most correctly answered question from GEFT

Gender	Grade	Percentage of correct answer	Percentage of wrong answer	Percentage of blank answer
Male	9th Grade	67.7	19.4	12.9
	10th Grade	92.5	3.8	3.8
	11th Grade	85.4	7.3	7.3
Female	9th Grade	68.9	23.3	7.8
	10th Grade	73.8	19.7	6.6
	11th Grade	76.4	14.5	9.1

Table 9 showed descriptive analysis of most incorrectly answered question for GEFT. It indicated that 68.9 % of the female and grade 10 students answered question six (from the first section) incorrectly. Male and grade 9 students followed them with the 57 %. In addition male and grade 10 students has the lowest percentage of incorrect answers for the question 6 from GEFT.

Table 9
Descriptive statistical results for most incorrectly answered question from GEFT

Gender	Grade	Percentage of correct answer	Percentage of wrong answer	Percentage of blank answer
Male	9th Grade	9.7	57	33.3
	10th Grade	18.9	41.5	39.6
	11th Grade	9.8	51.2	39

Table 9 (cont'd)
Descriptive statistical results for most incorrectly answered questions from GEFT

Gender	Grade	Percentage of correct answer	Percentage of wrong answer	Percentage of blank answer
Female	9th Grade	7.8	56.7	35.6
	10th Grade	11.5	68.9	19.7
	11th Grade	5.5	52.7	41.8

Table 10 and Table 11 showed the descriptive analysis results for most correctly and incorrectly answered questions from PSVT according to gender and grade level. According to Table 10, question 13 from PSVT answered correctly with the 79.2 % of male and grade 10 students. Male and grade 10 participants had the highest percent of the correct answer for this question like the most correctly answered question from GEFT. It was followed by female and grade 11 participants with the 74.5 %. Like GEFT, male and grade 9 participants had the lowest percent of correct answer (67.7 %) for most correctly answered question from PSVT.

Table 10
Descriptive statistical results for most correctly answered question from PSVT

Gender	Grade	Percentage of correct answer	Percentage of wrong answer	Percentage of blank answer
Male	9th Grade	67.7	28	4.3
	10th Grade	79.2	20.8	0
	11th Grade	68.3	26.8	4.9
Female	9th Grade	68.9	30	1.1
	10th Grade	70.5	24.6	4.9
	11th Grade	74.5	23.6	1.8

Table 11 indicated that 90.6 % of male and grade 10 participants answered question 18 incorrectly. Male and grade 9 participants followed grade 10 participants with 84.9 %. Similarly, grade 9 and female students had 82.2 % of incorrect answer for this question. Male and grade 11 students had the lowest percent (65.9 %) of incorrect answer.

Table 11
Descriptive statistical results for most incorrectly answered questions from PSVT

Gender	Grade	Percentage of correct answer	Percentage of wrong answer	Percentage of blank answer
Male	9th Grade	10.8	84.9	4.3
	10th Grade	3.8	90.6	5.7
	11th Grade	24.4	65.9	9.8
Female	9th Grade	12.2	82.2	5.6
	10th Grade	23	70.5	6.6
	11th Grade	9.1	76.4	14.5

Further evidence towards instrument validity

In the previous section, descriptive results were given according to gender, grade level and school type for GEFT and PSVT. In this section, the difference between compared groups was investigated whether it was statistically significant or not. In addition, correlation between students' scores on PSVT and GEFT are investigated.

As shown in Table 12 and Table 13, independent sample t-test was used to investigate if there was a statistically significant difference between male and female students according to their total scores on GEFT and PSVT, respectively. In this statistical test alpha level was .05. Assumptions of variance dependency was checked by using a homogeneity of variance test. For this assumption null hypothesis was ''there is no statistically significant difference between variances of male and female students.'' Levene's test for the equality of variances was conducted and $F(391)=0.038$, $p>.05$. The null hypothesis is failed to be rejected. According to the result of the statistical test for GEFT, there was no statistically significant difference in mean scores of male (M=6.03, SD= 3.85) and female (M=6.24, SD=3.94) participants.

In Table 13, results of the Levene's test equality of variances was given. According to Table 13, $F(391)=10.30$, $p<.05$. The null hypothesis is rejected. According to the result of the statistical test for PSVT, there was no statistically significant difference

in mean score of male (*M*=10.66, *SD*=4.26 and female (*M*=10.39, *SD*=3.49) participant.

Table 12
Independent sample t-test result of total score on GEFT with respect to gender

		F	Sig.	t	df	p	Mean difference
Total Score on GEFT	Equal variances assumed	.038	.845	-0.523	391	.602	-0.206
	Equal variances not assumed			-0.523	389	.601	-0.206

Table 13
Independent sample t-test result of total score on PSVT with respect to gender

		F	Sig.	t	df	p	Mean difference
Total Score on PSVT	Equal variances assumed	10.30	.001	0.689	391	.491	0.270
	Equal variances not assumed			0.683	360	.495	0.270

In addition, one-way ANOVA was applied to compare means of the participants' total score for both GEFT and PSVT. Test of homogeneity of variances was applied. According to Table 14, Levenes' test of equality of variances are shown. Alpha level of .05 is used in this test. Therefore, homogeneity of variances are found for both GEFT and PSVT and it met for the presented analysis, $F(3, 389) = 1.07$, $p > .05$ for GEFT and $F(3, 389)=1.51$, $p > .05$ for PSVT.

Table 14
Test of homogeneity of variances

	Levene Statistic	df1	df2	p
GEFT	1.07	3	389	.360
PSVT	1.51	3	389	.211

Results of one-way ANOVA test is given at Table 15. For this assumption null hypothesis was ‘‘there is no statistically significant difference in mean scores of schools’’. Therefore, null hypothesis was rejected according to Table 15 for both GEFT and PSVT. There was statistically significant difference between mean scores of different schools, $F(3,389) = 5.55$, $p < .05$ for GEFT and $F(3, 389) = 4.25$, $p < .05$ for PSVT.

Table 15
One-way ANOVA results for compare means of different schools

		Sum of Squares	df	Mean Square	F	p
GEFT	Between Groups	244.20	3	81.41	5.55	.001
	Within Groups	5701	389	14.66		
	Total	5945	392			
PSVT	Between Groups	186.50	3	62.18	4.25	.006
	Within Groups	5696	389	14.64		
	Total	5882	392			

In addition, one-way ANOVA compared the mean scores between schools and determined which schools mean scores were statistically different based on total scores of participants for GEFT and PSVT. The mean scores of schools for GEFT, School 1 (M=4.96, SD=3.83), School 2 (M=6.74, SD=4.03), School 3 (M=5.72, 3.24) and School 4 (M=6.88, SD=4.02). The mean scores of schools for PSVT, School 1 (M=9.32, SD=4.08), School 2 (M=11.10, SD=3.76), School 3 (M=10.70, SD=3.24) and School 4 (M=10.85, SD=4.06).

After the homogeneity of variance assumption is satisfied, Bonferroni post-hoc test was used to determine which schools' mean scores was statistically significantly different. The result of this test is given at Table 16 and Table 17 for GEFT and PSVT, respectively.

Table 16
The mean difference result for GEFT by using Bonferroni post-hoc

(I) School	Mean Difference (I-J)			
	(J) School			
	School 1	School 2	School 3	School 4
School 1		-1.78*	-0.76	-1.92*
School 2	1.78*		1.02	-0.14
School 3	0.76	-1.02		-1.16
School 4	1.92*	0.14	1.16	

Table 17
The mean difference result for PSVT by using Bonferroni post-hoc

(I) School	Mean Difference (I-J)			
	(J) School			
	School 1	School 2	School 3	School 4
School 1		-1.78*	-1.39	-1.52*
School 2	1.78*		0.40	0.26
School 3	1.39	-0.40		-1.14
School 4	1.52*	-0.26	1.14	

In order to examine the mean score difference between grade levels one-way ANOVA test was used. Firstly, test of homogeneity of variances was applied. According to Table 18, Levenes' test of equality of variances are shown. Alpha level of .05 is used in this test. Therefore, homogeneity of variances are found for both GEFT and PSVT and it met for the presented analysis, $F(2, 390) = .264$, $p > .05$ for GEFT and $F(2, 390)=2.48$, $p > .05$ for PSVT.

Table 18
Test of homogeneity of variances for grade levels

	Levene Statistic	df1	df2	p
GEFT	.264	2	390	.768
PSVT	2.48	2	390	.085

Results of one-way ANOVA test is given at Table 19. For this assumption null hypothesis was ‘‘there is no statistically significant difference in mean scores of grade levels’’. Therefore, null hypothesis was rejected according to Table 19 for both GEFT and PSVT. There was statistically significant difference between mean scores of grade levels. $F(2,390) = 7.367$, $p < .05$ for GEFT and $F\ (2, 390) = 11.80$, $p < .05$ for PSVT.

Table 19
One-way ANOVA results for compare means of grade levels

		Sum of Squares	df	Mean Square	F	p
GEFT	Between Groups	216.40	2	108.20	7.37	.001
	Within Groups	5729	390	14.69		
	Total	5945	392			
PSVT	Between Groups	335.50	2	167.80	11.80	0.00
	Within Groups	5547	390	14.22		
	Total	5882	392			

In addition, one-way ANOVA compared the mean scores of grade levels and determined which grade levels’ mean scores were statistically different based on total scores of participants for GEFT and PSVT. The mean scores of grade level for GEFT, Grade 9 (M=5.35, SD=3.67), Grade 10 (M=6.93, SD=3.95) and Grade 11 (M=6.71, 3.99). The mean scores of schools for PSVT, Grade 9 (M=9.55, SD=3.71), Grade 10 (M=11.57, SD=3.41) and Grade 11 (M=11.14, SD=4.26).

After the homogeneity of variance assumption is satisfied, Tukey post-hoc test was used to determine which grade levels' mean scores was statistically significantly different. The result of this test is given at Table 20 and Table 21 for GEFT and PSVT, respectively.

Table 20
The mean difference result for GEFT by using Tukey post-hoc

I Grade	Mean Difference (I-J)		
	J Grade		
	Grade 9	Grade 10	Grade 11
Grade 9		-1.58*	-1.36*
Grade 10	1.58*		0.22
Grade 11	1.36*	-0.22	

Table 21
The mean difference result for PSVT by using Tukey post-hoc

I Grade	Mean Difference (I-J)		
	J Grade		
	Grade 9	Grade 10	Grade 11
Grade 9		-2.02*	-1.59*
Grade 10	2.02*		0.43
Grade 11	1.59*	-0.43	

In addition, correlation between students' total score on GEFT and PSVT was computed. As reported in Table 22, the result of the Pearson correlation indicated that there was a statistically significant and positive correlation between students' total score on GEFT (M = 6.14 and SD = 3.89) and PSVT (M=10.52 and SD = 3.87), r (393)=.421, p <.01.

Table 22
The correlation between students' total score on GEFT and PSVT

		GEFT	PSVT
GEFT	Pearson Correlation	1	.421*
	Sig. (2-tailed)		<.01
	N	393	393

*. Correlation is significant at the .01 level (2-tailed).

CHAPTER 5: DISCUSSION

Introduction

In the previous chapter findings of these research was reported. In this chapter, results of research were discussed. Students' scores on GEFT and PSVT and their distributions according to gender, schools and grade level were given in the first section of the Chapter 4. These were results used to answer the research questions 2 to 7. In addition, correlation results between students' total scores on GEFT and PSVT were explored. Discussion about the correlation was related to the first research question of this study.

Overview of the study

This research was conducted to find a relationship between students' cognitive style and their spatial visualization ability. The first part of the descriptive statistical analyses was conducted on students' total scores GEFT and PSVT. In addition, distribution of students' total score on GEFT and PSVT with respect to gender, schools and grade level were obtained. Also, item analysis was done to find the item difficulty values and item discrimination of GEFT and PSVT. Independent sample t-test was used to find the difference between male and female participants' total scores on GEFT and PSVT. Lastly, one-way ANOVA was conducted to compare the participants' total score in different schools. Lastly, correlation was conducted to explore the relationship between students' total score on GEFT and PSVT.

The research question of this research were:

1. Is there a statistically significant relationship between students' cognitive style and their spatial visualization ability in some selected high schools in Ankara?
2. Are there any statistically significant difference between students' cognitive style by gender?
3. Are there any statistically significant difference between students' spatial visualization ability by gender?
4. Are there any statistically significant difference between students' cognitive style by schools?
5. Are there any statistically significant difference between students' spatial visualization ability by schools?
6. Are there any statistically significant difference between students' cognitive style by grade?
7. Are there any statistically significant difference between students' spatial visualization ability by grade?

Major findings

Discussion of descriptive data results

In this part of the research participants' total score for GEFT and PSVT based on gender, age, grade level and different schools were discussed. There were 18 questions on GEFT and there were 36 question on PSVT. Means of the students' total score were 6.14 and 10.52 for GEFT and PSVT as shown in Chapter 4. Cronbach alpha value for GEFT was .749 and it was .841 for PSVT. According to

Nunnally, they were an acceptable reliability value for achievement tests (Nunnally, 1994, p.257).

There were other studies about GEFT throughout the history. Carter and Loo (1980) conducted GEFT to examine the performance of undergraduates on GEFT. The participants of this study was 173 female and 93 male undergraduate students. According to their research mean score was 13.04 for female and 13.85 for male participants. In another research, Thompson and Melancon (1987) conducted GEFT to undergraduate students and the sample consisted of 60 % of female and 40% male undergraduate students. The mean age of the participants was 21.4 for this research. At the end, they found that mean of the GEFT score was 11.2. In addition, Ates and Cataloglu (2007) conducted a research to find the relationship among students' cognitive style, conceptual understanding and problem-solving skills in Mechanics. Participants were 213 (female=111, male=102) freshmen students. The mean score was 10.6. These research were conducted to the undergraduate students' from different universities. The mean scores of the participants in this study was 6.14 for GEFT. There were difference between previous research. However, one can argue that this difference was because of the mean age of the participants. Mean scores of participants can change according to their age. There could be difference between high school students' total score and undergraduate students' total score on GEFT.

PSVT also conducted by different researchers throughout the history. For example, Baki et al. (2011) conducted a research about PSVT with the pre-service first year mathematics teachers. In this case mean score of the sample was 18. In the current study mean score of participants for PSVT is 10.52. Difference between the mean

score of this research and Baki's research was because of the age difference of participants between two studies. Also, Birinci (2016) conducted PSVT to investigate the pre-service mathematic teachers' spatial ability for the preferences of representation in terms of definite integrals is her research. Participants of the research was 23 female and 22 male pre-service mathematics teachers. The mean score of the research was 19.17. The result was similar with Baki's research. The difference in mean age of the participants affect the result of participants' total score in PSVT.

Discussion about results of gender differences

In this part, answers to the research question two and three ''Are there any difference between students' cognitive style by gender?'' and ''Are there any difference between students' spatial visualization ability by gender?'' were explored.

In this research, there were 206 female and 187 male participants. Mean score of female participants was 6.24 and male participants was 6.03 for GEFT. Also mean score of female participants was 10.39 and male participants was 10.66. Mean values of male and female participants were close to each other for GEFT and PSVT. There were small differences between male and female participants' mean score. In GEFT, mean of the female participants was greater than the mean of the male participants. However, in PSVT male students' mean score was greater than the mean score of female participants. However, according to independent sample t -test, there was no statistically significant difference in mean score of male and female participants for GEFT and PSVT, as reference to Table 10 and Table 11 at Chapter 4.

Different studies were examined to investigate the relationship between gender and GEFT results. In the current study, female participants' mean score was higher than male participants mean score. In the history, DeSanctis and Dunikowski (1983) conducted a research with 185 business students. According to their research, mean value of the male participants was 12.1 and female participants' mean score was 12.6. Moreover, Weiss et al (2003) investigating gender differences in cognitive functions and they used a test similar to GEFT. According to their result, mean value of the female participants were higher than the male participants' mean value. Therefore, the current study is in consisted with DeScantis and Dunikowski and Weiss et al. research.

Although there was not statistically significant difference in the mean score of female and male participants, male participants' mean score was greater than female participants' mean score for PSVT. There were some research about the mean score difference between male and female participants for PSVT. For example, Battista (1990) conducted a research about the relationship between spatial visualization ability and gender by using an adapted version of PSVT. In the research rotation was used and participants (female=53, male=75) were high school students. Result of Battista's research showed that male participants have higher mean score than female participants. In addition to Battista's research, Yazici (2014) conducted a study with preservice teachers which received trainings in different areas. Result was in agreement with current study. Male participants have higher mean value than female participants for PSVT.

Discussion about results on different schools

This study conducted four different Anatolian high schools in Çankaya, Ankara. Different schools were chosen since different methods of teaching can be applied by teachers in different schools. Therefore, it was significant to investigate students' cognitive style and spatial ability by conducting the research at different schools to have variety of results.

Table 6 showed mean scores of four different school for GEFT and PSVT. According to Table 6, there were difference between the mean scores of School 1 (M=4.96) and School 4 (M=6.88) for GEFT, for PSVT there were difference in mean scores of School 1 (M=9.32) and School 2(M=11.1). However, in order to investigate whether these differences are significant or not one-way ANOVA was used. According to result of one-way ANOVA, there was statistically significant difference between the mean scores of different schools. Another test was applied to find which schools' mean score was statistically significantly different. According to the result of this test from Table 16 and Table 17, there were statistically significant difference between the mean scores of School 1 and School 2 and also School 1 and School 4 for GEFT and PSVT. For GEFT and PSVT mean scores was statistically significantly different for same schools. For both test there were difference between school 1 and school 2, also school 1 and 4. It showed that the results of the tests were consistent.

In addition, students enter the high school according to result of high school entrance exam before 2018. Therefore, in this study grade 10 and grade 11 students enter the high school according to their success. When the ranking of the high schools were

considered, School 2 has the highest ranking then School 4 followed it, School 3 is the next one and the last one is School 1. Therefore, the results were consistent with the ranking of the schools. According to results, there were statistically significantly difference between highest ranking school (School 2) and the last one (School 1) also second highest ranking school (School 4) and the last one (School 1). Grade 10 and Grade 11 students determined the result of the GEFT and PSVT. In addition, Grade 9 students entered high school according to their home address. They also had an impact on the mean scores of GEFT and PSVT since they continued their education in the same region as primary school. Thus, results were consisted when the difference between schools were considered.

Therefore, the answers to the research questions ‘‘Are there any statistically significant difference between students’ cognitive style by schools?’’ and ‘‘Are there any statistically significant difference between students’ spatial visualization ability by schools?’’ were discussed in this part.

Discussion about results on grade level

In this section answer to the research question ‘‘Are there any differences between students’ cognitive style by grade?’’ and ‘‘Are there any differences between students’ spatial visualization ability by grade?’’ were investigated

This research was conducted in different grade levels to investigate if there was a difference in the mean score of different grade levels. Mean scores of different grade levels were increased as the grade level increased from Grade 9 to Grade 10 or Grade

11 for GEFT and PSVT. However, there was no considerable amount of difference between Grade 10 and Grade 11's mean scores of GEFT and PSVT.

In order to test whether the mean difference is statically significant or not one-way ANOVA is used. According to the result of one-way ANOVA, Table 19 showed that there was statistically significant difference between mean scores of grade levels. After the difference was found as statistically significant, to determine which grade levels' mean scores was statistically significantly different, another test is conducted. Table 20 and Table 21 showed the result of this test for GEFT and PSVT, respectively. According to Table 20 and Table 21, there was statistically significant difference between grade 9 and grade 10 and also grade 9 and grade 11 for GEFT and PSVT. This result showed that students' cognitive style and spatial visualization ability can differ between grade 9 and grade 10 or grade 11.

There were researches in the history about grade level differences of students' mean scores for GEFT and PSVT. Panek et al. (1980) conducted a research about reliability and validity of GEFT across the life span. According to their research they divided ages in 7 groups. GEFT is applied these groups and means are calculated for them. Groups are started from age 17 and finished with 72. Result of this study showed that mean scores of participants started to increase from age 17 to 48 years. However, after the age of 48, mean scores of participants started to decrease. Therefore, this research is in agreement with the current study. When the maturity level of age increased students' cognitive style also can differentiate.

Related research conducted about PSVT in the history. Ben-Chaim et al. (1985;1988) conducted a research with the fifth, sixth seventh and eighth grade students to

investigate spatial visualization ability. According to them, when the students' grade level increased, their mean score in PSVT also increased. It showed that students' three-dimensional thinking increased with their age.

Discussion about item analysis

In this research two tests were conducted to investigate participants' cognitive style and spatial visualization ability. Items in both tests were analysed according to participants' answers for tests.

Firstly, unanswered items for GEFT and PSVT analysed. Unanswered items by female and male participants are in parallel with each other for GEFT. There were two part of these tests and limited time for part one and part two was given separately to answer questions in parts. There were 9 question in each part. One can deduce that students left unanswered questions at the end of the parts mostly. From Figure 22, unanswered items in GEFT can be seen. Thus, time is an important factor for them to finish their task. They spent most of the time for the questions that they had difficulty to find figures and so they do not have any time to do last questions. Item difficulty levels also had an impact on the result of unanswered items in tests. The comparison of Figure 22 and Figure 24 explains the relationship with unanswered questions and item difficulty of these questions. According to Figures, questions which are left unanswered by participants were difficult questions such as question 3, 9 and 18 on GEFT. Time also had an effect on the difficulty values of the questions since they did not have enough time to answer especially last questions in GEFT. Item discrimination values of GEFT was significant for differentiate students and it was in parallel for female and male participants. Item difficulty values of

Thompson and Melancon (1987) is in agreement with the current study. The values are a little bit high but values change according to item was similar with the current research. According to their research, last questions of the parts seems difficult than others as like the current study.

Unanswered items for PSVT also analysed and the Figure 23 showed unanswered items frequency for PSVT. Although there were three parts in PSVT, time was given for the whole parts in the beginning of this test. Therefore, at the end of the test quantity of unanswered items increased since participants cannot manage time and they do not have enough time to answer all questions in the test. Therefore, time is an important factor to finish all the question in tests. According to Sevimli's (2009) research, for the last part of PSVT, 44 % of students did not give any answer for the questions. Therefore, this research also in agreement with current findings. In addition item difficulty level was affected from time like GEFT. Since students do not have time to finish all the questions correctly, one can deduce from Figure 25, through the end of the test items seems difficult. This is in agreement with the unanswered items at the end of the test. Item discrimination values were in parallel with female and male participants. However, according to Figure 27, items can differentiate female students than male students.

Discussion about correlation results

In this section correlational analysis result between students' cognitive style and spatial visualization ability was discussed. Research question ''Is there a statistically significant relationship between students' cognitive style and their spatial

visualization ability in some selected high schools in Ankara?'' was investigated in this part.

According to Silverman (1989), when the matching between cognitive style and the way they taught is more, students can gain more spatial ability. Therefore, appropriate cognitive style is a significant factor to increase spatial ability of the students. Kolb (1984) found that there were positive correlation between students' cognitive style and spatial visualization ability. Pitta-Pantazi and Christou (2009) investigated that there was a relationship between students' creative ability and object visualization. In addition, according to Sternberg (2012) who is working in the area of general creativity, creativity is related to cognitive styles. In the light of this information, there were a positive correlation between cognitive style and spatial visualization ability.

According to Table 22, there was a positive correlation between students' cognitive style and spatial visualization ability r (393) = .421, p <.01. Therefore, the current research is in agreement with the previous research. It showed that cognitive style has an effect on spatial visualization ability. One can deduce that teachers may first investigate students' cognitive style and according to their cognitive style, teachers can arrange their method of teaching or using abilities of students.

General results

The aim of the present study was to explore the relationship between students' cognitive style and their spatial visualization ability. Study was conducted in four different school in Çankaya, Ankara. Result of this study showed that there was

positive correlation between students' cognitive style and spatial visualization ability. Teachers can prepare their lessons to investigate students' cognitive style. According to their cognitive style classroom activities can be prepared and spatial abilities of the students can be analyzed.

In addition, the difference between genders were investigated for GEFT and PSVT. According to result, there were no statistically significant difference between the mean score of GEFT and PSVT by gender. Although, mean score of female participants was higher than the mean score of male participants for GEFT, male participants mean score was higher than female participants mean score for PSVT. It can be said that female students more field independent than male students. In addition item analysis showed that female and male students showed same behavior with the exception of several questions. It showed that in high there is no difference in female and male participants' cognitive style and spatial visualization ability. However, these results cannot be generalized for all high school students.

Also, difference between students' cognitive style and spatial ability according to schools was discussed by conducting of one-way ANOVA test. According to result, there were statistically significantly difference between the mean scores of School 1 and School 2, also School 1 and School 4 for GEFT and PSVT. The difference happened since students from Grade 10 and 11 went to high school according to their high school entrance exam. Therefore, difference was investigated between highest ranking schools and lowest ranking schools. In addition, results showed that cognitive style and spatial ability can be developed through the years.

One-way ANOVA is conducted to investigate the difference between cognitive style and spatial ability according to grade level. Result of this test showed that there was statistically significant difference between grade 9 and grade 10 and also grade 9 and grade 11. It showed that when the age of the participants increased their cognitive style will differ. In the beginning of the high school students has low spatial ability and they were more field dependent. However, after they finish their first year in the high school, they became more field independent and their spatial abilities developed. It also showed that cognitive style and spatial ability can be developed through the year. Teachers have significant responsibilities to analyze cognitive style and spatial visualization abilities of the students.

Implications for practice

Students' cognitive style and spatial visualization ability are very important for their whole life. Teachers can use the relationship between cognitive style and spatial visualization ability to prepare effective lessons for students. Although they can use variety of teaching method, appropriate methods can be used for each student with different cognitive style and spatial ability.

Not only teachers but also students can do practices to develop their spatial ability. There should be extra hours for students to do some exercises about their weakness. These extra hours can be managed by teacher like guidance class. For example, one of the guidance class, teachers should do some tests or exercises about students' cognitive style and spatial ability. After analysing students' cognitive style and spatial visualization ability, teachers can prepare extra activities or homework to develop their skills.

In addition, according to results of item analysis, item difficulty values showed that female and male participants had almost the same result for GEFT and PSVT. The pattern was same for female and male participants. Also, in item discrimination results, students in different gender have nearly same results. In high school level teachers do not need to differ their cognitive style and spatial ability according to different gender.

Recommendation of further research

This study is conducted only district of Ankara and it cannot be generalized for all high school students in Turkey. Firstly, test can be conducted in different districts of Turkey with using different kind of high schools such as private schools can be sample of further research. Therefore, comparison between school type and students' mean score on tests can be done.

Although it will give some information about cognitive style and spatial abilities of students in Turkey, high schools in different countries can be sample of further research. Therefore, it will give opportunity to compare students' abilities and styles with Turkey.

Moreover, research can be done not only for the high school students but also the whole life span of life. For example, different tests can be prepared to investigate kindergarten students' cognitive styles and spatial abilities. Therefore, students can be taught according to their cognitive styles and spatial abilities from an early age. Also, students' cognitive style and spatial ability difference will be compared with

the kindergarten students from different countries. Interview with the teachers of kindergarten can be a way of conducting a research in the future.

In addition, in the future research computer-based tests can be prepared and applied to students. Nowadays, individuals learn how to use mobile phone at an early age. Different tools can be used in the future research to investigate students' cognitive style or spatial ability. Nowadays students have online classes, and all of the students use technology efficiently. If the tests were applied by using technology, it can be interesting for students. Their creativity with technology can be better than paper pencil assessment.

Limitations

All participants were volunteer. Answers were provided by participants' full and sincerely cooperation. No extra time or credit was provided for students.

It was assumed that tests were applied in the same environmental condition.

Sample was limited to schools in Çankaya district of Ankara, Turkey.

Participants was limited to Anatolian high school students. It cannot be generalized as all high school students.

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APPENDICES

Appendix A: Turkish Version of Group Embedded Figures Test

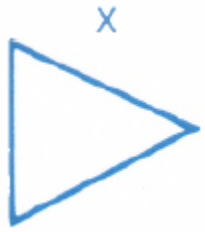
Gömülü Şekil Testi

Ad-Soyad:_____Cinsiyet:_____

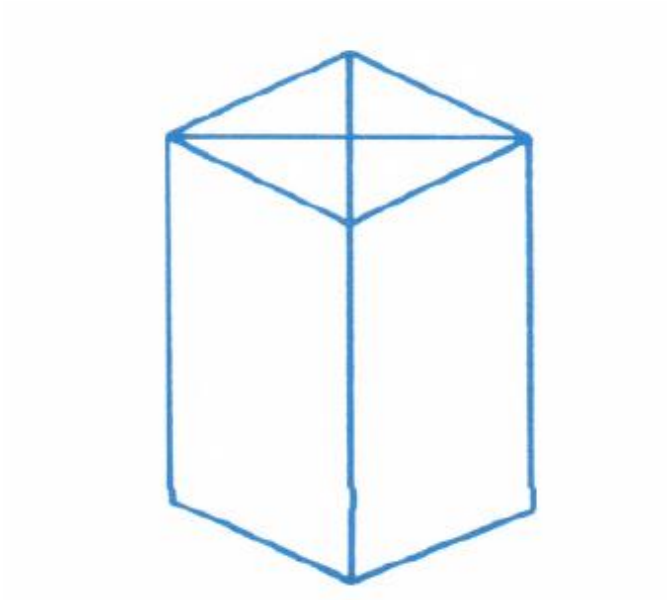
Bugünün Tarihi:_____ Doğum Tarihi:_____

YÖNERGELER: Bu test karmaşık desenler içerisinde gizli olan basit şekilleri bulabilme becerisini ölçer.

Aşağıda X diye adlandırdığımız bir basit şekli görebilirsiniz.



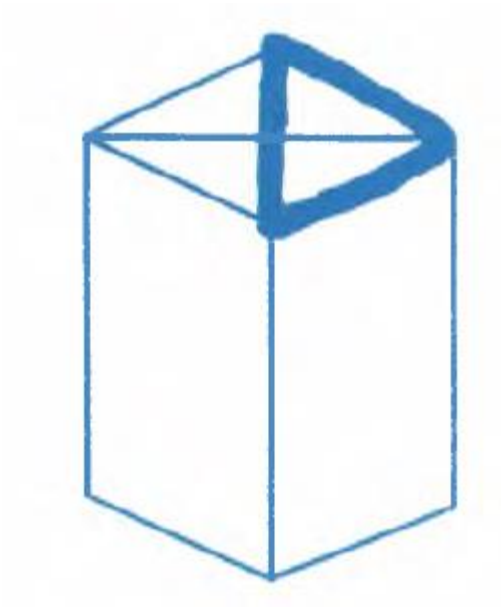
‘’X’’ ile adlandırılan bu basit şekil aşağıdaki karmaşık desen içerisinde gizlenmiştir:



Karmaşık desen içerisinde ki basit şekli bulmaya çalışın ve karmaşık desen üzerindeki çizgileri takip ederek bu basit şekli çiziniz. Karmaşık desen içerisinde ki basit şekil, yukarıda basit formu gösterilen şekille AYNI BOYUTTA ve AYNI ORANDA olmalı, AYNI YÖNE bakmalıdır.

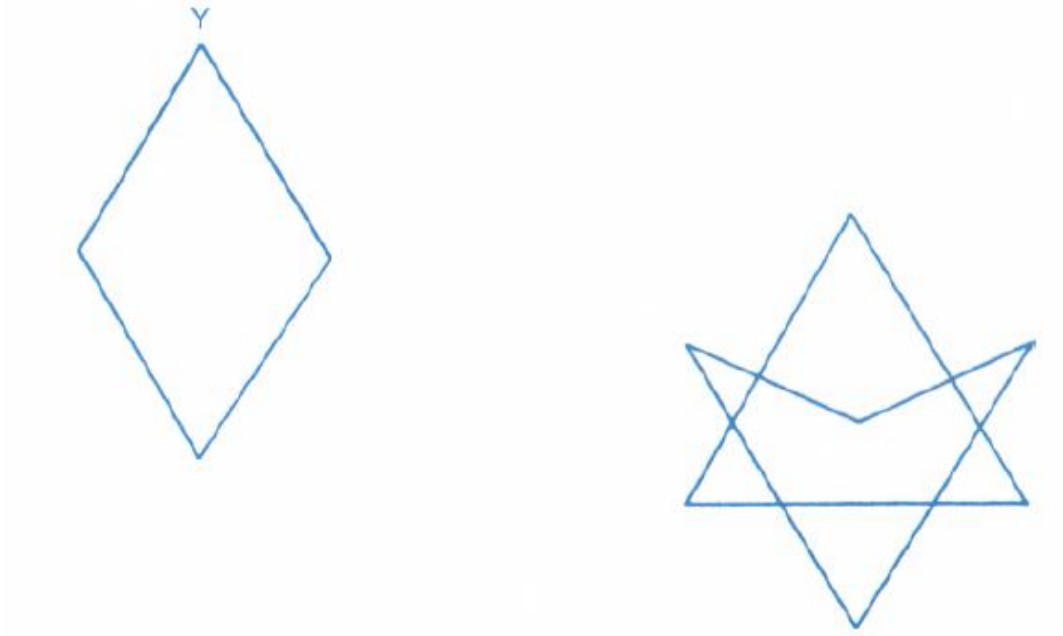
Bitirdiğinizde çözümünüzü kontrol etmek için sayfayı çevirin.

Aşağıda gördüğünüz karmaşık desen üzerindeki çizgileri kullanarak basit şeklin bulunduğu doğru çözümdür.



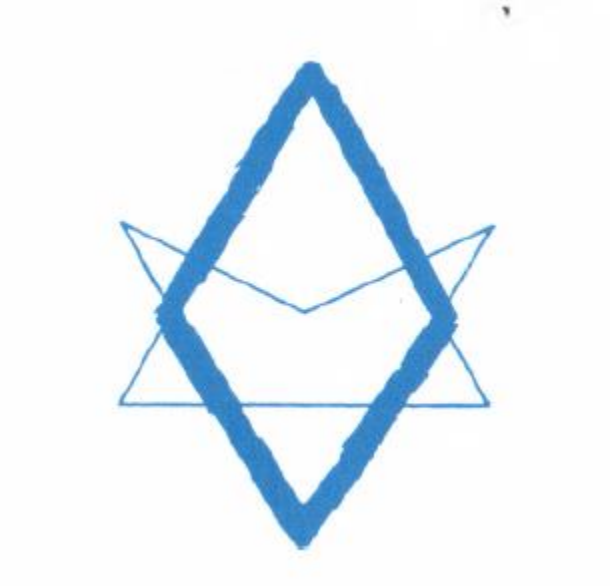
Burada sağ üstteki üçgen doğru olan cevaptır. Sol üstteki üçgende aynıdır ancak üçgen ters yöne doğru bakmaktadır. Bu yüzden sol üstteki üçgen doğru cevap değildir.

Şimdi başka bir alıştırma problemini deneyelim. ‘’Y’’ olarak adlandırılan basit şekli aşağıdaki karmaşık şeklin içerisinden bulunuz ve bulduğunuz basit şeklin izini çiziniz.



Bir sonraki sayfaya bakarak cevabınızı kontrol ediniz.

Çözüm:



Gelecek sayfalarda üstteki soruya benzeyen sorular olacaktır. Her soruda bir karmaşık desen ve bu desen içerisinde gizlenmiş basit şekilleri simgeleyen bir harf göreceksiniz. Her soruda bulacağınız basit şekli görmek için kitapçığın en arka sayfasına bakın. Daha sonrada kurşun kalemle karmaşık şekil içerisinde bulduğunuz basit şekli çizin. Bunu yaparken aşağıdaki noktalara dikkat ediniz.

1. Gerekli sıklıklarda arkadaki basit şekillere bakın.
2. BÜTÜN HATALARI SİLİN.
3. Soruları sırayla yapın. Sorularda kesinlikle takılmadığınız müddetçe soruları geçmeyiniz.
4. HER SORUDA SADECE BİR TANE BASİT ŞEKİL bulun. Birden fazla görebilirsiniz ama sadece bir tanesini çizin.
5. Karmaşık desenin içerisindeki basit şekil her zaman arka sayfadaki basit şekil ile AYNI BOYUTTA, AYNI ORANDA olmalı ve AYNI YÖNE doğru bakmalıdır.

İLK BÖLÜM

1

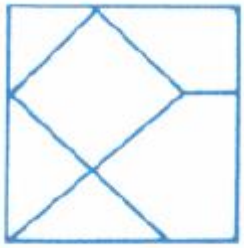
‘’B’’ basit şeklini bulunuz.

2

‘’G’’ basit şeklini bulunuz.

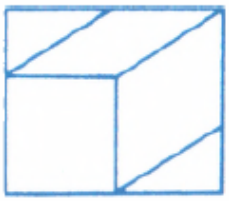
Bir sonraki sayfaya geçiniz.

3



‘’D’’ basit şeklini bulunuz.

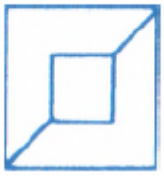
4



‘’E’’ basit şeklini bulunuz.

Bir sonraki sayfaya geçiniz.

5



‘’C’’ basit şeklini bulunuz.

6

‘’F’’ basit şeklini bulunuz.

Bir sonraki sayfaya geçiniz.

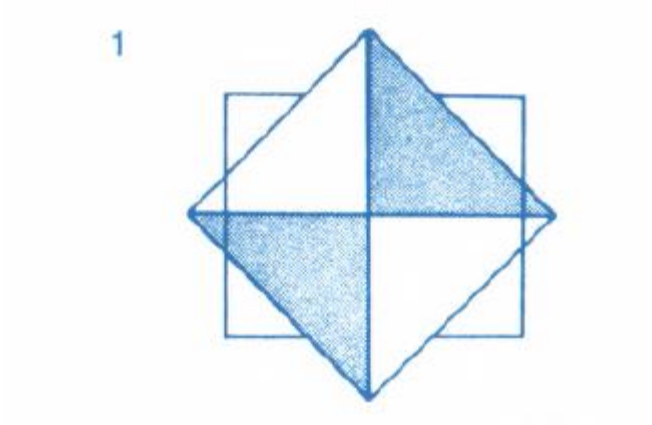
7

‘’A’’ basit şeklini bulunuz.

Lütfen Testi Bırakın. Gelecek Yönergeleri Bekleyin.

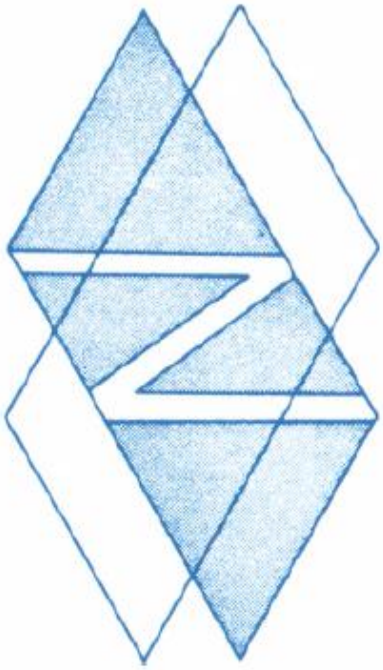
İKİNCİ BÖLÜM

1



‘’G’’ basit şeklini bulunuz.

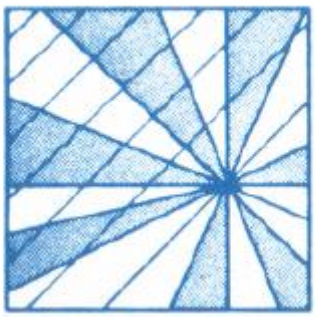
2



‘’A’’ basit şeklini bulunuz.

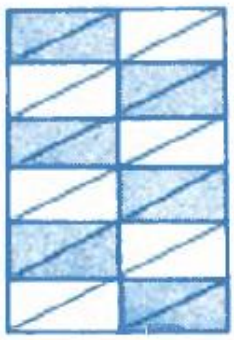
Bir sonraki sayfaya geçiniz.

3



‘’G’’ basit şeklini bulunuz.

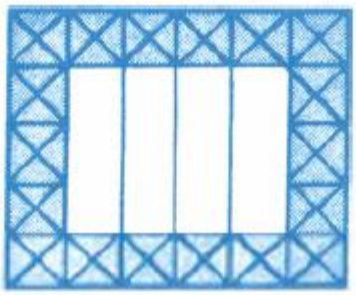
4



‘’E’’ basit şeklini bulunuz.

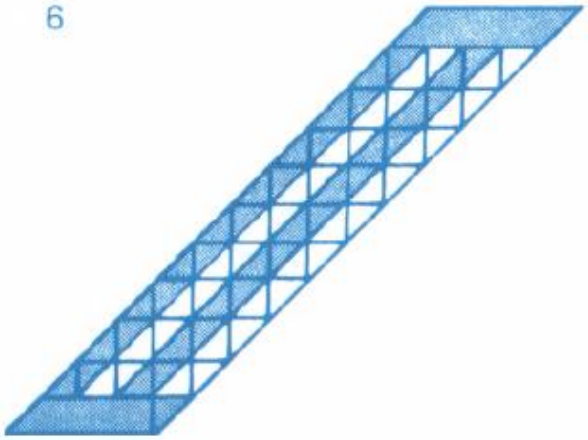
Bir sonraki sayfaya geçiniz.

5



‘’B’’ basit şeklini bulunuz.

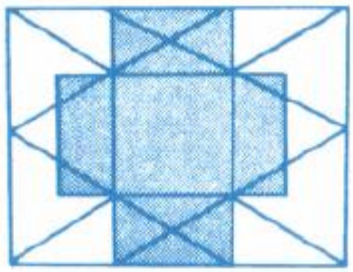
6



‘’C’’ basit şeklini bulunuz.

Bir sonraki sayfaya geçiniz.

7



‘’E’’ basit şekliniz bulunuz.

8

‘’D’’ basit şeklini bulunuz.

Bir sonraki sayfaya geçiniz.

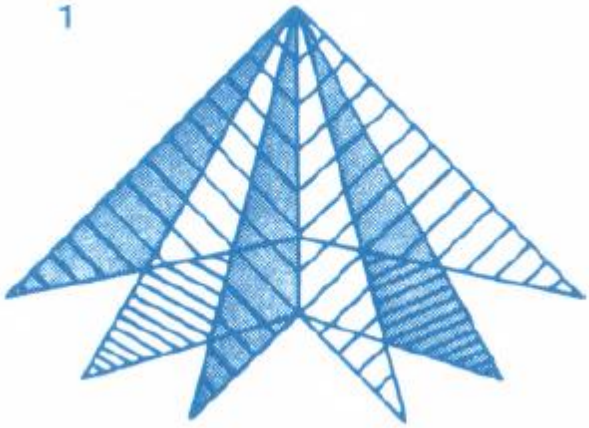
9

‘’H’’ basit şeklini bulunuz.

Lütfen Testi Bırakın. Gelecek Yönergeleri Bekleyin.

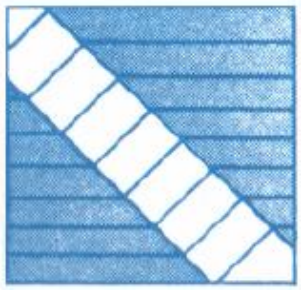
ÜÇÜNCÜ BÖLÜM

1



‘’F’’ basit şeklini bulunuz.

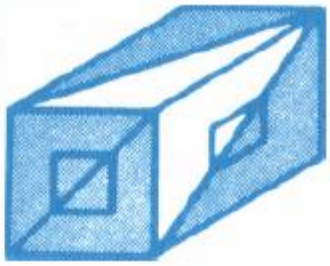
2



‘’G’’ basit şeklini bulunuz.

Bir sonraki sayfaya geçiniz.

3



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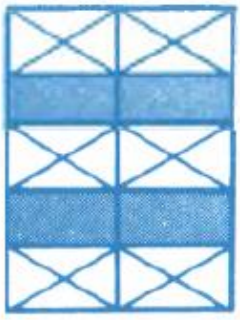
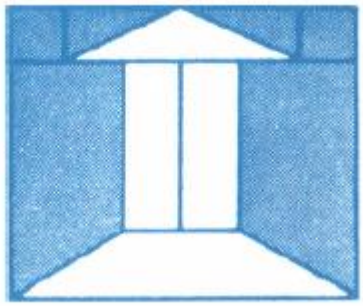
4



‘’E’’ basit şeklini bulunuz.

Bir sonraki sayfaya geçiniz.

5



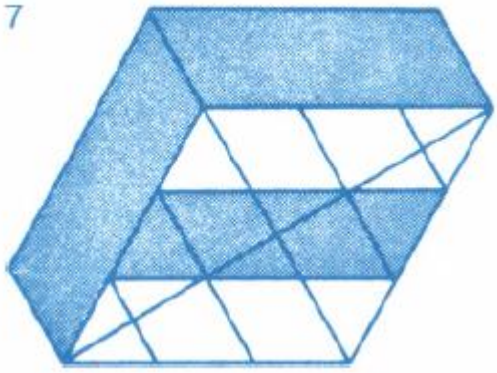
‘’B’’ basit şeklini bulunuz.

6

‘’E’’ basit şeklini bulunuz.

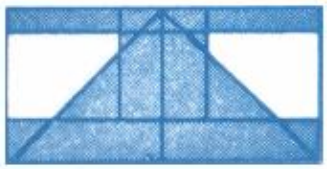
Bir sonraki sayfaya geçiniz.

7



‘’A’’ basit şeklini bulunuz.

8



‘’C’’ basit şeklini bulunuz.

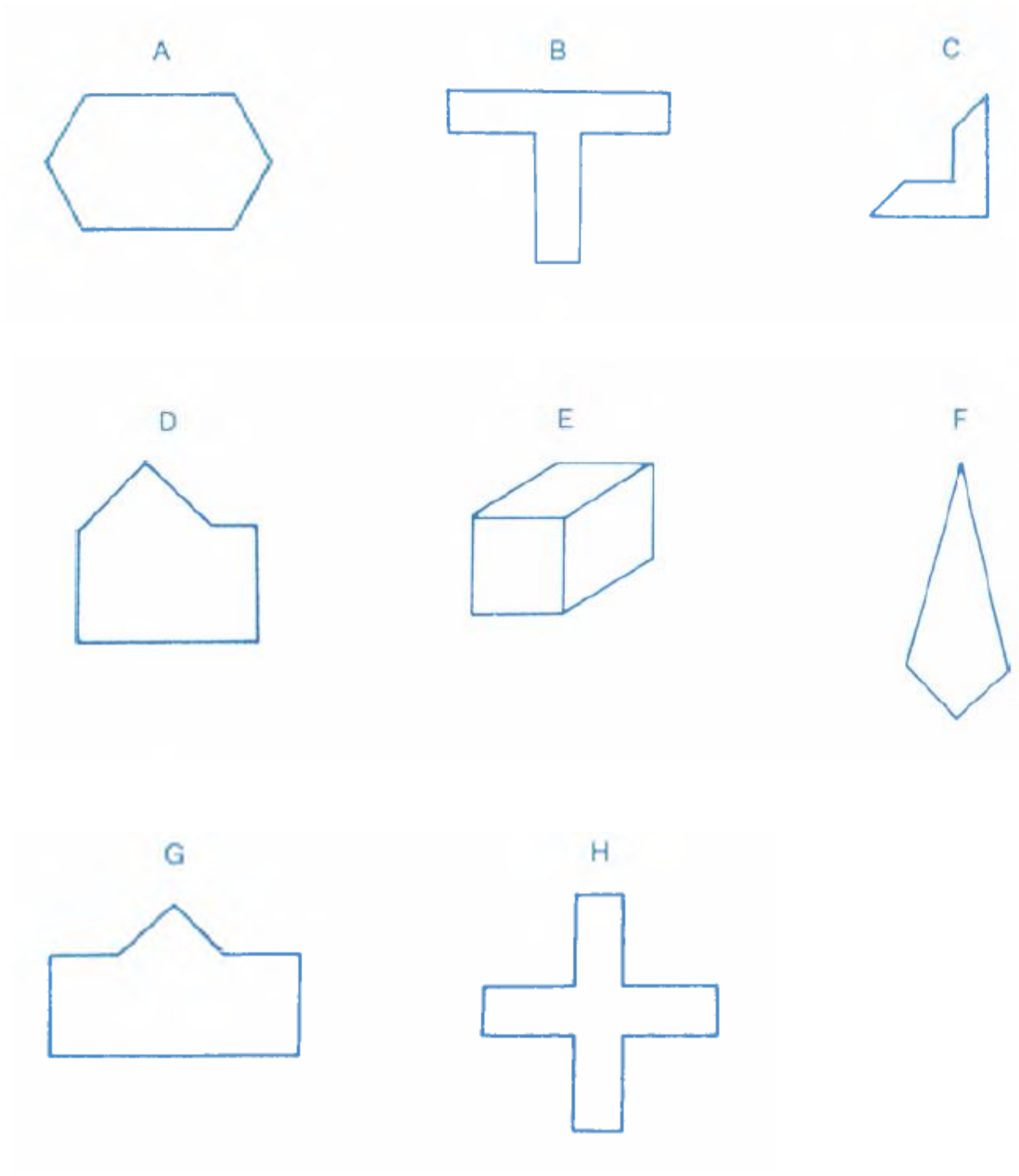
Bir sonraki sayfaya geçiniz.

9

‘’A’’ basit şeklini bulunuz.

Lütfen Testi Bırakın. Gelecek Yönergeleri Bekleyin.

BASİT ŞEKİLLER



Appendix B: A Turkish Version of Purdue Spatial Visualization Test

009199-1

PURDUE UZAMSAL GÖRSELLEME TESTİ

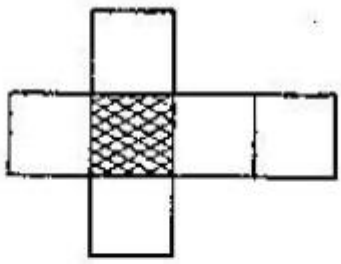
Roland Guay , PhD

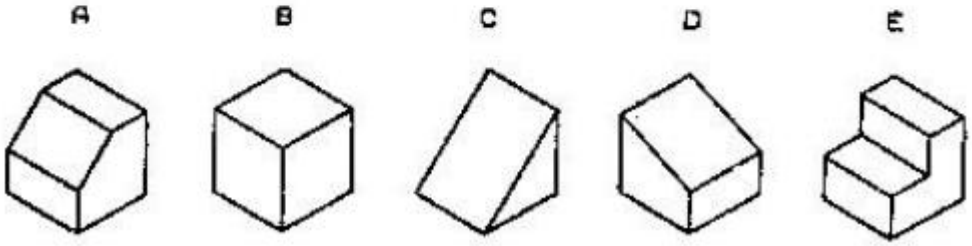
Lütfen size testi nasıl cevaplayacağınız anlatılana kadar kitapçığı açmayınız

UYARI: Bu kitapçık üzerinde herhangi bir işaretleme yapmayınız. Cevapları cevap kağıdına işaretleyiniz.

BÖLÜM 1: OLUŞTURMA

Yönerge: Bu testin ilk bölümü 12 sorudan oluşmaktadır. Bu sorular sizin üç boyutlu nesneleri katlayarak ne şekilde görselleştireceğinizi belirlemek üzere tasarlanmıştır. Aşağıda bu testin ilk bölümünde yer alan soru tiplerine yönelik bir örnek verilmiştir.





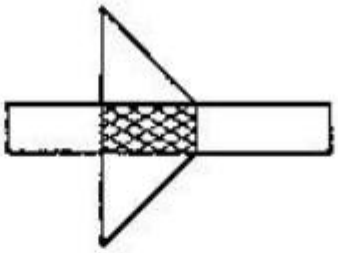
Yukarıda beş tane üç boyutlu cisim ve bir tane açılım bulunmaktadır. Açılım üç boyutlu bir nesnenin iç yüzeyini göstermektedir. Açılımda taralı kısımlar cismin tabanını göstermektedir. Sizden istenilen;

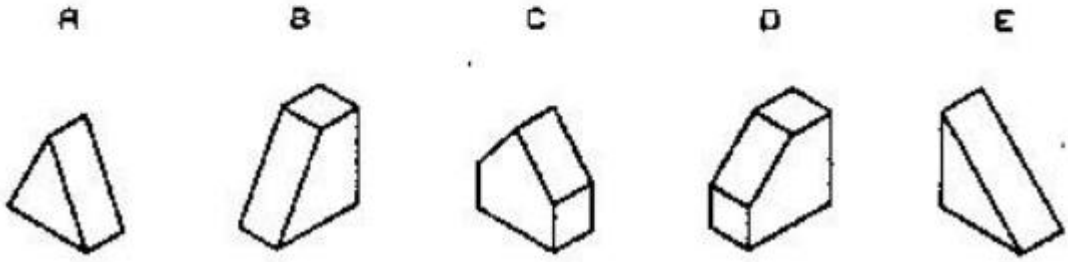
1. Bu açılımı üç boyutlu nesne olarak katladığınızda, zihninizde nasıl gözüktüğünü belirlemeniz,
2. Yapılan katlamalar ile oluşan üç boyutlu şekli, A, B, C, D, E şıkları arasından seçmenizdir.

Yukarıda gösterilen örneğin doğru cevabı hangisidir?

A, C, D ve E şıkları yanlıştır. Verilen açılımın katlanmasıyla B şıkkındaki gibi bir nesne elde edilir. Bu testin üç bölümündeki her bir sorunun yalnıza bir doğru cevabı bulunmaktadır.

Şimdi aşağıdaki örneğe bakınız ve verilen açılım katlandığında elde edilebilecek üç boyutlu cismi şıklar arasından belirlemeye çalışınız? Verilen açılımın cismin içerisini ve taralı kısmın cismin alt yüzeyini gösterdiğini unutmayınız.



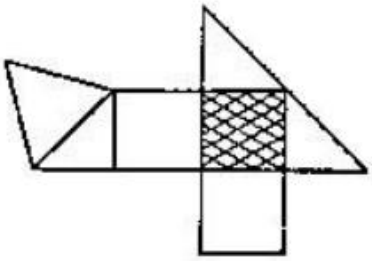


Örnekteki doğru cevap E şıkkıdır.

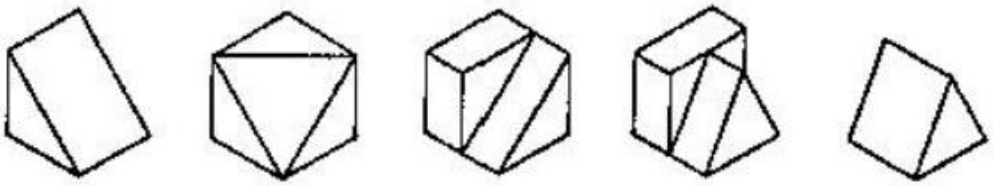
Test boyunca her bir soru için belirlediğiniz cevapları, cevap anahtarına koyu renkli kalemle işaretleyiniz.

Uyarı: Kitapçık üzerine herhangi bir işaretleme yapmayınız. Cevaplarınızı cevap kağıdına işaretleyiniz. Başlarken gerekli açıklamalar yapılacaktır.

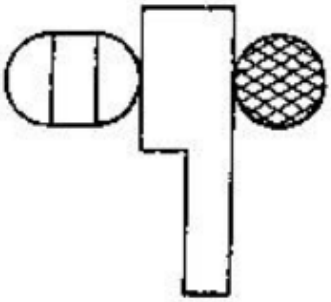
1



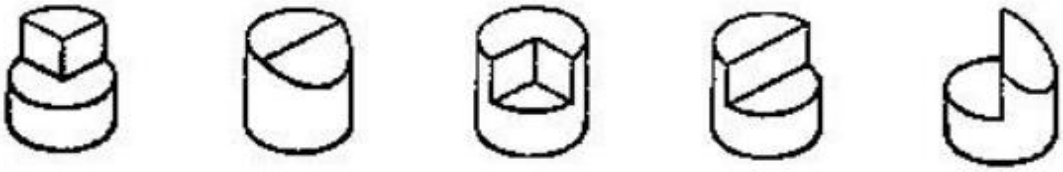
A B C D E



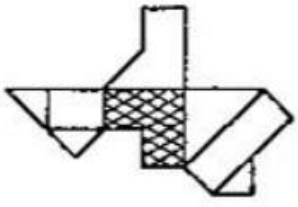
2



A B C D E

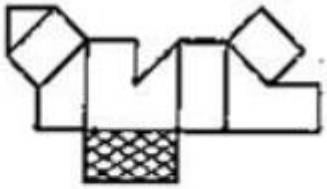


3

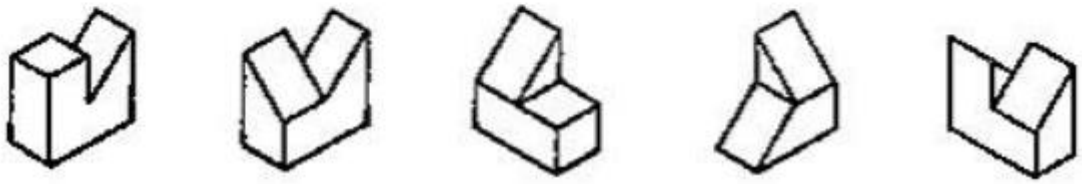


A B C D E

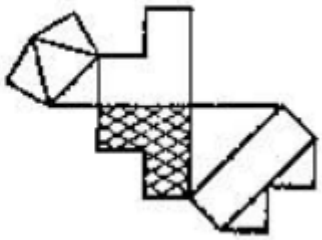
4



A B C D E

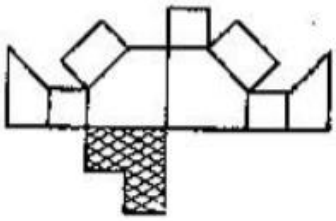


5

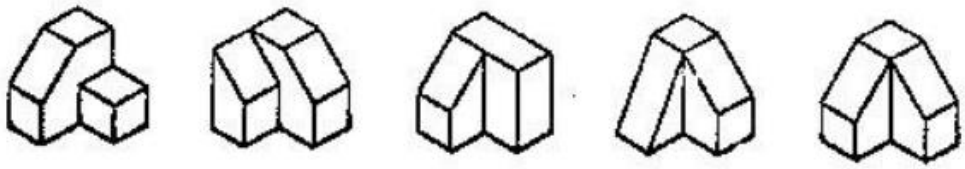


A B C D E

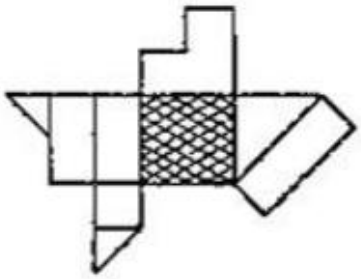
6



A B C D E



7

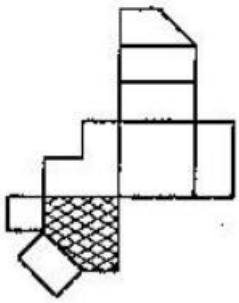


A B C D E

8

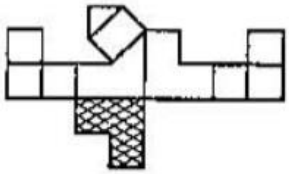
A B C D E

9

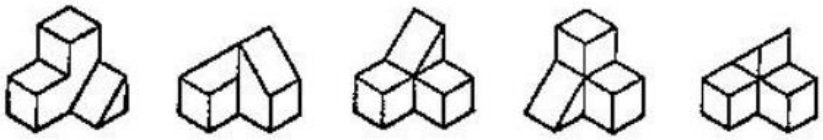


A B C D E

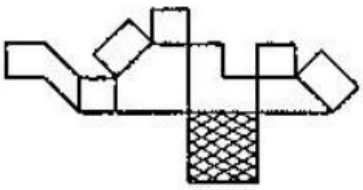
10



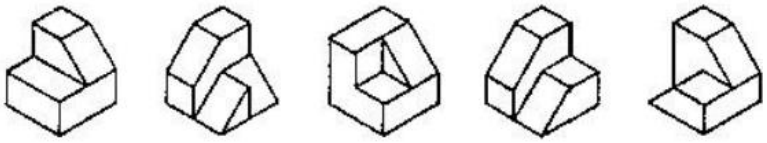
A B C D E



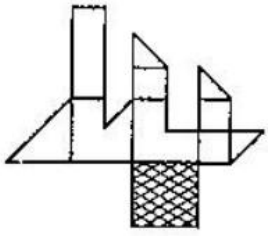
11



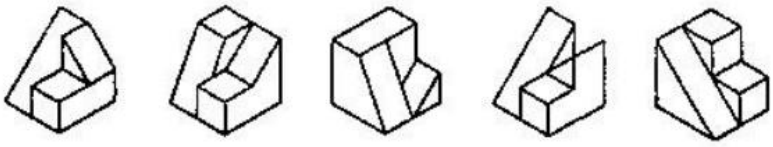
A B C D E



12



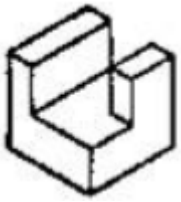
A B C D E

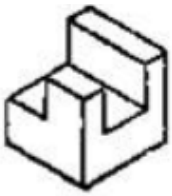


Uyarı: Bu kitapçık üzerinde herhangi bir işaretleme yapmayınız. Cevaplarınızı cevap kağıdına işaretleyiniz.

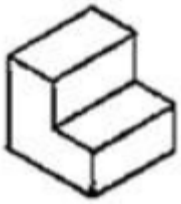
BÖLÜM 2: DÖNDÜRME

Yönerge: İkinci bölüm 12 sorudan oluşmaktadır. Bu bölümdeki sorular üç boyutlu nesnelerin döndürülmesini ne şekilde görselleştireceğinizi belirlemek üzere tasarlanmıştır. Aşağıda görülen soru tipi ikinci bölümde bulunan soru tiplerine bir örnektir.

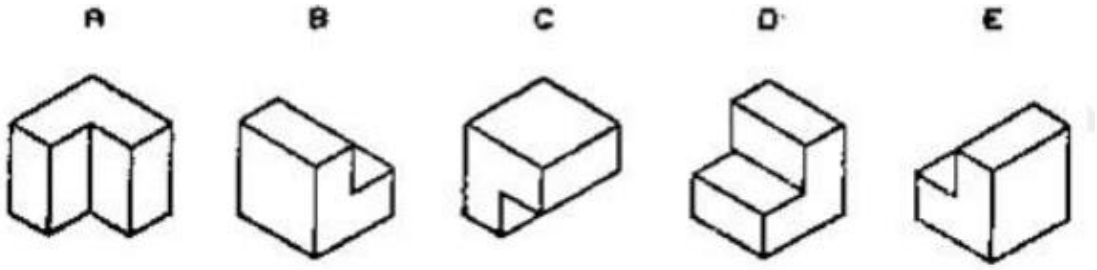


Şeklinin döndürülmüş hali  ‘dır.

Sizden istenilen:



Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?



1. Sol üst kısımda yer alan nesnenin, sağ üst kısımdaki nesneye dönüşmesi için gerekli adımları bulmanız,
2. Sorunun orta kısmında bulunan nesnenin tam olarak aynı adımlar ile döndürüldüğü zaman nasıl göründüğünü bulmanız,

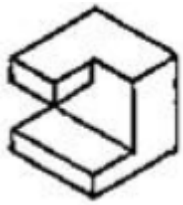
3. Orta kısımda bulunan cisim gerekli adımlar uygulanarak döndürüldüğünde, elde edilen görünümün verilen şıklardan hangisinde (A, B, C, D ve E) doğru olarak gösterildiğini bulmanız, istenmektedir.

Yukarıda gösterilen örnekte doğru cevabı hangisidir?

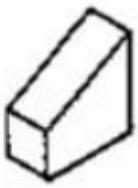
A, B, C ve E cevapları yanlıştır. Gerekli döndürme adımları uygulandığında D şıkkının doğru olduğu görülmektedir. Her sorunun yalnızca bir doğru cevabı olduğunu hatırlayınız.

Şimdi bir diğer örneğe geçelim. Aşağıda verilen örnekte döndürülme işlemi uygulandıktan sonra doğru pozisyonda bulunan şekli belirlemeye çalışınız.

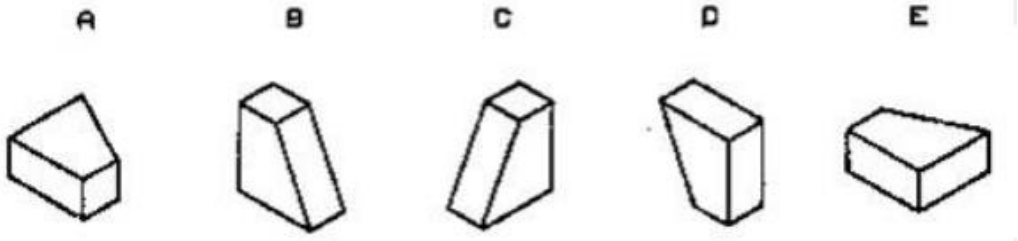
Şeklinin döndürülmüş hali



'dır.



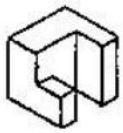
Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

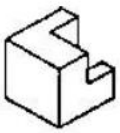


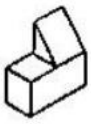
Dikkat ederseniz bu örnekteki döndürme yönergesi daha karmaşıktır. Bu örnek için doğru cevap B seçeneğidir.

Uyarı: Bu kitapçık üzerine herhangi bir işaretleme yapmayınız. Cevapları cevap kağıdına işaretleyiniz. Başlarken gerekli açıklamalar yapılacaktır.

13



Şeklinin döndürülmüş hali  'dir.



Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

A 

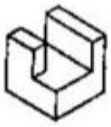
B 

C 

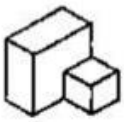
D 

E 

14



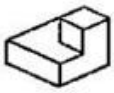
Şeklinin döndürülmüş hali  'dır.

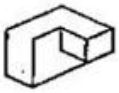


Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

A 

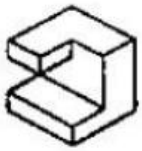
B 

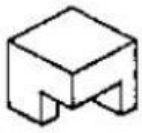
C 

D 

E 

15



Şeklin döndürülmüş hali  'dir.

Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

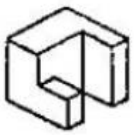
A 

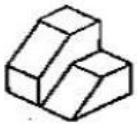
B 

C 

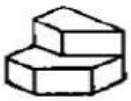
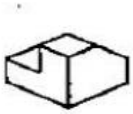
D 

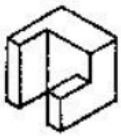
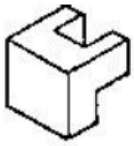
E 

16  Şeklinin döndürülmüş hali  'dir?

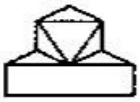


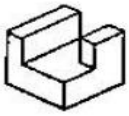
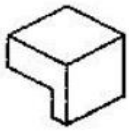
Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

A 
B 
C 
D 
E 

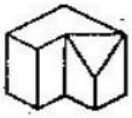
17  Şeklinin döndürülmüş hali  'dır.

Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

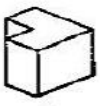
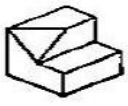
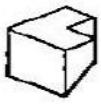
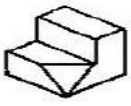
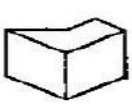
A 
B 
C 
D 
E 

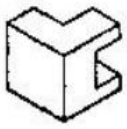
18  

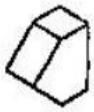
Şeklin döndürülmüş hali 'dir.



Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

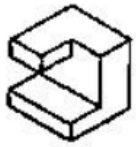
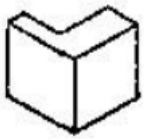
A 
B 
C 
D 
E 

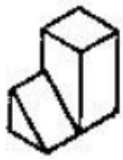
19  Şeklin döndürülmüş hali  'dir.



Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

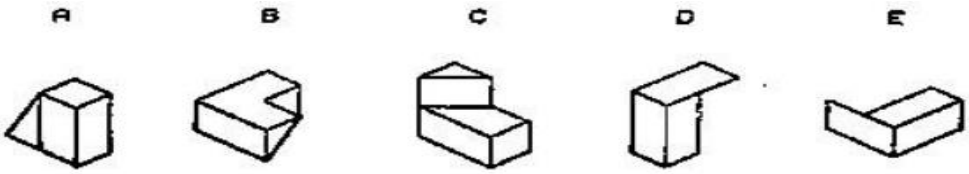
A B C D E

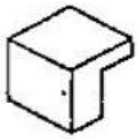
20  Şeklinin döndürülmüş hali  'dır.



Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

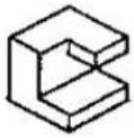
A B C D E



21  Şeklin döndürülmüş hali  'dir.

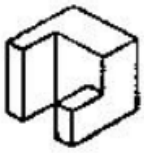
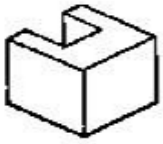
Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

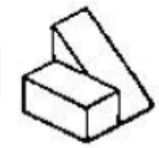
A B C D E

22  Şeklin döndürülmüş hali  'dir.

Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

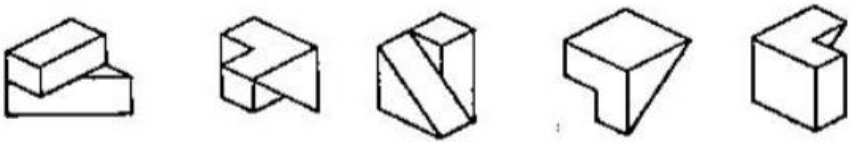
A B C D E

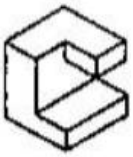
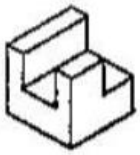
23  Şeklinin döndürülmüş hali  'dır.

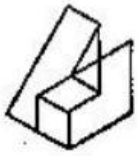


Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

A B C D E

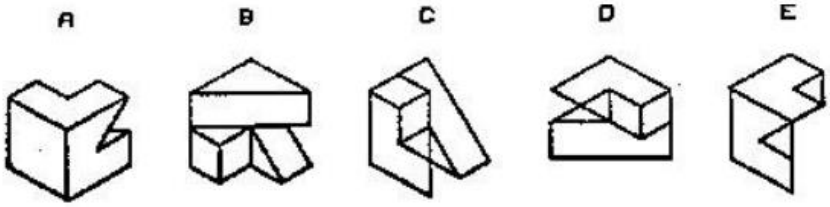


24  Şeklin döndürülmüş hali  'dir.



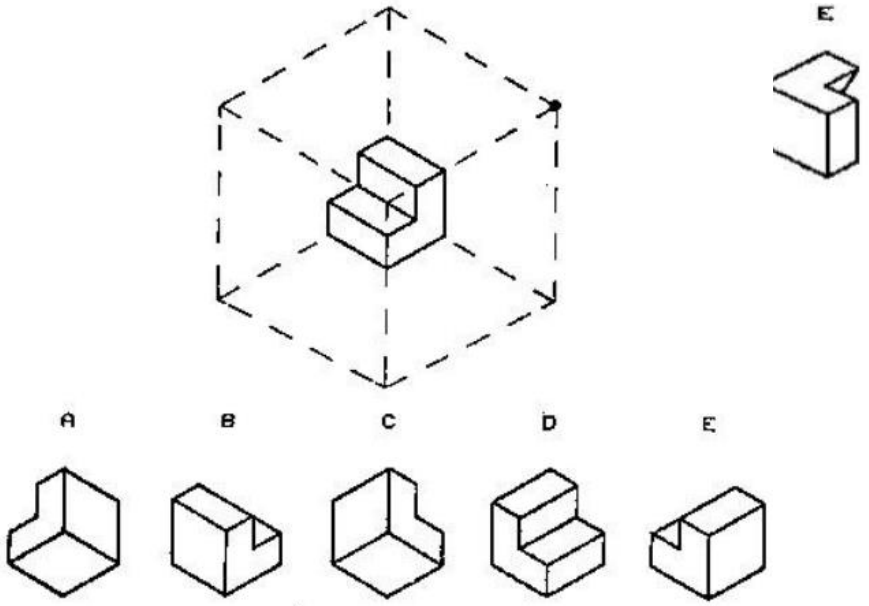
Şeklinin döndürülmüş hali aşağıdakilerden hangisidir?

A B C D E



BÖLÜM 3: GÖRÜNÜMLER

Yönerge: Testin üçüncü bölümü 12 sorudan oluşmaktadır. Bu sorular sizin çeşitli bakış açılarından, üç boyutlu cisimleri ne şekilde görselleyebileceğinizi belirlemeye yönelik olarak tasarlanmıştır. Aşağıdaki verilen soru, üçüncü bölümde yer alan soru tiplerine bir örnektir.



Yukarıdaki örnek saydam bir kutunun ortasına yerleştirilmiş bir cismi göstermektedir. Beş çizim aynı cismin farklı noktalardan bakıldığında oluşan görüntülerini temsil etmektedir. Saydam kutunun sağ üst köşesinde yer alan siyah nokta, cisme bakılması istenen durumu göstermektedir.

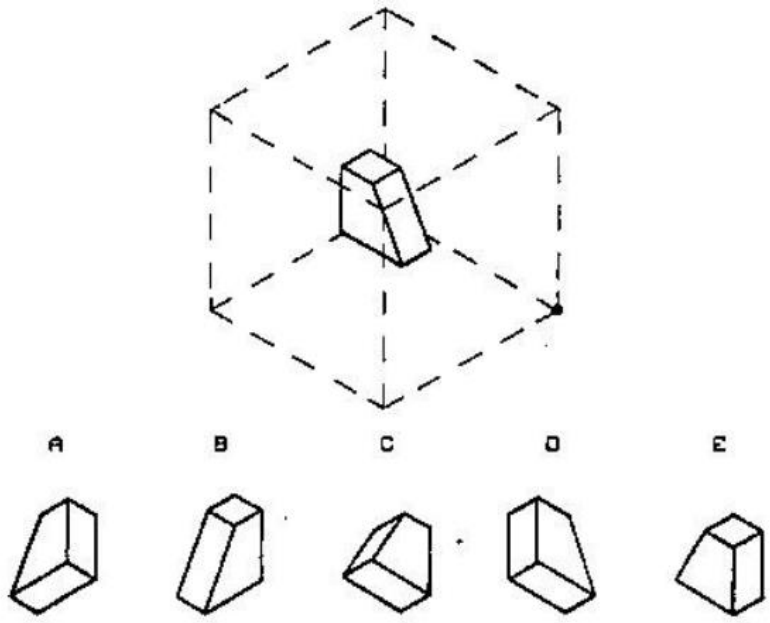
Sizden istenen;

1. Bu saydam kutunun köşesindeki siyah noktanın sizinle cam kutu arasında oluncaya kadar hareket etmesi gerektiğini hayal etmeniz,
2. Bu bakış açısı doğrultusunda saydam kutuda içerisindeki nesnenin zihninizde nasıl göründüğünü bulmanız,
3. Verilen A, B, C, D ve E şıkları arasında size göre doğru olan cevabı işaretlemenizdir.

Yukarıda verilen örnekte doğru cevap hangisidir?

A, B, C ve D şıkları yanlıştır. Sadece E şıkkı verilen bakış açısı doğrultusunda cismin görünümünü temsil etmektedir. Önceki bölümlerde olduğu gibi her sorunun yalnızca bir doğru cevabı bulunmaktadır.

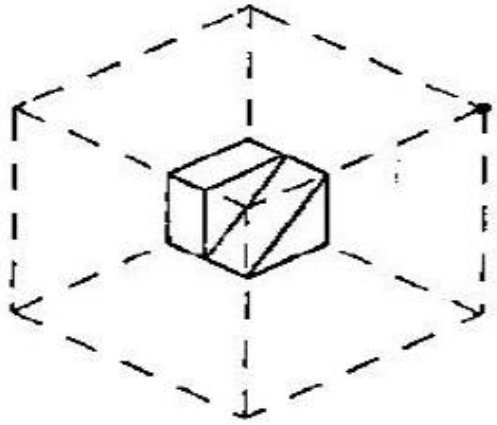
Şimdi aşağıda verilen bir sonraki örneğe bakarak, gösterilen noktadan cisme bakıldığında cismin nasıl göründüğünü bulunuz. Nesne saydam kutunun ortasına konumlandırılmıştır. Siyah nokta, sizinle nesne arasında kalacak şekilde cismi hareket ettirerek zihninizde görselleyiniz.



Bu örneğin doğru cevabı C şıkkıdır.

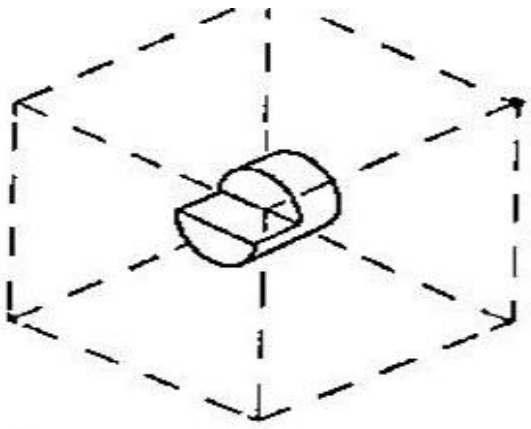
Ne zaman başlayacağınız size söylenecektir.

25



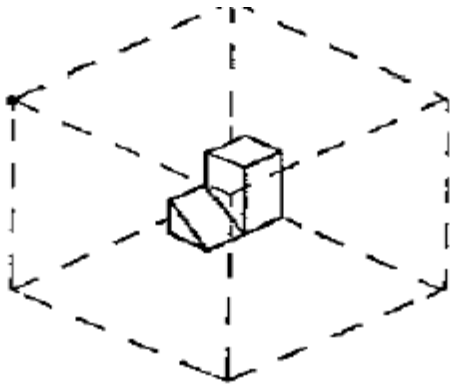
A B C D E

26



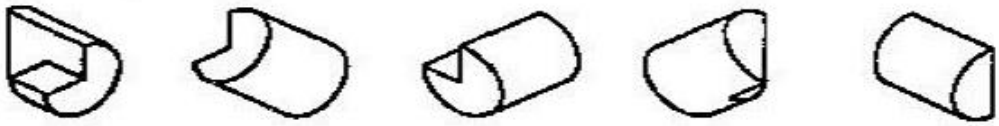
A B C D E

27



A B C D E

A B C D E



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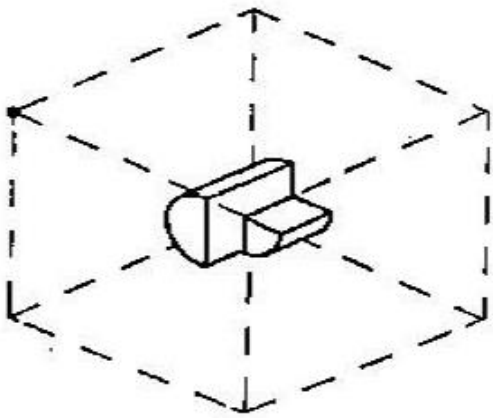
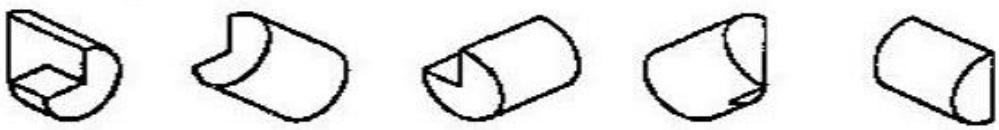


A B C D E



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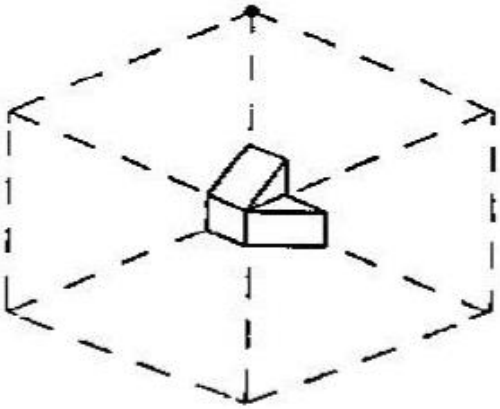
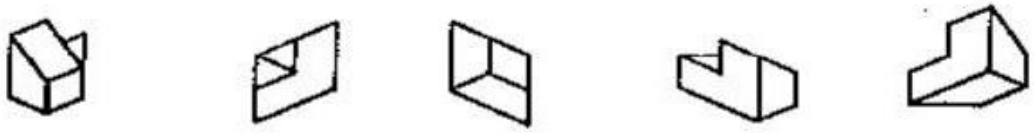


A B C D E



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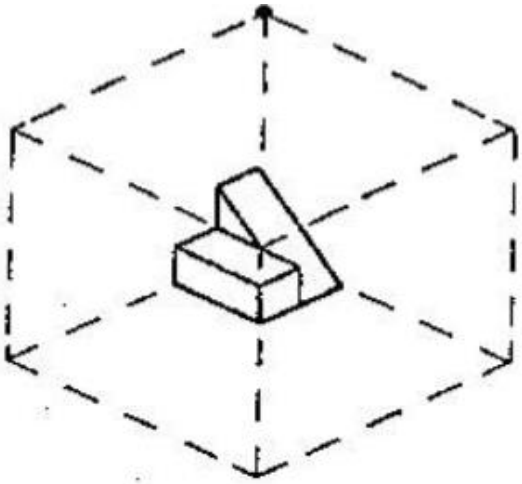
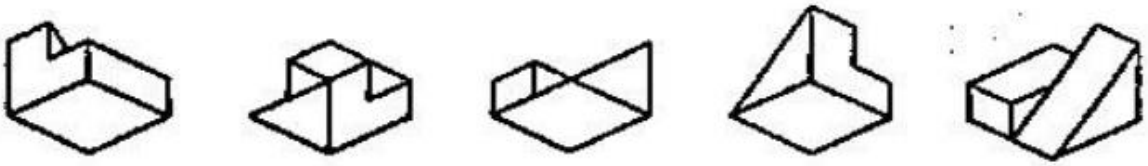


A B C D E



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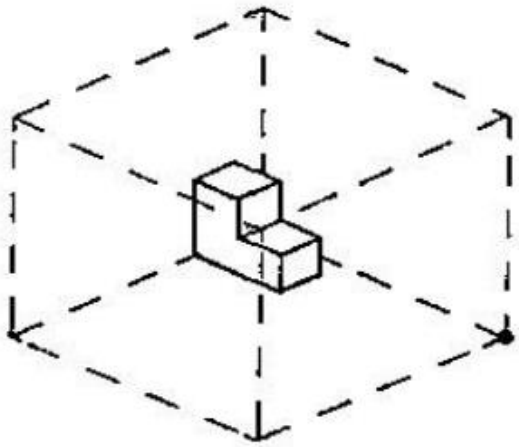
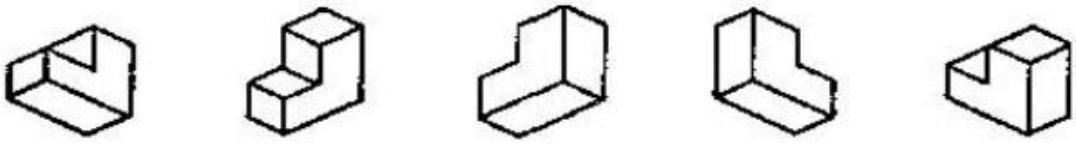
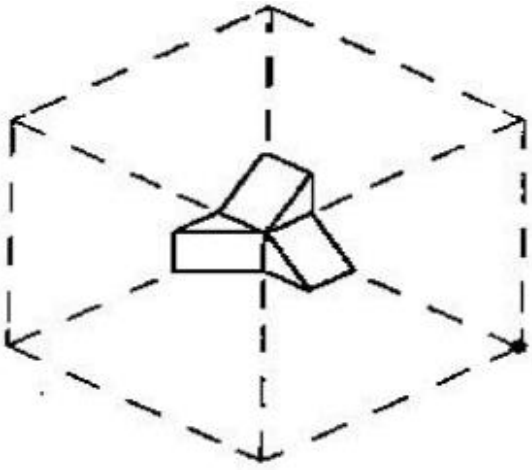


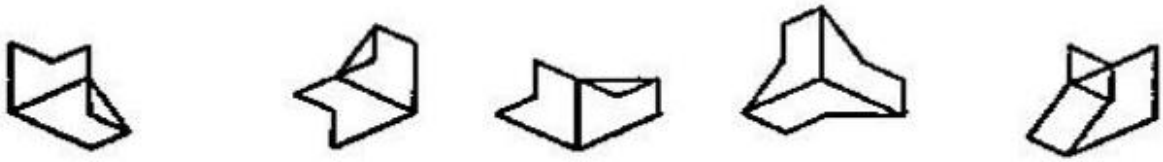
A B C D E



32



A B C D E



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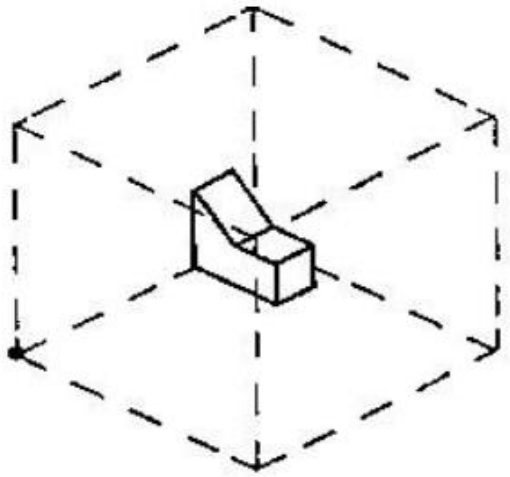
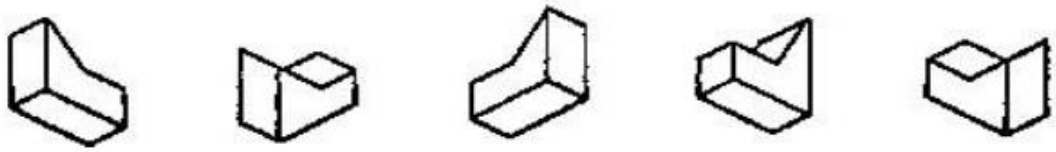
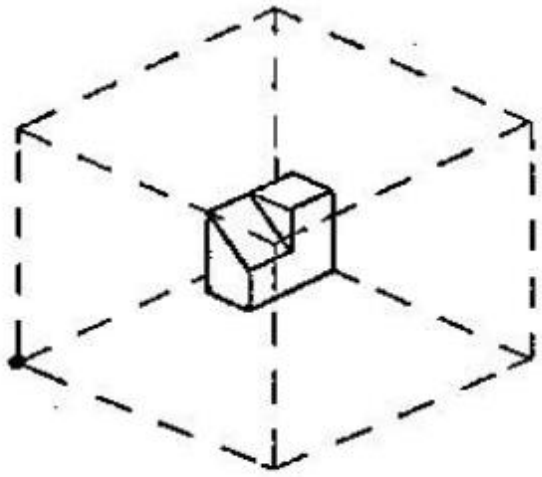


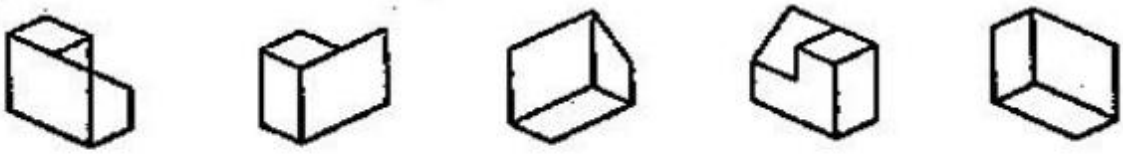
A B C D E



34



A B C D E



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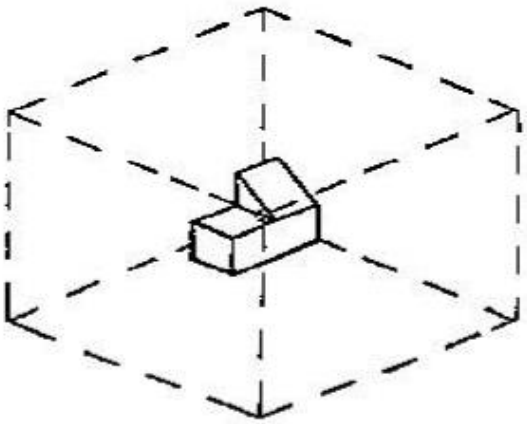
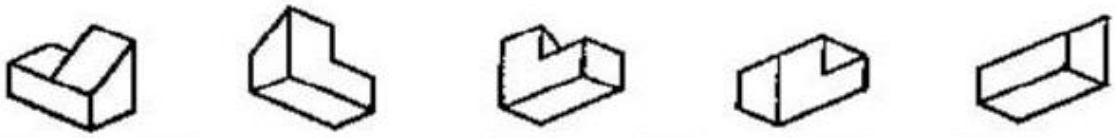


A B C D E



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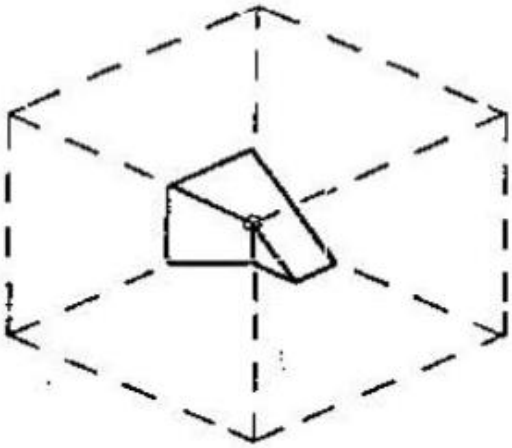
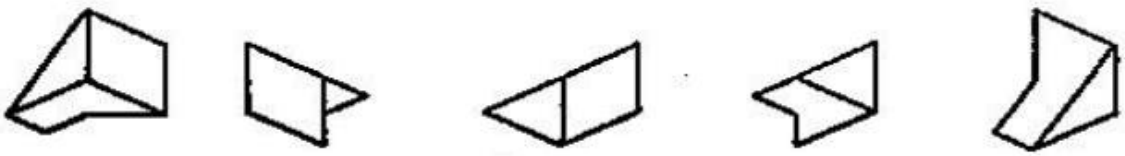
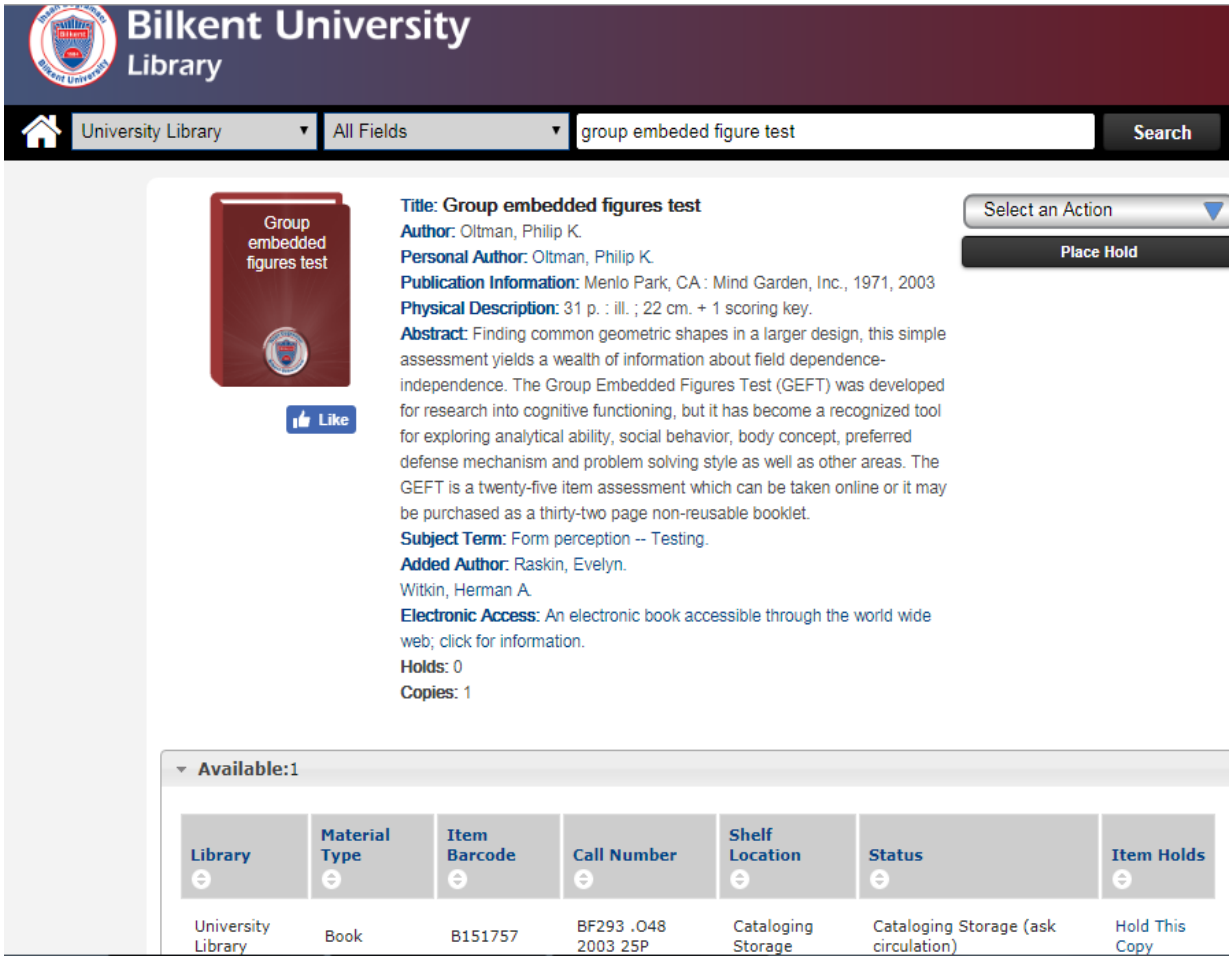


A B C D E

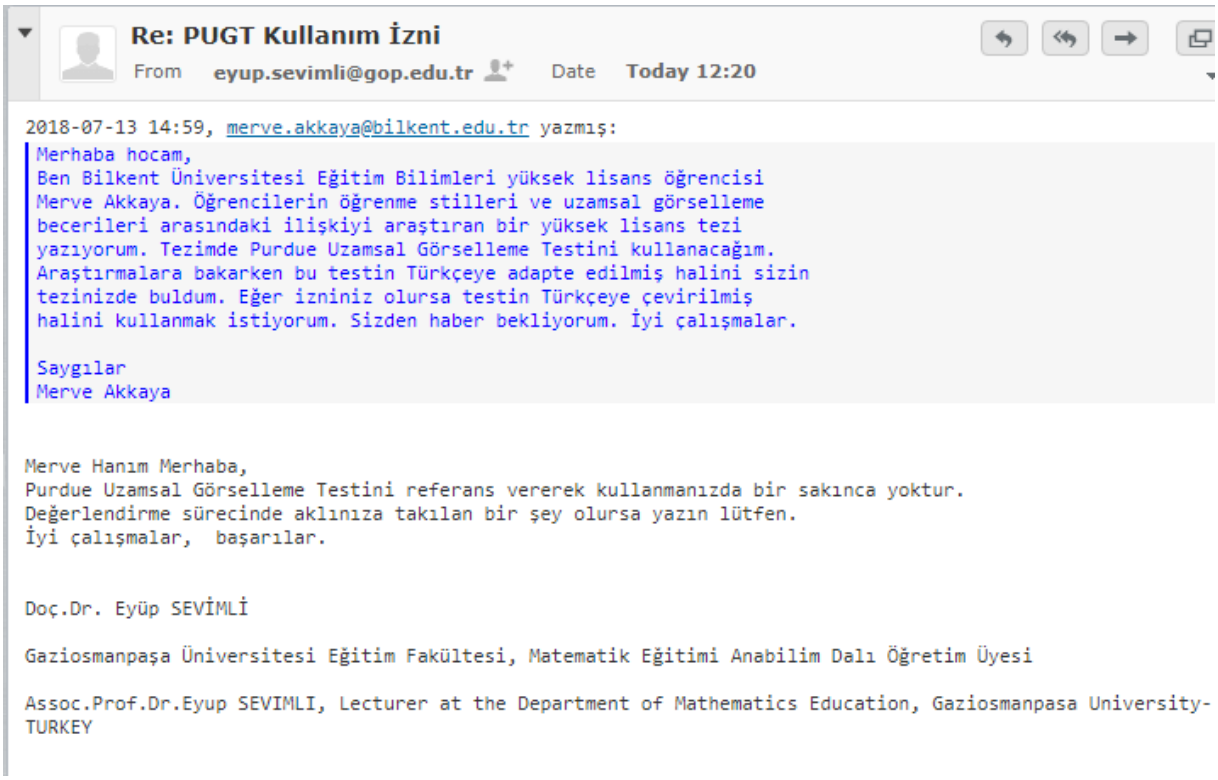


Appendix C: Permission for GEFT

Right of use for GEFT is purchased by Bilkent University Library. This screenshot showed that Bilkent University had this test in library.



Appendix D: Permission for PSVT



Re: PUGT Kullanım İzni

From **eyup.sevimli@gop.edu.tr** Date **Today 12:20**

2018-07-13 14:59, merve.akkaya@bilkent.edu.tr yazmış:

> Merhaba hocam,
> Ben Bilkent Üniversitesi Eğitim Bilimleri yüksek lisans öğrencisi
> Merve Akkaya. Öğrencilerin öğrenme stilleri ve uzamsal görselleme
> becerileri arasındaki ilişkiyi araştıran bir yüksek lisans tezi
> yazıyorum. Tezimde Purdue Uzamsal Görselleme Testini kullanacağım.
> Araştırmalara bakarken bu testin Türkçeye adapte edilmiş halini sizin
> tezinizde buldum. Eğer izniniz olursa testin Türkçeye çevirilmiş
> halini kullanmak istiyorum. Sizden haber bekliyorum. İyi çalışmalar.
>
> Saygılar
> Merve Akkaya

Merve Hanım Merhaba,
Purdue Uzamsal Görselleme Testini referans vererek kullanmanızda bir sakınca yoktur.
Değerlendirme sürecinde aklınıza takılan bir şey olursa yazın lütfen.
İyi çalışmalar, başarılar.

Doç.Dr. Eyüp SEVİMLİ

Gaziosmanpaşa Üniversitesi Eğitim Fakültesi, Matematik Eğitimi Anabilim Dalı Öğretim Üyesi

Assoc.Prof.Dr.Eyup SEVIMLI, Lecturer at the Department of Mathematics Education, Gaziosmanpasa University-TURKEY