7TH-GRADE STUDENTS' TYPICAL ERRORS AND POSSIBLE MISCONCEPTIONS IN GRAPHS CONCEPT BEFORE AND AFTER THE REGULAR MATHEMATICS INSTRUCTION

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ABSTRACT

7TH-GRADE STUDENTS' TYPICAL ERRORS AND POSSIBLE MISCONCEPTIONS IN GRAPHS CONCEPT BEFORE AND AFTER THE REGULAR MATHEMATICS INSTRUCTION

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The purpose of this study was to investigate 7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction.

The study was conducted in an elementary school in the 2nd semester of 2009-2010 academic year in Afyonkarahisar. A mathematics teacher and 71 7th-grade students participated in the study. The data were collected through achievement tests administered to the students before and after the instruction and interviews conducted with the teachers and the selected eight students based on the results of the pretest and posttest. The teacher's instruction was also observed. Students were not exposed to a special treatment, but rather the influence of regular mathematics instruction on a group of 7th-grade students from the four classes taught by the same teacher was investigated.

The results of data analysis indicated that 7th-grade students had common typical errors and possible misconceptions about the usage, construction, reading, and interpretation of line, bar, and circle graphs before and after the regular instruction. The comparison of pretest and posttest results showed that while there were differences between the students' errors and misconceptions in pretest and

posttest, some misconceptions were decreased or increased, or did not change from pretest to posttest. The interviews conducted with the selected students addressed that the students had errors and misconceptions in graphs concept. Findings of the observation of teacher's instruction showed that the teacher did not fully discover and prevent students' typical errors and possible misconceptions. Moreover, the findings of the interview conducted with the teacher indicated that her knowledge of students' errors and misconceptions were limited. The results of this study showed that teachers' planning was important in understanding students' typical errors and possible misconceptions. Inservice training of teachers should put more emphasize in effective planning and understanding students' typical errors and possible misconceptions.

Key words: Misconception, Graphs Concept, Regular Mathematics Instruction

ÖZ

İLKÖĞRETİM 7.SINIF ÖĞRENCİLERİNİN ALIŞILMIŞ MATEMATİK ÖĞRETİMİNİN ÖNCESİNDE VE SONRASINDA GRAFİK KAVRAMINDAKİ TİPİK HATALARI VE KAVRAM YANILGILARI

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Bu çalışmanın temel amacı ilköğretim 7.sınıf öğrencilerinin alışılmış matematik öğretiminin öncesinde ve sonrasında grafik kavramındaki tipik hatalarını ve kavram yanılgılarını incelemektir.

Bu çalışma, Afyonkarahisar'da 2009-2010 öğretim yılının 2. döneminde bir ilköğretim okulunda gerçekleştirilmiştir. Çalışmaya bir matematik öğretmeni ve 71 ilköğretim 7.sınıf öğrencisi katılmıştır. Veriler, öğretimden önce ve sonra öğrencilere uygulanan başarı testleri, öğretmenle ve ön ve son sınav sonuçları dikkate alınarak seçilen sekiz öğrenci ile yapılan görüşmeler yoluyla toplanmıştır. Ayrıca öğretmenin öğretimi gözlenmiştir. Bu çalışmada öğrenciler özel bir davranışa maruz kalmamış, olağan matematik öğretiminin aynı matematik öğretmeninin farklı 7.sınıf şubelerinde öğrenim gören öğrencileri üzerindeki etkisi araştırılmıştır.

Veri analizi sonuçlarına göre ilköğretim 7.sınıf öğrencilerinin çizgi, sütun ve daire grafiklerinin kullanımı, oluşturulması, okunması ve yorumlanması ile ilgili hata ve kavram yanılgılarına sahip oldukları saptanmıştır. Ön ve son test sonuçlarının karşılaştırması, öğrencilerin ön ve son testteki kavram yanılgıları arasında farklılıkların olduğunu, bazı kavram yanılgılarının azaldığını veya arttığını veya

değişmediğini göstermektedir. Seçilmiş öğrencilerle yapılan görüşmeler öğrencilerin grafik kavramı ile ilgili kavram yanılgıları olduğunu yansıtmaktadır. Öğretmen öğretiminin gözlem bulguları, öğretmenin öğrencilerin hata ve kavram yanılgılarını tamamı ile keşfedemediğini ve engelleyemediğini göstermektedir. Öğretmen ile yapılan görüşme bulguları ise öğretmenin öğrencilerin hata ve kavram yanılgıları ile ilgili bilgilerinin kısıtlı olduğunu göstermektedir. Bu çalışmadan elde edilen sonuçlar, öğrencilerin hata ve kavram yanılgılarını anlamada öğretmen planlamasının önemli olduğunu göstermektedir. Öğretmen staj eğitiminde, iyi planlama yapmaya ve öğrenci hata ve kavram yanılgılarını anlamaya daha fazla vurgu yapılmalıdır.

Anahtar Kelimeler: Kavram Yanılgısı, Grafik Kavramı, Alışılmış Matematik Öğretimi

To My Father, Sıtkı TORTOP,

My Mother, Ayla TORTOP

and My Brother

who have always shown their trust in me

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My dearest family… My father… I know that he was always there and he watched me. I know that my mother and my brother were also always there whenever I needed them. Even though I always believed in myself, their encouragement really helped me in this and encouraged me to consider other perspectives and kept my hopes high about the future. Thank you all my family!

And special thanks for the mathematics teacher and the students who participated to this study.

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ABBREVIATIONS

MONE: Ministry of National Education

SBS: National Level Examination

f: Frequency

p: Significance level

t: T value

M: Mean

SD: Standard deviation

CHAPTER I

INTRODUCTION

One of the issues that researchers investigate in recent years is students' understanding of the scientific concepts driven by the fact that students have difficulties in understanding scientific concepts and they have common misconceptions. Misconception means "the perception of concepts by students in a different way than their scientifically accepted definitions" (Keşan & Kaya, 2007, p. 27). The formation of and increase in misconceptions is the result of not learning the concepts in a meaningful way in which the fulfillment of learning concepts around the basic concepts is important. Learning concepts requires classifying or denominating the objects and events. Concepts should be classified in a logical sequence and these concepts with the subject to which they are related must be arranged in such a way that relationships between the pieces forming the concepts are clearly seen. However, when students configure all the concepts in an undesirable and non-scientific way (Demirel, 2003), misconceptions appear.

Students' misconceptions might result from epistemological, psychological, or pedagogical reasons. The misconceptions in mathematics learning sometimes result from the nature and the properties of the content which addresses the epistemological reasons of misconceptions (Cornu, 1991). The psychological reasons of misconceptions are related to students' biological, cognitive, and sensory development. How students learn the new concepts is affected by students' prior knowledge, ability, skill, and availability. The pedagogical factors which cause misconceptions include teaching model selected and the application of these models, the analogy used by the teacher, textbooks, and the sequences and formats of concepts in these books (Özmantar, Bingölbali, & Akkoç, 2008).

Students have common misconceptions in certain mathematics topics and graphs is one of these topics. The complicated information or relationship can be presented by graphs in an effective way (Özgün-Koca, 2001). It is recently known that the vast amount of information encountered everyday should be performed

effectively by the people. In this context, graphs are often utilized in the presentation of such information by businesses, government, and the news media in daily life (Pereira, Mendoza, & Mellor, 1990). The use of graphs which are taught in mathematics classrooms is also widespread in order to represent and interpret relationship in many subject areas including science or social studies (Özgün-Koca, 2001). In fact, graphs are necessary for getting correct information about the subjects that are related to life (Taşar, İngeç, & Güneş, 2002).

Previous studies have shown that students have several problems in graphs concept. They often have difficulties in making connections between real objects and abstract representations (Friel, Curcio, & Bright, 2001). In addition, young children are unable to classify items appropriately based on form, size, orientation, function, or type (Pasnak, Holt, Campbell, & McCutcheon, 1991). Middle school students fail to understand how scale changes affect the appearance of graphs when interpreting them (Kerslake, 1981). Moreover, organization of numerical data is a real obstacle for the students in both middle school (Bright & Friel, 1998) and in elementary school. Students also have problems about the meaning of the origin. They are likely to define the value zero up to the x-axis and they also draw a circle graph by omitting zero since thinking it is a categorical variable. (Capraro, Kulm, & Capra, 2005). Furthermore, understanding the relationship between raw and grouped representations of data is another problem that the students have (Bright & Friel, 1998). They tend to sense histograms as representations of raw data including bars each of which belongs to an individual observation rather than grouped data (Lee & Meletiou-Mavrotheris, 2003). Students have problems in identifying the same data that is presented in different ways (Bright & Friel, 1998; Kerslake, 1981). In fact, when attempting to interpret or generate a newer representation, they have a tendency to transfer their knowledge about more familiar representations (Baker, Corbett, & Koedinger, 2001). They tend to reverse x and y coordinates and they transfer their knowledge on situations that are unfamiliar or newly encountered insufficiently (Kerslake, 1993). Also, the students cannot distinguish between categorical variables and quantitative variables while choosing the appropriate type of graph for a given data set. They confuse the bar and histogram graphs and do not think about the differences between those graphs (Capraro, Kulm, & Capraro, 2005).

The previous studies have focused on students' difficulties and errors in graphs, however, they have not targeted understanding students' misconceptions much. Hence, this study aims to specifically determine students' typical errors and possible misconceptions in graphs concept and the effect of the regular mathematics instruction which contribute to these errors and misconceptions in 7th-grade Turkish classrooms. It is proposed that the findings of this study would be beneficial in addressing the needs in this area and provide curriculum developers and teachers with a base for improving the mathematics instruction in graphs concept at schools.

1.1. Purpose of the Study

The main purpose of this study was to examine 7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction.

1.2. Research Questions

The specific research questions addressed in this study were:

1. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept before the regular mathematics instruction?

2. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept after the regular mathematics instruction?

3. What is teachers' awareness of 7th-grade students' typical errors and possible misconceptions in graphs concept?

The above research questions were investigated with one mathematics teacher who had eleven years of experience and this teacher's 71 7th-grade students in an elementary school in Afyonkarahisar in the spring semester of 2009-2010 academic year. The data for this study were collected through achievement tests (pretest and posttest) which were prepared based on same objectives and which were implemented to the students before and after the regular mathematics instruction on graphs and interviews conducted with the mathematics teacher, and eight students who were selected based on the results of the pretest and posttest.

1.3. Significance of the Study

Graphs have an important role not only in mathematics and science but also in other areas where the numbers are used such as health, sports, and economics (Özmantar, Bingölbali, & Akkoç, 2008). In fact, they are commonly used for the representation of mathematical functions and data in social and natural sciences. They are also utilized for the specification of scientific theories in textbooks and other print media which are used both in and out of the classroom (Kaput, 1987). In this context, using the mathematical representations in an effective way has an important role in the process of both answering the problems and conceptual understanding of the students (Winn, 1987). Hence, graphing and data analysis is now considered as important topics in all grades. The National Council of Teachers of Mathematics (NCTM, 2010) in the United States has recommended greater emphasis on data analysis within the mathematics curriculum at every grade level and standardized tests. Turkish mathematics curriculum is also affected from the innovations in the world and graphs take place with more importance in the new mathematics curriculum that has been implemented in Turkish schools since 2004-2005 academic year (MEB, 2005).

The emphasis on the teaching and learning of graphs concept have addressed students' difficulties and common misconceptions as an inevitable research area. The studies on students' misconceptions have tended to focus on the pedagogical factor and they address effective ways of teaching mathematics in order to avoid misconceptions. These efforts have resulted new curricula which prioritize conceptual understanding in many countries (NCTM, 1989). Since the students' conceptual structure interacts the new learning directly and the misconceptions form the part of this structure, the learning is affected by the misconceptions mostly in a negative way (Oliver, 1989). Therefore, research on students' misconceptions and errors specifically in graphs concept are very important to determine the effectiveness of the mathematics curriculum and to guide its improvement.

Mathematics teachers have a significant role in constructing a meaningful and purposeful teaching context for the graphs concept for the students (Ainley, 2000, as cited in Monteiro & Ainley, 2003). Therefore, they should be accustomed to the conceptions which the students extensively have and their ways of thinking on graphs. Also, to address these conceptions, the possible resources of them should also be known and understood by the teachers (Tirosh et al, 1998). Since

misconceptions and errors are the first step of an effective teaching (Williams et al, 2000), the teachers should use these terms whose meanings are confused by many people in their practice. However, Houssart and Welle (1999, as cited in OFSTED, 1994) state that the teachers have problems when they try to recognize the differences between simple errors made inattentively and fundamental lack of understanding. In this context, this study would also be beneficial to investigate teachers' awareness of 7th-grade students' typical errors and possible misconceptions in graphs concept.

1.4. Assumptions

The study is based on the following assumptions:

1. The instruments developed for data collection in this study is qualified enough to serve the purpose of the study.

2. The achievement tests administered to the students in this study measured their knowledge and skills and provided a context to observe their typical errors and possible misconceptions in graphs concept adequately.

3. The teacher and students who participated in the study responded to the questions in achievement tests and interviews sincerely and impartially reflected their opinions.

1.5. Limitations

The findings of the study are limited to the data which were collected only from the students and one mathematics teacher who was working in the participating school in the spring semester of 2009-2010 academic year in Afyonkarahisar. The students' typical errors and possible misconceptions in graphs concept are limited to the questions asked in the achievement tests. The influence of regular mathematics instruction was investigated with one teacher who had eleven years of experience, therefore the interpretations in this study would be limited to this teacher. In addition, there was an unexpected and unstructured event throughout the study. Although the pretest was administered to 125 7th-grade students, the posttest could be administered only 71 students because of the lack of students who were preparing for the National Level Examination (SBS) out of the school. Hence, the participants of

the study were limited to 71 7th-grade students in the study as a result of the SBS. The implementation of the posttest and the interviews conducted with the teacher and the students were postponed until the last week of the school due to the SBS as well. Therefore, the findings of the study should be interpreted within the limitations that were caused by the SBS related factors.

The regular classroom instruction of the participating teacher was observed in four sections that the teacher taught. The researcher was not allowed to start her observations before the actual observation. Therefore, it would be possible that the teacher and the students did not behave in the classroom as they would when there was no observer in the classroom, especially in the first week of the observation. Although it was emphasized before and during the study that the focus was on the teacher's regular mathematics instruction, the teacher might have changed her regular instruction due to being observed. Hence, the observation findings should be interpreted considering the possible observer effect.

1.6. Definitions of Important Terms

Concept: A concept is a unit of abstract idea restructured by an individual according to his/her mental structure (Demetgül, 2001).

Misconception: Misconception is defined an understanding of a concept by an individual as fundamentally different from its commonly accepted scientific meaning (Yağbasan & Gülçiçek, 2003).

Error: It is defined in this study as the wrong answers made as a result of carelessness, having misconceptions, or having the lack of knowledge. All misconceptions are errors, but not all errors address misconceptions.

Difficulty: In this study, difficulty is considered as anything hard to do or understand.

Graph: "A graph is information transmitted by position of point, line or area on a two-dimensional surface" (Fry, 1984, p. 5).

The nature of misconception, error, and difficulty as they were used in this study is explained in terms of on student's response to a question in the pretest used in this study. Figure 1.1 shows one student's response for part (b) in the 5th question in pretest.

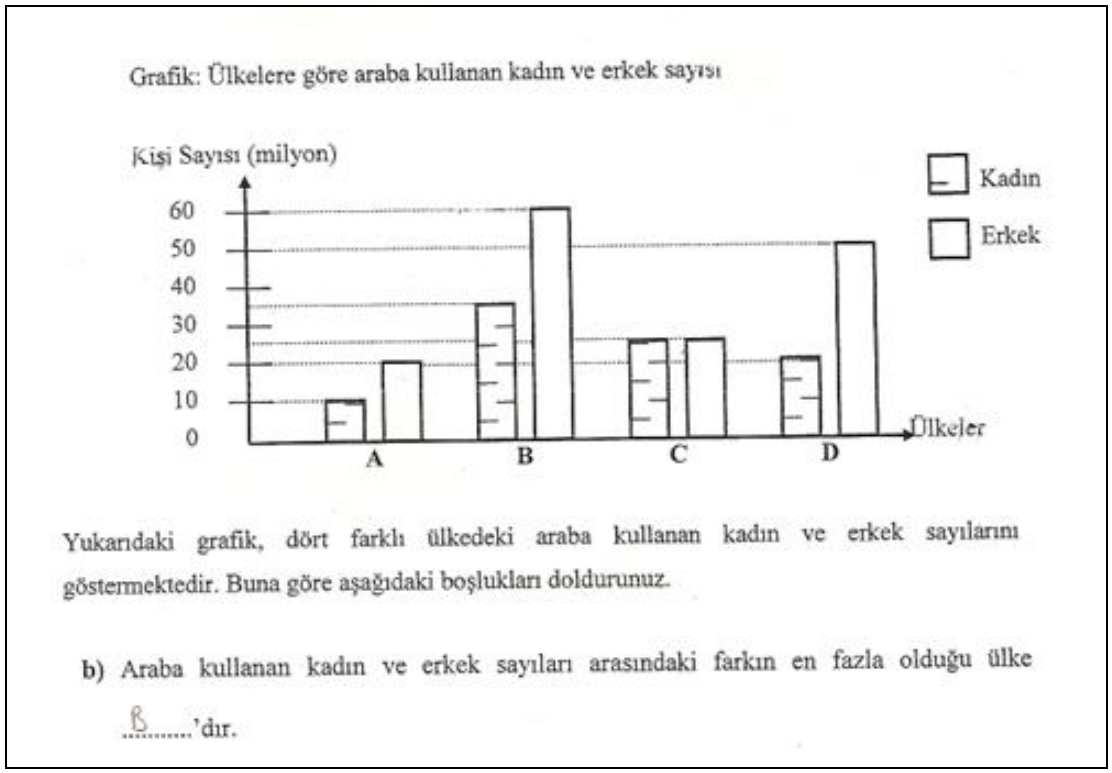


Figure 1.1. The Student's Response for Part (b) in the 5th Question in Pretest

The student gave an answer in part (b) such as "the country in which numbers of the woman and man were the most different is B." If she did not understand the question or answering the question was difficult for her, this could address that she had a difficulty about reading bar graphs. On the other hand, while she was calculating the differences between the numbers of woman and man, she might make a mistake as a result of her carelessness. Hence, this meant that her response was an error. Moreover, if she focused on the height of bars while reading the graphs and she thought that the highest bars gave the country in which numbers of the woman and man were the most different, her response would be an error but it might also address a misconception.

Regular Mathematics Instruction: It is the teachers' instruction that is presently provided to the students on the basis of elementary mathematics curriculum that has been implemented in Turkish schools since 2004-2005 academic year.

CHAPTER II

REVIEW OF RELATED LITERATURE

In this chapter, findings from the related literature review are presented in four sections. In the first section, the concept of "misconception" is introduced, the difference between "misconception" and "error" is described and the importance of misconceptions in constructivist theory of learning is explained. Second, graphing is handled by focusing on three issues: the graphs and the components of them, the importance of graphs in curriculum, and the meaning and the purpose of graphing. Thirdly, students' misconceptions in graphing are presented in a detailed historical review including two parts: constructing graphs, and reading and interpreting graphs. Finally, teacher's role in students' learning of graphs is expressed in the fourth and the last section.

2.1. Misconception and Error

Many teachers think that the students do not know anything when they come to schools and this idea causes them shape their attitudes towards the students in a different way. In the learning environment, they assume an important role of filling students' empty minds (Yağbasan & Gülçiçek, 2003) with the currently accepted disciplinary concepts, which are considered as expert concepts. However, students do not come to schools as empty minds (Resnick, 1983, as cited in Mestre, 1989). When the students enter the classroom, they have plenty of ideas or prior knowledge and they have existing conceptions expressing some of the mathematical and scientific phenomena that are addressed by the concepts presented in the classroom (Smith, diSessa, & Roschelle, 1993). Sometimes these conceptions that the students have are inconsistent with the expert concepts and this results in a difference between the students' conceptions and corresponding expert concepts.

Several terms have been used for characterization of students' conceptions, including preconceptions (Clement, 1982), alternative conceptions (Hewson & Hewson, 1984), naive beliefs (McCloskey, Caramazza, & Green, 1980), and naive

theories (McCloskey, 1983) as well as the standard terminology, misconception. Although all these terms have declared the fundamental differences between the students and the experts, the variation among them reflects differences in how researchers have characterized the cognitive properties of students' ideas and their relation to expert concepts (Bingölbali & Özmantar, 2009). Misconception means an understanding of a concept by an individual as fundamentally different from its meaning which is commonly accepted as scientific (Yağbasan & Gülçiçek, 2003). It is seen that the term "conception" forms the origin of all these terms and this shows how conception is important in understanding of the term "misconception" (Hammer, 1996). Hence, misconception is used to address students' conceptions that construct a systematic pattern of errors (Smith, diSessa, & Roschelle, 1993).

The meanings of "misconception" and "error" are generally confused by many people and these two terms are used interchangeably. While misconception is the perception of people's concepts in a different way than their understanding that is scientifically accepted (Keşan & Kaya, 2007), error is the conclusion of it. In other words, according to Nesher (1987, as cited in Bingölbali & Özmantar, 2009), error is the image on the surface and there is a misconception that causes and controls the formation of that image. Errors systematically made by the students are different from the errors of an ordinary operation and they mark the presence of a deep conception causing and controlling them through a cognitive structure (Olivier, 1989), or a misconception. As a result, while all misconceptions should be defined as an error, not all the errors could be perceived as a misconception (Eryılmaz & Sürmeli, 2002).

Misconceptions are generated in prior learning (Smith, diSessa, & Roschelle, 1993) and prior learning is an important factor for current learning in constructivism. According to the constructivist theory of learning, people do not passively receive the knowledge from the environment, rather, they are the responsible for their learning and constructing knowledge by them provides their learning (Garfield & Ben-Zvi, 2007). It is not possible that knowledge can be transferred as already formed in students' minds, the students shape it by themselves in their minds. Though what students learn is clearly affected by the teacher and so the instruction, the instruction does not determine the learning alone. The students are active participants in their construction of knowledge and this construction activity includes

interaction of both their existing ideas and new ideas (Olivier, 1989). For instance, new mathematical concepts and procedures are leant by the students by adding on their knowledge they already have (Yetkin, 2003). After interpreting the new information on the basis of the previous knowledge, the students construct their own meanings by making connection between the new and old information (Bransford et al., 2000). Hence, the knowledge is formed as a result of the interaction between current and existing knowledge structures (Olivier, 1989).

Students not only interpret knowledge but also organize and structure this knowledge into large units of interrelated concepts which are called "schemas." A schema is defined as the central building blocks in the construction of new knowledge (Piaget, 1970, as cited in Ward & Kushner-Benson, 2010). Therefore, learning basically involves the interaction between students' existing schemas and new ideas, and this interaction involves two interrelated processes such as "assimilation" and "accommodation." While the assimilation is the combination of new objects or situations into existing schemas, the creation of new schemas or modification of existing ones to account for new objects or experiences is called accommodation (Piaget, 1983). As a consequence, an idea is understood after placing it into an available existing schema (Olivier, 1989).

From a constructivist perspective, misconceptions are very important in terms of learning. Since the students' conceptual structure interacts the new learning directly and the misconceptions form the part of this structure, the learning is affected by the misconceptions mostly in a negative way (Oliver, 1989). Misconceptions hinder learning of expert concepts because of their strength and erroneous content (Smith, diSessa, & Roschelle, 1993). When the students use misconceptions to interpret and give meaning to new experiences, misconceptions can be problematic and they can impediment new learning. Moreover, misconceptions can be stable and difficult to change (Garfield & Ahlgren, 1988). Since they sometimes provide correct predictions, it becomes more difficult to replace the misconceptions (Cox & Mouw, 1992).

2.2. Graphing

A graph is the transmission of information in which a vast of descriptive writing is needed (Özgün-Koca, 2001) by using position of point, line, or area on a

two-dimensional surface (Fry, 1984). It is a picture of data in which a key message is transmitted into a small amount of space. Graphs are mostly used to show the relative sizes or quantities with the numerical data represented by them. They are also utilized to submit some important facts which are not seen obviously in numerical form for comparative purposes (Arvin & Colton, 1940).

Graphs share four similar structural components such as *framework, specifiers, labels*, and *background* (Friel, Curcio, & Bright, 2001; Kosslyn, 1989). The 1st component of a graph, the *framework* includes axes, scales, grids, and reference markings and it gives information about the kinds of measurements used and the things measured. The simplest framework having an L shape with one leg is formed by the x-axis for the data being measured and the y-axis for the measurements. Second, the visual dimensions of a graph involving lines, bars, point symbols, or other marks within the framework are called *specifiers* and they are used to represent data values. As a 3rd component, *labels* include coding techniques for depicting category membership such as the title. Finally, any coloring, grid, or picture in the superimposition on the graph is involved by the *background* of the graphs which is the last dimension (Kosslyn, 1989). However, the understanding of a particular graph is not only related to knowing these structural components very well. There is "the language" that each kind of graph has itself and that is associated with these components. As a result, the evidence of the students' knowledge about the graphs' structure is their graph interpretations (Friel, Curcio, & Bright, 2001).

The students' ability to graph and interpret data is a critical skill for the maximum potential of a graph and the students succeed this when they are able to interpret and generalize from the data that is represented to them. In fact, just being capable of reading information from a graph directly is not sufficient for the students in order to effectively use graphs (Pereira-Mendoza & Mellor, 1990). Therefore, The National Council of Teachers of Mathematics in An Agenda for Action (NCTM, 1980) called for an increased emphasis on drawing inferences from data. Within the context of data analysis, graphing has become an important component of the mathematics curriculum (NCTM, 2000). This increased emphasis is also reflected in the new mathematics curriculum that started to be officially implemented in the 2005 -2006 academic year throughout Turkish schools and graphing has taken its place with more importance in this new curriculum (MEB, 2005).

Since graphing is a topic where extensive learning occurs, it is seen as one of the critical topics in students' mathematical learning (Leinhardt, Zaslavsky, & Stein, 1990). According to the Gattis and Holyoak (1996, as cited in Parmar & Signer, 2005), graphing is defined as the representations in which the spatial information is utilized to deduce the consequences about non-spatial relations and concepts. As a result, graphing might be conceptualized as a process by which people can establish relationships between data, and infer information through the construction and interpretation of graphs. The purposes of graphing are the transmission of numerical data in a visual format (Arvin & Colton, 1940) and the transmission of the pattern and irregularities represented in the data which are not clear in the table form (Isaacs & Kelso, 1996, as cited in Capraro, Kulm, & Capra, 2005).

2.3. Misconceptions in Graphing

As the students have several problems in graphs concept, conducting researches in this area becomes an inevitable issue in education all around the world. It seemed that while the previous studies have focused on students' difficulties and errors in graphs, they paid little attention on misconceptions.

2.3.1. Constructing Graphs

By the 2nd and 3rd-grades, Turkish students are expected to collect data and to form and interpret object and picture graphs (MEB, 2008). At the primary level, the students are introduced to graphing by beginning to create object graphs in which a real life picture graph is formed by using physical objects. It is suggested by a National Statement on Mathematics for Australian Schools (Australian Education Council [AEC], 1991) that simple pictorial, block, and bar graphs should be slowly given to the children by giving the priority to the use of the actual objects or physical representations of objects or measurements. In fact, the primary school students who construct their knowledge by bridging a gap between their existing knowledge and new knowledge should learn constructing and interpreting bar graphs by using their existing development of the concept of one-to-one correspondence in representations like pictographs (Watson & Moritz, 1999).

Jones et al. (2000) developed a statistical thinking framework that characterizes children's statistical thinking according to four cognitive levels. The framework

consists of four key constructs as describing data, organizing and reducing data, representing data, and analyzing and interpreting data and these constructs are described at four developmental levels as idiosyncratic, transitional, quantitative, and analytical. Mental actions which are grouping, ordering, and summarizing data are included in organizing and reducing data (Moore, 1997). Organization of numerical data is a real obstacle for the students in both middle school (Bright & Friel, 1998) and in elementary school. In a research study, Nisbet, Jones, Thornton, Langrall, and Mooney (2003) investigated how children organized and represented data and also examined relationships between their organization and representation of data. They studied with 15 students, 3 from each of grades 1 through 5 in a Midwestern U.S. elementary school. While 60% of the children were able to rearrange categorical data, the numerical data could be reorganized by only 20% of them. Thus, the study showed that numerical data was more difficult for the children than categorical data in terms of reorganizing and representing.

Lehrer and Schauble (2000) investigated the process of data organization with elementary school children in grades 1, 2, 4, and 5. They examined how these children developed and justified models in order to categorize drawing made by them in the same grade levels. Their results suggested that children at higher grades used more cultivated strategies for organizing data than those in lower grades.

In another study, Nisbet (2002a) investigated the effect of the size of the data set on students' organization of data. Ten children in 7th-grade suburban school were given two numerical data sets to present in two graphs one of which includes 10 pieces of data and another involves 30 pieces of data. As a result of the study, it was found that the children were no more likely to represent the larger data set in an organized form than the smaller data set. The majority of the children represented the smaller data set without any organization. Similarly, the majority of them required prompting to organize the larger data set. Also, it was found that mathematical ability had some influence that children with more mathematical ability found it easier to organize the data than their less able counterparts. Nisbet (2002b) conducted another study to test the same hypothesis with 9th and 11th-grade students. In the study, the students were asked to draw graphs of two sets of numerical data, one with 10 pieces of data, and one with 30 pieces of data. With the smaller set, most students drew bar graphs that showed no reorganization of the data. However, with the larger set, more

students rearranged the data according to the frequencies of scores and then drew an organized representation. Those students having difficulty in reorganizing the data were given prompts drawing attention to the frequency of the numerical values in the raw data. For the grade 11 students, the ability to organize the data without prompting was greater for those of high mathematics ability. However, there was no similar ability effect for grade 9 students.

Several studies have demonstrated that many students at middle and elementary school have difficulty in accepting the meaning of organizing as sorting. Although some intelligent students in primary school are capable of organizing numerical data into classes (Nisbet, Jones, Thornton, Langrall, & Mooney, 2003), most of them focus on the characteristics of individuals rather than the group. Hence, sorting and classification are critical skills for the students. In the elementary school, students who develop these skills throughout kindergarten are academically more successful than others who do not (Dudek, Strobel, & Thomas, 1987). Moreover, often, young children are unable to classify items appropriately on the basis of form, size, orientation, function, or type (Pasnak, Holt, Campbell, & McCutcheon, 1991).

Students can organize data and construct appropriate type of graphs by the help of variables (Scheaffer, Watkins, & Landwehr, 1998). However, students generally miss the primary function of graphs as a representation of relationship between the variables since they focus on simple algorithms such as plotting data on the graphs (Brasell & Rowe, 1993, as cited in Özgün-Koca, 2001). They also cannot distinguish between categorical variables and numerical variables while choosing the appropriate type of graph for a given data set.

Representing data incorporates the construction of visual representations of data such as completing a data display constructed partially and constructing displays due to depict different organizations of a data set (Jones et al., 2000). The questions in which the translation from one representation to another is asked have been used more frequently in large scale tests. However, the students have problems in identifying the same data that is presented in different ways. In the TIMSS study, by using the data given in the table, only 30% of 3rd-grade students and 55% of 4th-grade students could complete a bar graph (Beaton et al., 1996).

Since the students at different grade levels are taught different sets of representations (NCTM, 2000), the representations encountered earlier levels are the

important models in learning new ones. In fact, when attempting to interpret or generate a newer representation, the students have a tendency to transfer their knowledge about more familiar representations (Baker, Corbett, & Koedinger, 2001). Baker, Corbett, and Koedinger (2002) examined how students learn to generate and interpret some of the important and commonly used representations of data such as histograms and scatterplots. They studied with 119 8th and 9th-grade students where each student completed two exercises in which they generated a histogram and a scatterplots. They found that middle school students tended to apply their extensive prior knowledge about the construction and interpretation of standard bar graphs while generating and interpreting scatterplots and histograms. 28% of the students who chose the correct axis variables placed the correct variables on the axes of the graph, but the graph they produced had one nominal variable and one quantitative variable rather than two quantitative variables. Hence, although the students chose the appropriate axis variables, they drew representations that were equivalent to a bar graph.

In another study, Baker, Baker, Corbett, and Koedinger (2001) investigated the importance of novice performance on selection, generation and interpretation for early data analysis. They studied with 52 students in 8th and 9th-grade classes where the students had some exposure to histograms, scatterplots and stem-and-leaf plots in the last two years, and considerably greater exposure to bar graphs before that. Students transferred their existing knowledge about bar graphs by constructing axes that were appropriate for a bar graph. In both graphs, the x-axis represented individual values of a categorical variable and the y-axis represented values of a quantitative variable, and each of these graphs was the informational equivalent of a bar graph.

Students also tend to reverse x and y coordinates as they insufficiently adjust their knowledge on situations that are unfamiliar or newly encountered (Kerslake, 1993). In addition, they are more likely to sketch graphs that pass through the origin since they believe that all graphs pass through the origin. On the other hand, students are likely to have mistakes such as defining the value zero up to the x-axis (Capraro, Kulm, & Capra, 2005). Capraro, Kulm, and Capra (2005) studied with 134 6th-grade students in 6 classes of three different teachers using the Connected Mathematics curriculum (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1998). The students were

administered an open-ended item that was entitled as Vet Club. The item was one of a series of measures used over a long-term project in order to assess students' understanding of data analysis and interpretation. The item provided students with data about the type and number of pets owned by 14 students and asked them to construct a graph that would help write a headline for a news story about the typical number of pets owned. Students were then asked to explain their choice of the typical number and then interviews were conducted with them to clarify their reasoning and to explore difficulties they had with constructing graphs for interpreting data. As a result of the study, it was found that the students created three types of graphs such as bar, circle, and line graphs. The students who represented their data using a bar graph believed that they needed to represent zero as a data point above the x-axis and they explained that it did not seem correct to leave a number without some representation. It was concluded that the students demonstrated a misconception about the meaning of origin. They were unaware of anything special about the intersection and they were not able to identify the intersection when it was referred to as the origin. Students who used a bar graph actually drew a histogram or called the bar graph a histogram since they were unable to differentiate between bar graphs and histograms. The students who chose a circle graph omitted zero as a categorical variable.

2.3.2. Reading and Interpreting Graphs

Interpreting graphics is very complicated for the students that Postigo and Pozo (2004) suggested "the students restrict themselves to reading data and processing specific aspects of the material and encounter problems when they have to go beyond this elementary level and interpret the information represented" (p. 628). The basic skill for the students is the ability to read and interpret graphs which is not taught effectively (Kirk et al., 1980) and it includes reading data on graphs and the formation of appropriate generalizations describing the relationships represented on graphs (Friel & Bright, 1995). Students' ability of reading graphs is studied by several researchers who have begun to search on the graphs concept in the elementary curriculum (Pereira-Mendoza, 1995).

Graph comprehension is being capable of translation between graphs or a table and a graph, and interpreting relationships or important factors that are given in

a graph (delMas, Garfield, & Ooms, 2005). Although there are many researchers who have marked graph comprehension as reading and interpreting graphs, graph construction or invention or graph choice are the other possible aspects of graph comprehension focused on by few researchers (Friel, Curcio, & Bright, 2001). There are three kinds of behaviors included by comprehension of information in written or symbolic form such as translation, interpretation, and extrapolation/interpolation (Jolliffe, 1991). Among these behaviors, translation needs an alteration in the communication. Depicting the data given in the table by using words and interpreting the original structure of the graph can be achieved in order to make a translation between graphs and tables. In the interpretation, not only the material is needed to be reorganized but also the important factors is required to be ordered from the less important one to more important. On the other hand, the extensions of interpretation, extrapolation, and interpolation need confirming the base of the communication and identifying some of the consequences. As a result, to extrapolate or interpolate, there is a need to be careful about the tendency in data or denoting implications (Wood, 1968, as cited in Friel, Curcio, & Bright, 2001).

The application of a schema theory of understanding general discourse to the comprehension of graphing included with three levels such as "reading the data", "reading between the data", and "reading beyond the data" (Curcio, 1987, as cited in Monteiro & Ainley, 2003). The first level of comprehension, "reading the data," includes inferring information in order to answer questions whose answers are given in the graph. It is related to the potential to comprehend the actual information which a practiced graph reader conceives quickly on a graph such as reading the title, checking the axes for variable names, and ranges of values, and a possible quick check of one or more specific data points. This activity might also be considered as "getting oriented to the graph." As a second level, interpolating and finding relationships in the data of a graph is called "reading between the data" which is related to considering two or more data points on the graph for comparison purposes. In this context, it is seen that this aspect is very important in two points that telling stories about the data and commenting on what the graph can say. Finally, "read beyond the data" involves extrapolation, prediction, or implication of the representation in order to answer the questions implied. It is the efficiency in which interpretative skills and deeper statistical reasoning are needed. As a result, among

all these three levels of comprehension, while "reading the data" and "reading between the data" are focused on elementary levels of questioning including data extraction, "reading beyond the data" is related to questioning involving both interpreting a graph and using the graph in order to predict or evaluate implications for the data (Pereira-Mendoza, 1995).

According to the Curcio's (1987, as cited Monteiro & Ainley, 2003) perspective, the graph could be viewed as a type of text in which prior knowledge about topic, mathematical content, and graphical form might influence the ability to comprehend the mathematical relationships that were expressed in graphs. In her study, she tried to identify the predictors of graph comprehension based on a schema theory model with using four traditional types of graphs such as pictographs, bar graphs, circle or pie graphs, and line graphs. In the study, she studied with 204 students in grade 4 and 185 students in grade 7. Data were collected on achievement in reading and mathematics, gender, prior knowledge of topic, mathematical content, graphical form, and graph comprehension. Results demonstrated that all independent variables except gender were unique predictors of graph comprehension for fourth graders. For the seventh graders, unique predictors included mathematics achievement, reading achievement, and prior knowledge of content. It was also found that there were no significant gender-related differences between 4th-grade pupils, but 7th-grade female students significantly out-performed male students in mathematics achievement. Hence, the fourth graders focused on a graph's surface structure including the topic and graphical form used. The seventh graders could read graphs more effectively and become concerned with a graph's mathematical content (Curcio, 1981).

In another study, Shah and Hoeffner (2002) reviewed the cognitive literature on how individuals comprehended graphs and the factors that influenced their interpretation. Since the reading of the graphs was not only a mathematics subject, their research was formed on the topic graphs in a way that it contained all the areas. In their study, three major factors were found such as the visual characteristics of a graph including format, animation, color, use of legend and size; an individual's graph knowledge, and knowledge and expectations that the individual has about the content of the graph data. He concluded that the readers had more difficulty when they were reading 3-dimensional graphs rather than 2-dimensional graphs. Besides,

the animations used in the same way were likely to complicate the comprehension and interpretation of graphs. Individual's knowledge of graphical schemas and conventions, and the content of the graph were likely to affect the comprehension of the graph. Individuals who were not expert might reach a conclusion by using their prior knowledge and expectations about that content before they examine the knowledge given in the graphs.

Students often have difficulties in making connections between real objects and abstract representations (Friel, Curcio, & Bright, 2001). Hence, what is given in the graphs affect students' understanding. Younger children are not able to understand the abstract ideas of a graph and they understand better if they see the actual object or a picture of the object in the graph. Computer software helps students to make connections between concrete and abstract representations in contrast to physical manipulative. In other words, by providing immediate visual or auditory feedback, software can make students to link their physical experiences with corresponding symbolic representations (Clements & McMillen, 1996).

Pereira-Mendoza and Mellor (1991) examined students' understanding of the information which is transmitted by bar graphs. In their study, they studied with 121 4th-grade students and 127 6th-grade students. During the study, they administered a total of 12 different graphs. They found that there were four general categories of graph-based errors such as topic, scale, data arrangement, and the fact that information was not shown on the graph. They stated that students had difficulty in reading the scale of a bar graph. Also, students believed that patterns must exist in a graph completely, and they said they could not give an answer since it was not on the graph. On the other hand, studies have showed that bar graphs are easier to comprehend than line graphs and that horizontal and vertical bars are equally understood.

Many students do not pay enough attention to the scale on both axes in a graph. Because of thinking every tick mark on a scale points a single unit, the students cannot read the graph with a different increment scale correctly (Dunham & Osborne, 1991). Especially, the young students who have a limited ability to count by the increments of more than one unit misread graphs (Friel, Curcio, & Bright, 2001). Students also think that the scales on both x and y-axes must be identical in order to see the relationship clearly. When interpreting graphs, middle school

students fail to understand how the appearance of the graph is affected when the scale is changed. They cannot realize the effect of scale on the proportions of a graph (Kerslake, 1981).

Understanding the relationship between raw and grouped representations of data is also another problem that the students have (Bright & Friel, 1998). The two main factors having effects on graph knowledge are the process of data reduction and the structure of graphs. Data reduction means that tabular and graphical representations presenting raw data are transmitted to other representations displaying grouped data or other representations (Friel, Curcio, & Bright, 2001) and the purpose of data reduction is "to identify appropriate representations of the data which remove as much detail from the data as is possible while providing sufficient information to address the specific question at hand" (Friel, Bright, Fierson, & Kader, 1997, p. 3). The different levels of data reduction are reflected by the graphical representations of numerical data. While a representation may display the original raw data, it may represent grouped data. For instance, while line and stem graphs use original data, grouped data is presented in box graphs and histograms. Graphical representations that are generally used in the early grades involve either the original data or tallied data which helps students better understand the transition between raw and grouped data (Friel & Bright, 1995). On the other hand, students who are in upper grades generally utilize the graphical representations of grouped data from which the data cannot be returned in its original form. In addition, the structure of the graphical representations of data may also impact understanding. For example, while graphical representations use one axis or two axes, they sometimes do not have any axis. Moreover, the axes of graphical representations using both axes may have different meanings. While the vertical axis of some type of graphs may represent each observation's value, the vertical axis of bar graphs and histograms provides the frequency of each observation presented on the horizontal axis. Hence, unless the students realize the different functions of both axes across these graphs, the confusion may develop (Friel & Bright, 1995; Friel, Bright, Frierson, & Kader, 1997).

The students tend to sense histograms as representations of raw data including bars each of which belongs to an individual observation (Lee & Meletiou-Mavrotheris, 2003). They also think that among the graphs, frequency bar graphs

were the most difficult type of graphs for interpreting (Bright & Friel, 1998). In fact, using intervals of data may be problematic for the students because of the increasing abstraction related to the process of data reduction. delMas, Garfield, and Ooms (2005) investigated how students reasoned about graphical representations of distribution. They found that students had difficulty in reading information from histograms and identifying what the horizontal and vertical scales represented. When the students were asked to identify what the vertical scale of the histogram was measuring, many students indicated the score values, rather than the frequency of scores for each value. This could represent a confusion over the terms "vertical" and "horizontal" axes, or it might indicate that some students were interpreting the histogram like a bar graph in which each bar represented an individual, and the bar height indicated the magnitude of some variable. It was also found that determining frequencies for specified values in a histogram was difficult for the students when the values were grouped into intervals. Only about one-fourth of the students correctly identified the number of values in a specified interval. In another research, Friel and Bright (1996) conducted a study of the ways that 76 students in grade 6 made sense of information presented through graphical representations and maybe connections between related pairs of graphs representations. The students were in three different middle school mathematics classes taught by the same teacher. Results indicated that students confused the axes of line graphs, histogram and histogram type graphs and they had problems using intervals of data. In both the line plot and the histogram, students confused the axes of the graphs and used either the number of x's or the y-axis as a source of information about the values of data rather than the frequencies occurrence of data values.

Students' difficulty in interpreting graphs increase as they deal with pictorial, circular, two-dimensional, and line graphs (Weintraub, 1967). On the other hand, students who can generally read data values in a graph perform poorly on higher-level tasks where additional computation or inference is needed (Shaughnessy & Zawojewski, 1999). However, the real world questions motivate the students and provide them with thoughtful interpretations. When real-world questions encourage students by providing them to see data analysis as a tool for inquiry are emphasized, they motivate the students and provide them to interpret more thoughtfully (McGatha, Cobb, & McClain, 1998).

2.4. Teacher's Role in Students' Learning of Graphs

The major obstacle of meaningful learning is the misconceptions (Keşan & Kaya, 2007) the students have. To remove these misconceptions, it is needed for the students that they learn all the concepts in a meaningful way in their school training and their conceptual changes are provided in their classrooms by the teachers (Özmantar, Bingölbali, & Akkoç, 2008). In this context, teachers have an important role in providing an effective learning environment for the students.

Nisbet (1999) examined the representations of categorical data generated by teacher education students and he found that the majority of the preservice teachers drew representations of the data which shows some reorganization of numerical data, not categorical data. Similarly, Nisbet (2001) found that teacher education students had similar difficulties in organizing numerical data. Only 19% of preservice teachers could produce an organized graph from numerical data while all of them could produce an organized graph from categorical data. Also, the majority of them drew separate bars for each individual piece of data without organizing the data into numerical categories. This shows that preservice and inservice teachers are likely to have certain misconceptions in the graphs concepts which might be transferred to their students.

Misconceptions and errors should be used in teachers' practice as they are the starting point for effective teaching (Williams et al., 2000). Since the students adhered to the misconceptions strictly, the misconceptions prevent their learning process. Removing misconceptions needs an identification of the misconceptions the students have and to make students discuss on these misconceptions instantly. Teachers should supply understandable experiences for their students by using activities, exercises, and examples (Hadjidemetriou & Williams, 2000). It is only possible to understand and reveal the students' misunderstandings or the nature of their misconceptions by asking the students to express their thinking (Wagner & Parker, 1993), therefore, teachers should understand their students' ways of thinking and they should use this knowledge to develop strategies that emphasize meaningful learning. Hence, the teachers should provide a discussion environment for the students to exchange and discuss their ideas (Hadjidemetriou & Williams, 2000).

CHAPTER III

METHOD

The focus of this chapter is the methodology used to conduct this study. This chapter will give information about the research design, the participants, data collection methods, procedures, and data analysis.

3.1. Research Design

The purpose of this study was to investigate 7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction. The study was conducted with one mathematics teacher and 71 7th-grade students in the spring semester of 2009-2010 academic year in Afyonkarahisar. The data gathering tools were achievement tests administered to the students before and after the instruction and interviews conducted with the teachers and the selected students based on the results of the pretest and posttest. Teacher's instruction was also observed.

In this study, students were not exposed to a special treatment, but rather the influence of regular mathematics instruction on a group of 7th-grade students from the four classes taught by the same teacher was investigated. Hence, the research design of the study could be considered as a one-group pretest-posttest design (Fraenkel & Wallen, 2006) without an actual experiment. The group could be considered as the 7th-grade students from four different sections of the same teacher. The study benefitted from both quantitative and qualitative methods. First, the quantitative data were collected through pretest and posttest and analyzed in both quantitative and qualitative ways. Then, qualitative data were obtained through the interviews conducted with the teacher and the selected students in order to clarify the quantitative findings.

3.2. Research Questions

The research questions were designed to examine 7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction. The research questions are given below:

1. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept before the regular mathematics instruction?

2. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept after the regular mathematics instruction?

3. What is teachers' awareness of 7th-grade students' typical errors and possible misconceptions in graphs concept?

In the study, the 1st research question in which typical errors and possible misconceptions that 7th-grade students have in graphs concept before the regular mathematics instruction was examined through the analysis of students' responses to the questions in the pretest. This research question was also examined according to the interview results conducted with the eight selected students on the basis of their responses to the pretest.

The 2nd research question in which the 7th-grade students' typical errors and possible misconceptions in graphs concept after the regular mathematics instruction was investigated through the analysis of students' responses to the questions in posttest, the interview results conducted with the eight selected students based on their responses to the posttest and the observation of the regular mathematics instruction in graphs concept in all the classrooms that the teacher taught.

The last research question was examined through the findings of the interview that was conducted with the teacher.

3.3. Participants

The study was conducted in an elementary school in Afyonkarahisar. Schools with at least ten year-experienced mathematics teachers were taken into consideration as the first criteria in selecting the schools. Having experience was important for the study because it was assumed that experienced teachers would know the students' typical errors and possible misconceptions and they would shape their instruction according to them. Hence, it was decided that studying with a teacher with more than ten years of experience would be more useful for the purpose of this study.

Among the elementary schools which had mathematics teachers with more than ten years of experience in Afyonkarahisar, an elementary school was determined to be the most suitable one according to the information the administrator provided that the student population in this school was heterogeneous in terms of achievement levels. It was assumed in this study that data gathered from students in different achievement levels would provide the study with a wider range of typical errors and possible misconceptions in graphs concept. In this school, there were two mathematics teachers and one of them who had eleven years of experience volunteered for the study. After the necessary permission from the Research Center for Applied Ethics at Middle East Technical University and Ministry of National Education (MONE) were taken, this mathematics teacher and among her 125 7th-grade students, 71 students who was administered to both pretest and posttest were became the participants of this study. They were in four different 7th-grade sections and the teacher claimed that each section had a heterogeneous group of students in terms of achievement levels in mathematics. The numbers of male and female students participated the study are given according to the four sections in Table 3.1.

Table 3.1. Numbers of Male and Female Participating Students in Sections

Sections	**Numbers of Male Students**	**Numbers of Female Students**	**Total**
7-A	10	8	18
7-B	15	9	24
7-C	11	9	20
7-D	5	4	9

The teacher had eleven years of experience and she had an experience of teaching mathematics to the seventh-grade students in the previous years. She had been working as a mathematics teacher in this elementary school for five years and she was also the mathematics teacher of the participating students of this study when they were in grade 6. The teacher was teaching all four sections of the 7th-grade students in the school. Typically, students have had an instruction on graphs concept

through the objectives in the MONE curriculum until the 7th-grade as given in Table 3.2.

Table 3.2. Objectives of Graphs Concept in Different Grade Levels in MONE Curriculum

Grade Level	Objectives
1st	• To read the tables.
2nd	• To gather data about a problem and construct an object graph. • To interpret an object graph.
3th	• To gather data about a problem. • To construct a picture graph. • To interpret a picture graph.
4th	• To construct a bar graph. • To interpret a bar graph.
5th	• To construct a line graph. • To interpret a line graph. • To describe the facility of using graphs.
6th	• To show and interpret the data by using suitable statistical representation forms. • To explain the situations that bar graphs might address incorrect interpretations.

3.4. Data Collection Methods

The data for this study were collected through two achievement tests (pretest and posttest) which were prepared based on same objectives and which were implemented to the 7th-grade students before and after the instruction, and interviews conducted with the mathematics teacher and eight students who were selected based on their responses to the questions in the pretest and posttest. The data collection methods, instruments, and procedures are explained below in detail.

3.4.1. Achievement Tests

The achievement tests were developed specifically for this study. First, the 7th-grade objectives in the elementary mathematics curriculum were examined. The five objectives given in the 7th-grade curriculum under the Table and Graphs topic are given in Table 3.3.

Table 3.3. The Objectives in the 7th-grade MONE Curriculum

The Objectives in the 7th-Grade MONE Curriculum
• To construct and interpret bar graphs and line graphs based on more than one criterion.
• To construct and interpret circle graphs.
• To develop ideas for the real life situations by constructing and interpreting statistical representation forms.
• To formulate predictions based on the data.
• To explain the situations that line graphs, pictographs, or object graphs might address incorrect interpretations.

Since each objective measured more than one behavior, the objectives were reorganized and the number of questions in the pretest and posttest was determined according to these new objectives. Table of specifications including the objectives and the number of questions in pretest and posttest are presented in the Table 3.4.

Table 3.4. Table of Specification for the Pretest and Posttest

Objectives		**Contents**			
		Line Graphs	**Bar Graphs**	**Circle Graphs**	**TOTAL**
Comprehension	To explain which statistical representation form can be used for given data.	Q-1	Q-1	Q-1	1
	To formulate predictions based on the data.	Q-4			1
	To explain the situations that line graphs, pictographs, or object graphs might address incorrect interpretations.	Q-6			1
Application	To construct a graph based on more than one criterion.		Q-2		1
	To construct circle graphs.			Q-3	1
	To interpret circle graphs.			Q-3	1
	To interpret bar graphs based on more than one criterion.	Q-4			1
	To interpret line graphs based on more than one criterion.		Q-5		1
	To interpret circle graphs.			Q-3	1

Table 3.4. (Continued)

Objectives		Contents			
		Line Graphs	**Bar Graphs**	**Circle Graphs**	**Total**
Analysis	To develop ideas for the real life situations by constructing and interpreting statistical representation forms.		Q-5		1

The 2nd questions in both tests were prepared according to the objective "to construct a graph based on more than one criterion." In these questions, the general term "graph" was used without stating a specific type of graph such as "bar graph" or "line plot" so that the students could answer the questions by using a graph type that they chose correctly. One more question, the 1st question, was added in order to investigate whether students had any knowledge about the type of the graphs before the instruction based on their previous mathematics courses or their daily lives. As a result, to establish the students' typical errors and possible misconceptions about graphs, the pretest and posttest were prepared with six open-ended questions. Each question in the pretest had a similar question in the posttest which was developed according to the same objective. One form was administered as a pretest before the instruction and the other was implemented as a posttest after the instruction. Students were given 45 minutes for both tests to complete. While the purpose of pretest was to determine students' prior knowledge, typical errors and possible misconceptions about the graphs before the regular mathematics instruction, the aim of posttest was to establish their typical errors and possible misconceptions after the regular mathematics instruction. The first forms of pretest and posttest are presented in Appendix C.

3.4.1.1. Pilot Study

The pilot study for the pretest was conducted in another elementary school in Afyonkarahisar. The school was selected by taking into consideration that it should have the teacher with similar characteristics, such as experience in teaching, and the students with similar characteristics, such as achievement level, when compared with the actual study school. Therefore, a mathematics teacher with ten years of experience and a group of 55 7th-grade students from two sections in this school

were the participants of the pilot study. The school administrator claimed that the students in these sections represented a heterogeneous group in terms of their achievement levels in mathematics. The teacher was teaching both sections of 7th-grade students in this school. Only the pretest was administered to the students in 40 minutes time period due to the time that the school administrators allowed for the pilot study. In the pretest, there were 7 open-ended questions with sub-questions. The objectives and the corresponding questions in the pilot pretest were the same as in Table 3.4, with the exception that questions 2 and 3 were referring to the same objective "to construct a graph based on more than one criterion." The piloted form of pretest is given in Appendix D.

After the implementation of pretest, some adjustments were made in the pretest and consequently in the posttest. First, it was observed that the students could not answer all the questions in the pretest in a given time period. Therefore, one of the two questions in which the objective "to construct a graph based on more than one criterion" was investigated was removed in the pretest and so in the posttest. One of the break times was added to the implementation time and period of conducting each test was extended to 45 minutes from 40 minutes. The last forms of pretest and posttest are given in Appendices E and G respectively.

In the 4th question in pretest, students were given a table including the students' numbers in a classroom and numbers of these students' sisters or brothers. Then, students were asked "draw a circle graph by using the data given in the table." Students tried to draw circle graphs which included both numbers of the students and numbers of their sisters or brothers. Hence, the question was changed as "draw a circle graph which shows numbers of the students by using the data given in the table." In the 5th question, it was asked "In which years is more than half of the woman population literate?" The students gave exact years as an answer to this question although the correct answer was a year range of 1965-1970. Therefore, the question was changed as "In which years or between the years is more than half of the woman population literate?" In the 6th question in which the students had to use the bar graph to reach the answer, it was seen that the students had difficulty in reading the values belonging to each bar, therefore, the values for each bars were represented by using broken lines. Finally, the 6th question had a sub-question as "In four countries, the total number of woman who drives a car is ……" In this

question, the students filled in the blank with the words addressing less or more rather than certain numbers. Hence, the instruction "give an answer with numbers" was added at the end of the question.

3.4.1.2. Validity and Reliability

Validity is the "appropriateness, correctness, meaningfulness and usefulness of the inferences" (Fraenkel & Wallen, 2006, p. 151) claimed based on the results of the study. In the study, to check the content validity of achievement tests, the table of specification was prepared based on the objectives in the elementary mathematics curriculum and the questions were developed based on the table. A mathematics education researcher and the mathematics teacher who had been teaching middle grades mathematics for three years in the school in which the pilot study was conducted were consulted for the appropriateness of the table of specification and the pilot pretest, the actual pretest, and posttest in terms of the content, language, and comprehensiveness. The tests were edited according to their opinions and judgments about their adequacy.

Reliability is the consistency of the results in a different time, location, and situation. In the reliability analysis of pilot study, Kuder-Richardson approaches was applied for the pilot pretest. Since the items in these tests had dichotomous responses, KR21 formula was used as all items in pretest was assumed to have equal difficulty in order to decide whether the test was reliable or not (Fraenkel & Wallen, 2006). The reliability estimate for scores on the pilot pretest was calculated as .70 indicating that the test could be used with a certain degree of confidence. While the minimum and maximum students' scores in pretest were 2 and 23 respectively, 2 and 30 were the minimum and maximum students' scores in posttest.

3.4.2. Observations

The teacher's instruction in participating students' classrooms in graphs concept was observed in this study in order to investigate the 7th-grade students' typical errors and possible misconceptions in graphs concept. The observations started after the implementation of the pretest and continued for two weeks during the graphs topic. During the observation process, the researcher did not participate in the lessons being observed and stayed as a non-participant observer. She focused on

the teacher's explanations of the concepts, questions, exercises, and problems solved in the class, homework assigned, and students' responses in the classroom to teachers' instruction and took detailed notes.

In the observation process, what teacher does in a lesson in a typical class hour was observed. For instance, she taught line graphs to 7th-grade students in section A. The classroom belonged to this section was comfortable learning environment for the students. Students were sitting in pairs most of the time and teacher's desk was located next to the board. There was no computer in the classroom and use of overhead projectors was not observed. Since instruction was given to the different grade levels in the mornings and in the afternoons in this school, this classroom was used by two different grade levels. The classroom in which the observation was conducted was used by 7th-grade students in the afternoons and by the lower grades in the mornings. The clipboard in this classroom was generally used by early grades to present their illustrations and there was not any example of graphs on the clipboard.

In the instruction process, the mathematics teacher firstly called the roll to understand which students came to school and which of them did not come. Then, she followed the curriculum and she taught line graphs as the first sequence of line, bar, and circle graphs under the topic "Statistics and Graphs" in this section. She first asked questions to the students about where they saw line and bar graphs in their daily lives and she wanted them to give examples. One student commented that he saw line graphs in stock market. Another student expressed as the following:

> *"I saw line graphs in hospitals. Iımmm…. In the elections. On the television, the bar graphs were given in the elections. I saw the people and the numbers of their votes."*

In order to give more examples about the use of line and bar graphs in daily life, the teacher explained that line graphs were used in general in organizing weather information, newspapers, and economics, and bar graphs were used in distribution of population in different years. Then, she asked questions about the difference between the constructing of line and bar graphs to the students. One student response was as follows:

"We draw line graphs by using lines… Iımmm… In bar graphs, bars are used."

She reminded students the differences between two types of graphs by saying while line graphs were graphs drawn by joining of points determined according to the data, showing data or information on graphs by using bars were called bar graphs. After that, she began with stating what the statistics and the graphs were as the first part of the Statistics and Graphs topic. Then, she emphasized the purpose of using line graphs and she told that line graphs were used for tracking changes over short and long periods of time. She asked the below question given in Figure 3.1 to the students and she wanted them to draw a line graph.

Question:

Table: Numbers of visitors

Days	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Numbers of visitors	3	4	5	5	4	9	11

Draw a line graph by using the data given in the table above.

Figure 3.1. The Question Asked to Draw a Line Graph

She selected one student to draw the line graph on the board so that all students could see clearly. She emphasized that the title was very important to interpret a graph and she wanted students not to forget writing the title and names of both axes and when needed, she directed him while drawing the graph on the board by asking questions about the constructing of line graphs when he needed such as what the name of axis on which you plot the numbers of visitors must be, whether the arrows should be put at the end of the axes or not. She emphasized that the title was very important to interpret a graph and she wanted students not to forget writing the title and names of both axes. One of the students plotted the values of the variable in the exact same order on the line graph as given in the table. As a result, the teacher warned her by saying that values must be plotted in numerical order in equal intervals. The teacher did not control how the other students were drawing their

graphs as she only focused on the student's drawing on the board. Also, she did not show any example of a line graph including more than one criterion in all sections although the objective given in the curriculum was "to construct and interpret bar graphs and line graphs based on more than one criterion." She did not use any materials while teaching line graphs.

3.4.3. Interviews

3.4.3.1. Student Interviews

Students would have misconceptions although they could answer the questions in the achievement tests correctly. Therefore, there is a need to examine their thinking process deeply in order to understand their misconceptions (Çakır, 2005) often through asking them to explain their responses. In this study, students' responses for each question in the pretest and posttest were compared and examined in depth. Then, eight students who seemed to have tendency to have typical errors and possible misconceptions were selected for the interviews in four sections. The teacher was not asked or informed about the selected students in order to prevent any possible bias. Students were not informed about the other students who participated in the interviews. The students and their incorrect responses are given in the Table 3.5.

Table 3.5. The Students and Their Incorrect Responses

Students	Incorrect Responses
A	• Data given in percentage are only used in circle graphs.
B	• Draw a bar graph with a vertical axis representing categorical variable and a horizontal axis representing a quantitative variable identify the value, zero up to the horizontal axis.
C	• Draw a line graph with a categorical vertical axis and quantitative horizontal axis.
D	• Draw circle graphs to show the data in two criteria.
E	• The value on the horizontal axis is zero although the graphs started from a number different from zero.
F	• Write "line graph" or "bar graph" as the title of the graph.
G	• Ratios not given in percentage cannot be shown in circle graphs.
H	• Only bar graphs are used to show the data in two criteria.

One-to-one interviews were conducted with the students and each interview was conducted in 30 minutes time period in an empty classroom in the school. At the beginning of each interview, the student was informed about the purpose of the interview and they were informed that they could leave the interview at any time they would want to. They were told that it was one of the phases of the study and they were wanted to explain their answers that they gave in the tests deeply. It was emphasized that their teacher was not informed about their identity and the interview responses would not affect their mathematics grade. Then, the questions which they could not respond correctly on each of pretest and posttest in a written way were asked in order to understand the reasoning behind. Detailed notes were taken during the interviews and students' responses were not audio-recorded. One example of interview protocol used in the student interview is given in Appendix I.

3.4.3.2. Teacher Interview

The interview was conducted with the teacher in an empty classroom in the school after the posttests were administered and it took 50 minutes. She was informed about this phase of the study, that the main interest was on her ideas, and the interview data would only be accessed by the researchers. For the interview, a teacher interview protocol was developed based on the students' answers in both pretest and posttest. The interview protocol had six questions aiming to investigate teacher's understanding of students' misconceptions and errors. Specifically, the knowledge of the teacher about the difference between "misconception" and "error" was investigated in one question and the remaining five questions including some of selected students' incorrect responses in both pretest and posttest were about whether selected student answers were misconception or error. Detailed notes of teacher's responses were taken during the interview. The interview protocol prepared for teacher interview is given in Appendix K.

3.5. Procedures

In the spring semester of the academic year 2009-2010, after searching the elementary schools in Afyonkarahisar with mathematics teachers of at least ten years of experience, an elementary school was visited by the researcher, and the administrator of the school and the mathematics teacher was informed about the

purpose and the nature of the study. They were informed that the research study was about a master thesis and 7th-grade students would be studied, achievement tests would be administered to the students before and after the mathematics instruction on graphs, and interviews would be conducted with the mathematics teacher and the students selected based on the pretest and posttest. Then, information about the students' achievement levels was gathered and as a result of the visiting of school and getting information about the school, students and the teacher, it was decided that the school was suitable to conduct the research, and the teacher volunteered for the study and the administrators volunteered to support the researcher.

The data collection procedure started after the necessary permissions were obtained from the Ministry of National Education (MONE) and Research Center for Applied Ethics at Middle East Technical University. The school administrator was also provided with one copy of the Ministry permission.

In the implementation process of pretest, the students in four 7th-grade sections were informed about purpose of the study and the value and importance of their contribution to the study to ensure the confidentiality of their responses. It was said that the study was about the master thesis and they would not be assigned any grades. Then, the pretest was implemented in all four sections by the researcher.

The instruction process of the teacher in each class was observed in the two week period in which the graphs topic was taught. A total of 9 class hours were observed in each section. The observations started after the pretest was implemented. Although the researcher intended to start observations before the graphs concept in order to establish a rapport with the teacher and the students, and get used to the classroom environment, she was not allowed by the school administrators. Therefore, the observations started when the graphs concept started. The teacher made declaration about the researcher that she was a graduate student and she was preparing a master thesis about the graphs concept. Therefore, she would observe the lessons while graphs topic was being taught in each section with an average numbers of 30 students by sitting on a desk at the back of the classroom alone for two weeks.

The posttest could not be administered to the students at the end of the graphs topic due to the very limited student population in all four 7th-grade sections because of the National Level Examination (SBS). Therefore, the posttest was administered to the students in the last weeks of the second semester after the instruction on the

graphs concept was completed. The posttest was implemented in all four sections by the researcher.

The results of both pretest and posttest were examined in depth and compared. As a result of this analysis, eight students in different sections were selected for the interviews. However, due to the National Level Examination (SBS), these students were not at school after the posttests and one-to-one interviews could not be conducted until the last day of the spring semester. In the last day of the semester, the interviews were conducted with these students in order to gather detailed information about their thinking in their answers for the pretest and posttest questions. The students were informed about the value and importance of their contribution to the study in the beginning of interviews and that their identity would not be given to the teacher, other students, and the administrators. Finally, an interview was conducted by the teacher in the last day of the semester and she was asked to explain whether the students' answers were due to possible misconceptions or typical errors.

7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction were sought through data collection procedure described below. The data collection procedure and the implementation times are given in Table 3.6.

Table 3.6. Data Collection Procedure with the Implementation Times

Data Collection Procedure	Implementation Time
Pretest	May, 2010
Observation of the instruction	May, June, 2010
Posttest	June, 2010
Interview with the selected students	June, 2010
Interview with the teacher	June, 2010

3.6. Data Analysis

In this study, the data were analyzed according to the research questions which were designed to examine 7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction. The specific research questions addressed in this study were:

1. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept before the regular mathematics instruction?

2. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept after the regular mathematics instruction?

3. What is teachers' awareness of 7th-grade students' typical errors and possible misconceptions in graphs concept?

The 1st research question was sought through the analysis of the pretest responses and the interviews conducted with the selected students. The typical errors and possible misconceptions the students had in graphs concept before the regular mathematics instruction were identified by the analysis of pretest results which focused on students' incorrect responses in each question. The results of the interviews conducted with the students were also analyzed in order to support the pretest results. Interviews with the selected students specifically focused on their responses in the pretest and the rationale behind those responses. Students' interview data were analyzed through the questions in the pretest. The rubric of pretest is given in Appendix F.

The 2nd research question was examined through the analysis of the posttest responses, the classroom observations, and the interviews conducted with the selected students. Students' typical errors and possible misconceptions in graphs concept after the regular mathematics instruction were detected through the analysis of students' incorrect responses in each question in posttest. The observation notes of teacher's instruction and the interviews with the students were analyzed to support posttest results. Description of participating teacher's instruction was provided in detail in order to provide a clear picture of the regular mathematics instruction took place during the graphs concept. The analysis of these notes focused on the questions asked in the classroom by the teacher and the students, responses given for these questions, and teacher's explanations and the examples during the teaching of the topic. Differences in teaching in sections were also emphasized. Interviews with the selected students specifically focused on their responses in the posttest and the rationale behind those responses. Students' interview data were analyzed through the questions in the posttest. The rubric of posttest is given in Appendix H.

The interview conducted with the teacher was analyzed in detail in order to understand teacher's conception of misconception and error in order to respond to

the 3rd research question. Her responses were analyzed based on the students' typical errors and possible misconceptions that she was presented. The research questions and the data gathering instruments are given in Table 3.7.

Table 3.7. The Research Questions and Data Gathering Instruments

Research Questions	Data Gathering Instruments
1. What are typical errors and possible misconceptions that 7th-grade students have in graphs concept before the regular mathematics instruction?	• Pretest • Interviews with selected students
2. What are typical errors and possible misconceptions that 7th-grade students have in graphs concept after the regular mathematics instruction?	• Posttest • Observation of instruction • Interviews with selected students
3. What is teachers' awareness of 7th-grade students' typical errors and possible misconceptions in graphs concept?	• Interview with the teacher

3.6.1. Validity Threats

Fraenkel and Wallen (2006) states nine threats to internal validity in weak experimental designs such as one-group pretest-posttest design. They are history, maturation, instrument decay, data collector characteristics, data collector bias, testing, statistical regression, attitude of subjects, and implementation. Although the study did not fully represent an experimental design, the validity threats seemed necessary to address.

In educational studies, there might be events which are not expected or structured throughout the study. The events that can affect the responses of the participants directly are known as history threats (Fraenkel & Wallen, 2006). Although, in the beginning of the study, the time period between the application of pretest and posttest was determined as two weeks by with the approval of the mathematics teacher, the posttest could not be administered to the students at the end of the graphs topic since there was a limited student population in four sections due to the National Level Examination (SBS). Also, while studying SBS, the students could study the graphs topic and this would directly affect their performances in posttest. Hence, there was a history threat in the study that students might have

performed differently if the posttest was administered right after the instruction on the graphs concept was completed.

It is stated by Fraenkel and Wallen (2006) that the data might be variated by data gatherer and scorer in an unconscious way in order to reach the desired results and this is referred as the data collector bias. In this study, the researcher did not direct the students toward a certain response during the implementation of pretest and posttest. She prepared detailed score keys in order to investigate students' responses in the pretest and the posttest. The researcher observed the instruction of the teacher without intervening her teaching or directing her through certain issues. In addition, the interviews were conducted with the teacher and the selected eight students by the researcher according to the interview protocols. The researcher did not direct the teacher or the students towards the answers that she would like to hear. Instead, she emphasized that her interest was on the participants' actual responses. Although all the data collection was conducted by the researcher, she remained unbiased and non-directive during the data collection.

According to Fraenkel and Wallen (2006), in intervention studies in which the pretest is used before the intervention, the improvement in posttest might be the result of the intervention or usage of the pretest and this is referred as testing threat. In the study, the time period between the applications of equivalent form achievement tests was long enough and this eliminated the testing threat in the study.

When the subjects in a study are changed according to their low or high performances in pretest administered before the intervention, this will result a regression threat (Fraenkel & Wallen, 2006). In the study, the school administrators provided the information that the students were heterogeneous in their achievement levels, including low, mid, and high achievers. Therefore, the regression threat was eliminated to a high degree.

Fraenkel and Wallen (2006) state that the attitudes and the participations of subjects in a study can threaten the study which is referred as attitude of subjects threat. In the beginning of the study, the participants including the teacher and the 71 7th-grade students were informed about the purpose of the study by the researcher and the students were told that the study was about the master thesis and no grades would be assigned to them. The participants were told that they were helping a

graduate student in her study. In general, no negative attitude of participants during the test implementation, the interviews, and the observation were detected.

If the treatment or method is not administered by the researcher in an experimental group, the experimental group might behave reluctantly and this is known as implementation threat (Fraenkel & Wallen, 2006). In the study, the students were not exposed to a special treatment, but rather the influence of regular mathematics instruction on their typical errors and possible misconceptions in the graphs concept was investigated. The teacher was informed that she was not expected to conduct a certain instruction, rather she was encouraged to conduct her regular instruction since the focus was on the effects of regular mathematics instruction. Hence, the students were taught by their mathematics teacher in a regular way, eliminating the implementation threat.

CHAPTER IV

RESULTS

In this chapter, the results of data analysis are presented in detail according to the three research questions. The findings of interview conducted with the selected students and the observation notes of teacher's instruction are also given in depth, and then, all results are summarized. The questions that were sought in this study are given below:

1. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept before the regular mathematics instruction?

2. What are the typical errors and possible misconceptions that 7th-grade students have in graphs concept after the regular mathematics instruction?

3. What is teachers' awareness of 7th-grade students' typical errors and possible misconceptions in graphs concept?

4.1. Analysis of Pretest and Posttest Results

4.1.1. Reliability Analysis of Achievement Tests

In the reliability analysis of pretest, Kuder-Richardson approaches were applied as the test included dichotomous items. Since all items in pretest were assumed to have equal difficulty, KR21 formula was used to decide whether the test was reliable or not. The reliability estimate for scores on the pretest was found as .75. Similarly, the reliability estimate for scores on posttest was found as .77. Hence, since each reliability coefficient of pretest and posttest was greater than 0.70, these tests could be used with a certain degree of confidence. There was a statistically significant increase in scores from pretest (M=11.97, SD=4.98) to posttest (M=15.04, SD=5.93, p<.0005).

4.2. 7th-Grade Students' Typical Errors and Possible Misconceptions in Graphs Concept before the Regular Mathematics Instruction

7th-grade students' typical errors and possible misconceptions in graphs concept before the regular mathematics instruction were investigated through the analysis of pretest results of the students. Though the pretest was administered to 125 7th-grade students, the posttest could be administered only 71 students because of the lack of students who were preparing for the National Level Examination (SBS) out of school. Hence, 71 7th-grade students were the participants of this study. The pretest in the study was administered to the students before the instruction and it included six open-ended questions which were prepared according to the reorganized 7th-grade objectives in the elementary mathematics curriculum. One more objective to investigate whether students had any knowledge about the types of the graphs before the instruction on the basis of their previous mathematics courses or their daily lives was also included.

Each objective in the questions in the pretest was based on students' typical errors and possible misconceptions in different graphs sub-concepts. The results of the analysis of each question are given under six topics referred to the different sub-concepts of students' typical errors and possible misconceptions. Numbers of the questions in pretest and the related topics are given in Table 4.1.

Table 4.1. Numbers of Questions in Pretest and the Related Sub-concepts

Questions	Topics
1st	• Use of Line, Bar and Circle Graphs
2nd	• Constructing Line and Bar Graphs
3rd	• Constructing and Interpreting Circle Graphs
4th	• Reading and Interpreting Line Graphs
5th	• Reading and Interpreting Bar Graphs
6th	• Explaining the Situations Line Graphs Represent

4.2.1. Use of Line, Bar and Circle Graphs

The objective "to explain which statistical representation form can be used for given data" was evaluated in the 1st question in pretest. The 1st question is given in Figure 4.1 below:

Question 1:

Table: The forest ratios of regions

Regions	**The forest ratios (%)**
Akdeniz	24
Doğu Anadolu	11
Ege	17
Güneydoğu Anadolu	3
İç Anadolu	7
Karadeniz	25
Marmara	13

The forest ratios of regions in Turkey are given in the table above. Accordingly,

a) Is it suitable to show the data given in the table by using a line graph? Explain your answer.

b) Is it suitable to show the data given in the table by using a bar graph? Explain your answer.

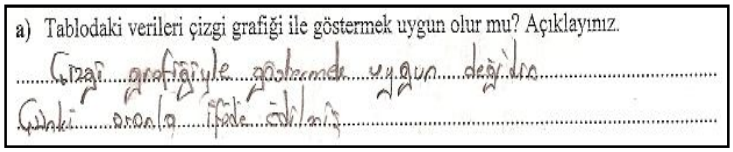
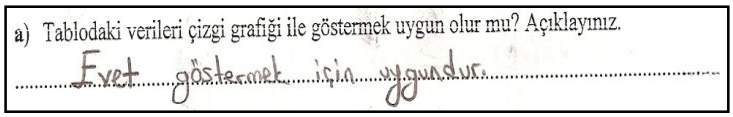
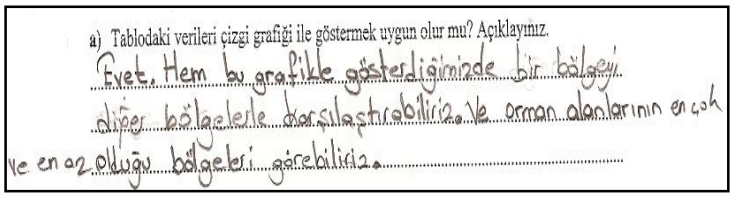
c) Is it suitable to show the data given in the table by using a circle graph? Explain your answer.

Figure 4.1. The 1st Question in Pretest

The 1st question included three parts in which the students were expected to give a short answer "yes" or "no" and to explain their answer in detail. Hence, the possible combinations of correct and incorrect responses for three parts and students' explanation were analyzed and the frequency of these combinations was calculated.

The analysis of the 1st question focused on only three situations in each part in which students' typical errors and possible misconceptions could be determined clearly: (i) correct answer with incorrect explanation, (ii) incorrect answer with explanation, and (iii) incorrect answer without any explanation. The frequency of correct and incorrect responses and examples of each response for part (a) in the 1st question is given in Table 4.2.

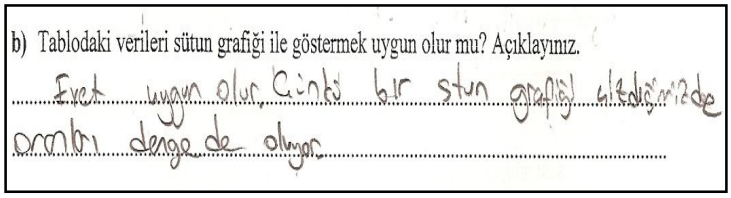
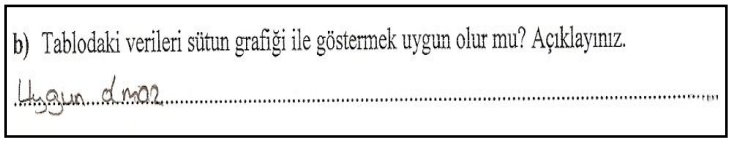
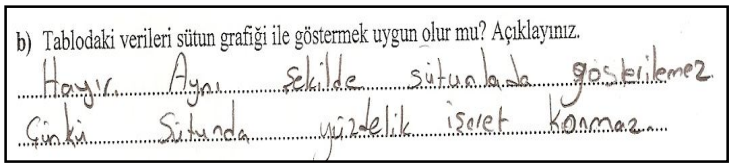
Table 4.2. The Frequency of Correct and Incorrect Responses with Examples for Part (a) in the 1st Question

	Response Type	Frequency of students for each response (f)
Part a (Line Graphs)	Correct answer with incorrect explanation.  	**10**
	Incorrect answer without any explanation.  	**11**
	Incorrect answer with explanation.  	**36**

In part (a), the most common students' answers in the situations (i) and (ii) showed that the students explained the purpose of line graphs by using the property of bar and circle graphs. While the students explained that line graphs were not suitable to use for the given data because of including percentage ratios of data, they said that line graphs were suitable to show the given data to compare regions and to see the regions in which the forest ratios were the least and the greatest. This response might be because of possible misconceptions that the line graphs were used to compare things between different groups and they were the most suitable type of graphs for showing percentage ratios. The students also gave the answer "yes" without any explanation. They might have a general opinion that all types of graphs could be used for any given data so that the data could be seen clearly.

Table 4.3 below presents the frequency of students' correct and incorrect responses and examples of each response for part (b) of question 1.

Table 4.3. The Frequency of Correct and Incorrect Responses with Examples for Part (b) in the 1st Question

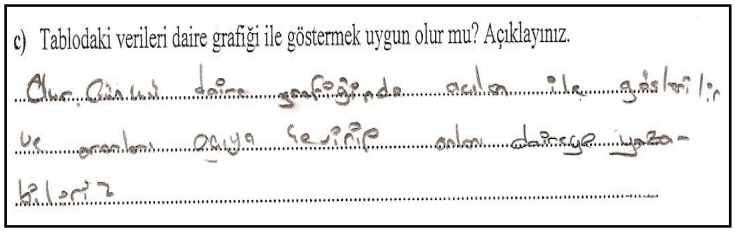
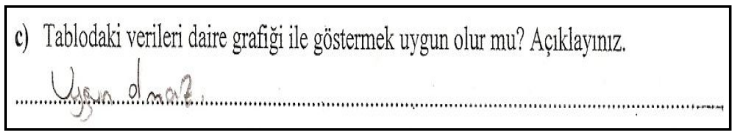
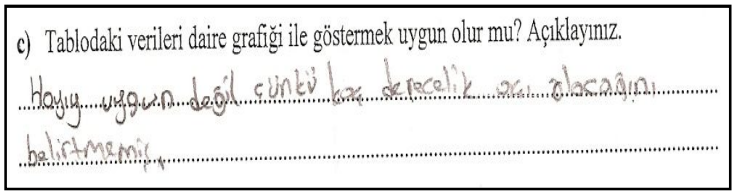
	Response Type	Frequency of students for each response (f)
Part b (Bar Graphs)	Correct answer with incorrect explanation.  	**24**
	Incorrect answer without any explanation.  	**4**
	Incorrect answer with explanation.  	**8**

In part (b), the students' "correct answers with incorrect explanations" showed that they had incorrect knowledge about the purpose of using bar graphs. One example of students' answers was that bar graphs were suitable to show the data given in the table since the forest ratios of regions were balanced. Moreover, their "incorrect answers with explanation" showed that bar graphs were not suitable for showing given data because the forest ratios were given in percentage and the circle graphs were needed to show such kind of data. It seemed that the students answered the question in these ways due to the possible misconception of the data given in percentage were only used in circle graphs. The students, on the other hand, gave the

answer "no" as an incorrect answer without any explanation which was likely because of not having any idea about the use of bar graphs.

Table 4.4 below presents the frequency of students' correct and incorrect responses and examples of each response for part (c) of question 1.

Table 4.4. The Frequency of Correct and Incorrect Responses with Examples for Part (c) in the 1st Question

	Response Type	**Frequency of students for each response (f)**
Part c (Circle Graphs)	Correct answer with incorrect explanation.  	**14**
	Incorrect answer without any explanation.  	**8**
	Incorrect answer with explanation.  	**14**

In part (c), an interesting "correct answer with incorrect explanation" was that the circle graphs were suitable to represent the data given in the table, but the transformation of percentages into degrees was needed. Similarly, the most common incorrect answer with explanation was that the circle graphs were not suitable to show the given data since the degrees of the forest ratios were not given.

In the study, the interview was conducted for selected eight students to examine their thinking process deeply in order to understand their incorrect

responses by asking them to explain their responses. For the 1st question in the pretest, Student A expressed his answer "circle graphs" as the following:

> "*Iuummm…Forest ratios of regions were given in percentage…So here, line and bar graphs cannot be used. Circle graphs can be used."*

Hence, although in the interviews the students were expected to explain their reasons of their responses in pretest, some of them could not explain their responses and they only repeated their responses in pretest.

It seemed that the students answered the question in these ways due to the possible misconceptions that ratios were not represented in circle graphs and only degrees could be used in circle graphs. In addition, students who wrote "no" without any explanation were likely to lack the knowledge about the property of circle graphs.

In the study, before the observation process, while the students had knowledge about the two types of graphs, line and bar graphs, they did not have any knowledge about the circle graphs. Hence, that the students gave responses in the pretest in these ways due to their prior knowledge.

4.2.2. Constructing Line and Bar Graphs

The objective "to construct a graph based on more than one criterion" was evaluated in the 2nd question in pretest. The 2nd question is given in Figure 4.2 below:

Question 2:

Table: Numbers of girls and boys in 7th-grade sections

	Number of girls	**Number of boys**
7-A	10	15
7-B	14	12
7-C	12	13
7-D	11	14

Numbers of girls and boys in 7th-grade sections in a school are given in the table above. Draw a graph by using the data given.

Figure 4.2. The 2nd Question in Pretest

In the 2nd question, the students were expected to choose the most suitable type of graph for data given in the table and draw it accurately. Students' responses were analyzed under the possible combinations of correct and incorrect responses for the topics, type of graph, headings, axes, vertical axis, and horizontal axis to investigate the students' typical errors and possible misconceptions and the frequency of each response was calculated.

In the analysis process of 2nd question, only the most common incorrect response types were examined to determine typical errors and possible misconceptions the students had.

The frequency of students' incorrect responses and examples of each response for the topic "type of graph" in the 2nd question was given in Table 4.5.

Table 4.5. The Frequency of Students' Incorrect Responses with Examples for Type of Graph in the 2nd Question

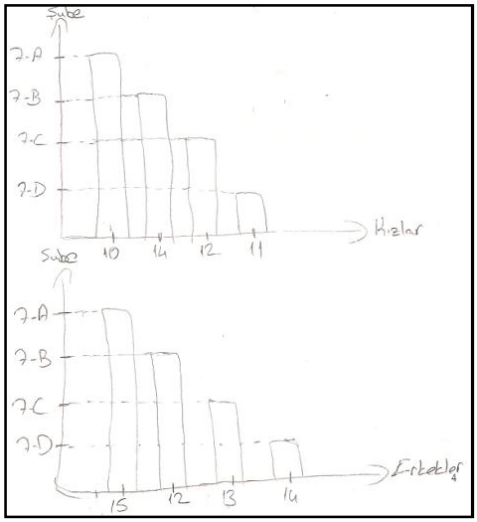
Response Type		**Frequency of students for each response (f)**
Type of Graph	Draw more than one bar graph.  	**6**

Table 4.5. (Continued)

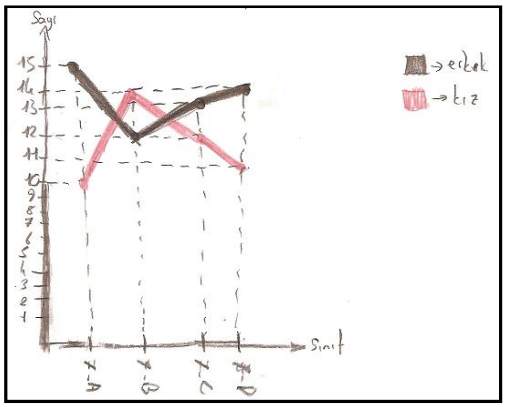
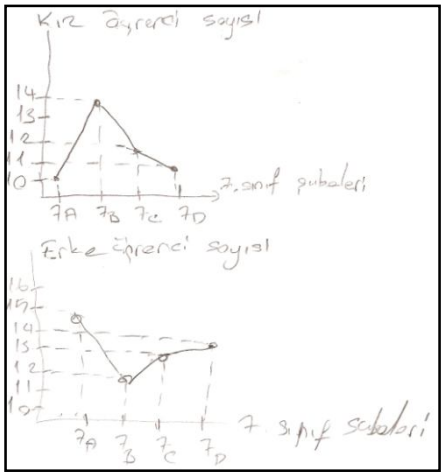
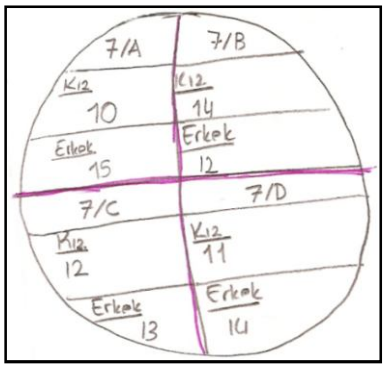
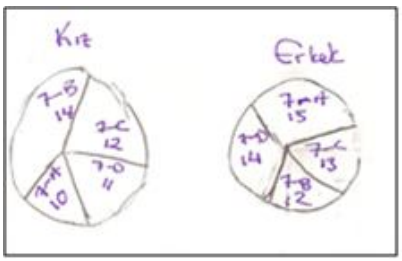
	Response Type	Frequency of students for each response (f)
Type of Graph	Draw a line graph. 	**15**
	Draw more than one line graph. 	**4**
	Draw a circle graph. 	**1**

Table 4.5. (Continued)

Response Type		Frequency of students for each response (f)
Type of Graph	Draw more than one circle graph. 	**2**

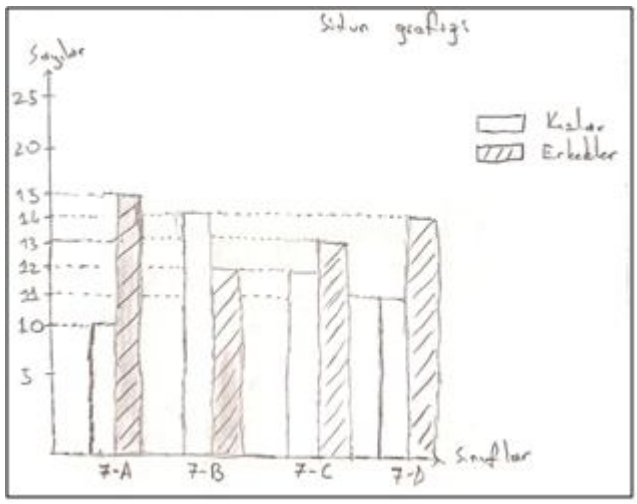
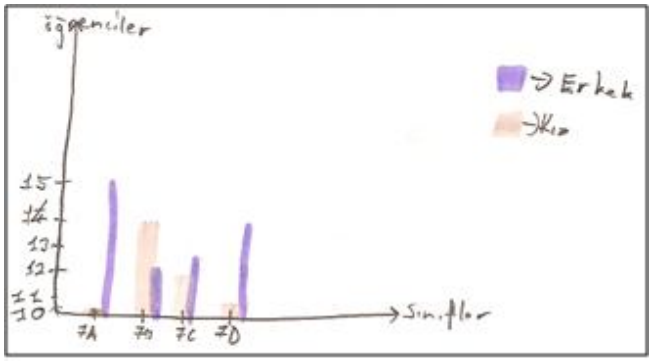
Under the topic, type of graph, the results of 2nd question in pretest showed that while there were students who drew two bar graphs, drawing a line graph was another choice of students. Also, the students drew one circle graph or two circle graphs to show the data given in the table.

Before the observation process, the students had knowledge about the two types of graphs, line and bar graphs. They learnt to draw line and bar graphs to show the data including one criterion in previous years. However, they did not have any knowledge about the circle graphs. They will learn to draw bar and line graphs to show the data including more than one criteria and draw circle graphs in the 7th-grade. Hence, that the students chose to draw line, bar and circle graphs for given data based on one criterion and two criteria in pretest due to the typical errors made as a result of carelessness, having the lack of knowledge, or having misconceptions.

The results also showed that the responses of students who drew one bar graph or two bar graphs were different in their choice of using axes of the graphs. Most of the students who chose to draw a bar graph to show the given data used vertical axis for showing four sections and used horizontal axis for showing numbers of boys and girls in these sections. However, among these students some students drew vertical bars instead of horizontal bars with the possible misconception that bars in bar graphs would always be drawn vertically and this might be the result of their prior knowledge.

Table 4.6 below presents the frequency of students' incorrect responses and examples of each response for the topic "headings" of question 2.

Table 4.6. The Frequency of Students' Incorrect Responses with Examples for Headings in the 2nd Question

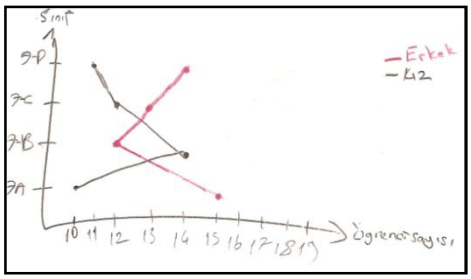
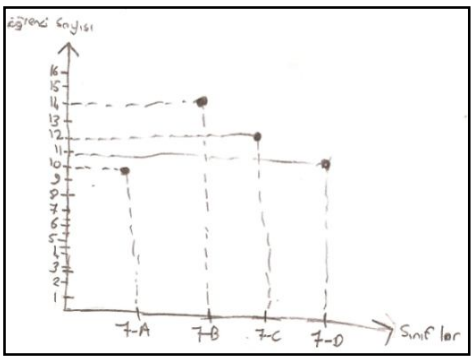
	Response Type	Frequency of students for each response (f)
Headings	Write an incorrect title for the graph.  	**1**
	Write no title for the graph.	**59**
	Write an incorrect name for horizontal axis.	**0**
	Write no name for horizontal axis.	**36**
	Write an incorrect name for vertical axis.  	**2**
	Write no name for vertical axis of the graph.	**41**

Under the topic, headings, an interesting incorrect response was that writing "bar graph" as the title of the graph. In the interview, Student B was asked why she wrote "bar graph" as the title for the graph and she explained that "*I drew a bar graph, so the title must be 'bar graph'.*" Hence, these students seemed to have possible misconception that the title of a graph was the type of it, which might be due to their prior knowledge.

The analysis of pretest results also showed that the students generally could not write the title or names of vertical axis or horizontal axis. In addition, the students' responses showed that they wrote incorrect name for the vertical axis such as "students" instead of "numbers of students." Hence, that the students wrote incorrect responses for the name of vertical axis or they did not write any title or names for axes might be due to the typical errors made as a result of carelessness, having the lack of knowledge, or having misconceptions.

Table 4.7 below presents the frequency of students' incorrect responses and examples of each response for the topic "axes" of question 2.

Table 4.7. The Frequency of Students' Incorrect Responses with Examples for Axes in the 2nd Question

	Response Type	**Frequency of students for each response (f)**
Axes	In line graphs, use vertical axis for showing four sections and use horizontal axis for showing numbers of boys and girls in these sections. 	**3**
	In line graphs, the points plotted on graph are not joined with straight lines. 	**7**

Under the topic, axes, the students' responses showed that there were students who chose a line graph for showing the data given in the table. They used vertical axis for showing four sections and used horizontal axis for showing numbers of boys and girls in these sections. In the interview, Student C was asked questions about his responses such as why he chose a line graph to draw and why he drew a line graph with a vertical axis representing categorical variable and a horizontal axis representing quantitative variable. He expressed the following:

> *"I chose a line graph because I wanted to make something different. Iummm… I saw bar graphs like that and I thought that I could draw a line graph in this way."*

It seemed that the students drew line graphs in this way due to the possible misconception that like bar graphs, a line graph could be drawn by using a vertical axis representing values of a categorical variable and a horizontal axis representing values of a quantitative variable, which might be because of their prior knowledge.

The analysis of students' responses also showed that the students drew line graphs not by joining the points they determined on the graph according to the given data with straight lines. It seemed that the students drew line graphs in this way because of the possible misconception that line graphs did not show continuous situations, which might be due to their prior knowledge.

Table 4.8 below presents the frequency of students' incorrect responses and examples of each response for the topics "vertical axis" and "horizontal axis" of question 2.

Table 4.8. The Frequency of Students' Incorrect Responses with Examples for Vertical and Horizontal Axes in the 2nd Question

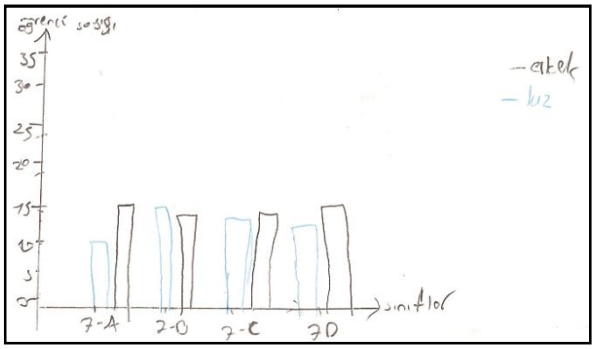
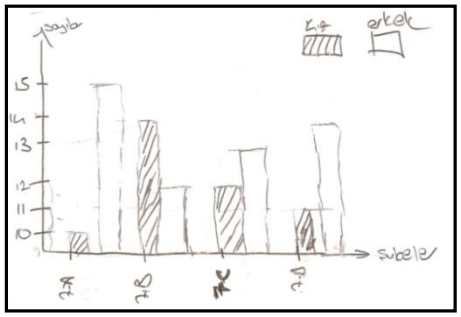
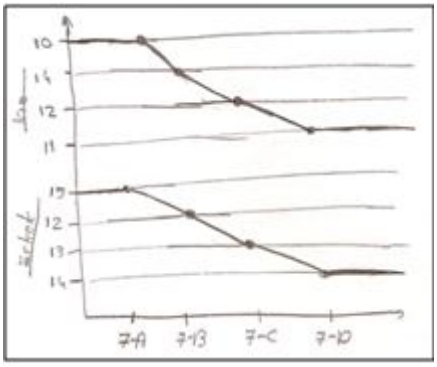
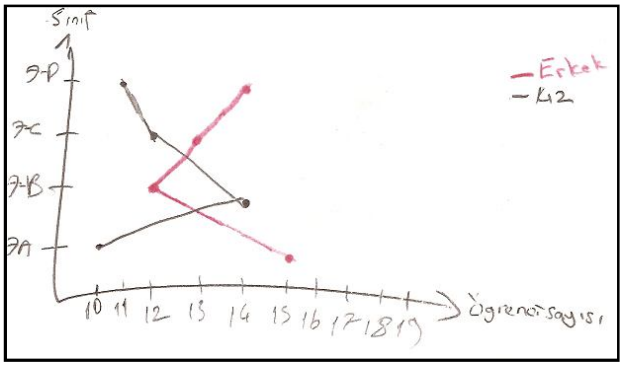
	Response Type	Frequency of students for each response (f)
Vertical Axis	Put zero above vertical axis. 	**2**
	In line or bar graphs, plot the values of the variable in vertical axis in numerical order with appropriate intervals and no space between identical values by not taking into consideration to the distance between the starting point, zero and the first value in the order. 	**23**
	In line or bar graphs, plot the individual values of the variable in vertical axis, often in the exact same order as given in the table. 	**8**

Table 4.8. (Continued)

Response Type		Frequency of students for each response (f)
Horizontal Axis	Identify zero to the right of intersection point of both axes on horizontal axis.	**0**
	In line or bar graphs, plot the values of the variable in horizontal axis in numerical order with appropriate intervals and no space between identical values by not taking into consideration to the distance between the starting point, zero and the first value in the order. 	**2**
	In line or bar graphs, plot the individual values of the variable in horizontal axis, often in the exact same order as given in the table.	**0**

Under the topics, vertical and horizontal axes, the students drew graphs with a horizontal axis for showing four sections and a vertical axis for showing numbers of boys and girls in these sections did not put zero on the intersection point of axes, rather they identify zero up to the horizontal axis. It seemed that the students drew graphs in this way because of a possible misconception of the place of zero could be changed on the axes according to the given data, which might be due to their prior knowledge.

Many students also drew graphs by plotting the values of numbers of boys and girls in the exact same order as given in the table. Also, although there were students who plot the values of the variable in numerical order with appropriate intervals and no space between identical values, they did not consider the distance between the starting point, zero and the first value in the order. It seemed that the students drew graphs in these ways due to the possible misconception of plotting the individual values of the variable in the exact same order as given in the table or plotting the

values of the variable in numerical order with appropriate intervals by only taking into consideration of the data given in the table, which might be because of their prior knowledge.

4.2.3. Constructing and Interpreting Circle Graphs

The objective "to construct and interpret circle graphs" was evaluated in the 3rd question in pretest. The 3rd question is given in Figure 4.3 below:

Question 3:

Table: Numbers of sisters and brothers of the students

Numbers of sisters and brothers	Numbers of students
0	2
1	9
2	6
3	1

Numbers of sisters and brothers of the students in a classroom are given in the table above. Accordingly,

a) Draw a circle graph showing numbers of students by using the data given.

b) Interpret the graph.

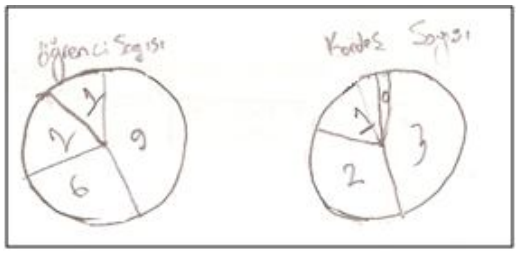
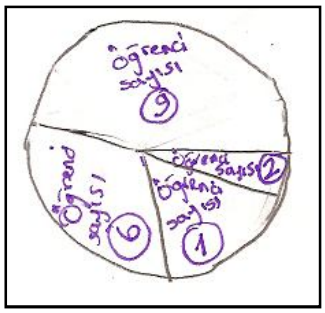
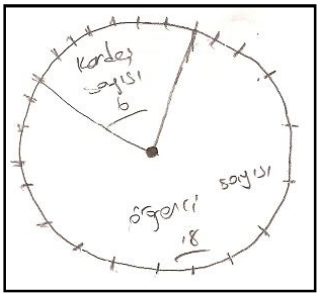
Figure 4.3. The 3rd Question in Pretest

The 3rd question included two parts in which the students were expected to draw a circle graph to show the data given in the table accurately and to interpret it correctly. Hence, to investigate the students' typical errors and possible misconceptions, incorrect responses were analyzed and the frequency of each response was calculated.

In the analysis process of 3rd question, only the most common incorrect response types were examined to determine the students' typical errors and possible misconceptions.

The frequency of students' incorrect responses and examples of each response for part (a) in the 3rd question was given in Table 4.9.

Table 4.9. The Frequency of Students' Incorrect Responses with Examples for Part (a) in the 3rd Question

	Response Type	Frequency of students for each response (f)
Part a	Draw more than one circle graph.  	**6**
	Write an incorrect title for the circle graph.	**0**
	Write no title for the circle graph.	**38**
	Show the numbers of students directly as given in the table without converting them into degrees.  	**35**
	Show both students' numbers and numbers of sisters and brothers of them in the circle graph as given in the table.  	**8**

In the 3rd question, although the students were wanted to draw a circle graph showing only numbers of students, they drew two circle graphs one of which was used to show students' numbers and other was used for representing numbers of

sisters and brothers of these students by including the value, zero. In addition, most of the students also did not convert numbers of students given in the table into degrees and they showed the numbers of students directly in the circle graph as given in the table. Moreover, many students did not write any title for the circle graphs. Hence, these might be the result of the students' typical errors made as a result of carelessness, having the lack of knowledge, or having misconceptions.

The students also drew a circle graph by showing both students' numbers and numbers of sisters and brothers of them as given in the table. It seemed that the students drew the circle graphs in this way due to the possible misconception of circle graphs could be used to show the data including two criteria, which might be due to their prior knowledge.

Table 4.10 below presents the frequency of students' incorrect responses and an example of these responses for part (b) of question 3.

Table 4.10. The Frequency of Students' Incorrect Responses with an Example for Part (b) in the 3rd Question

	Response Type	**Frequency of students for each response (f)**
Part c	Incorrect interpretation. b) Çizdiğiniz grafiği yorumlayınız. 2 tane öğrencinin kardeşi yok 9 tane öğrencinin 1 kardeşi var 6 tane öğrencinin 2 kardeşi var 1 tane öğrencinin 3 kardeşi var.	**30**

In the situation "incorrect interpretation", many students did not interpret the graph, they rather wrote how many sisters and brothers the students in the classroom given in the table had. In the interview, when Student D was asked to explain his response, he could not comment his response rather, he only repeated it as follows:

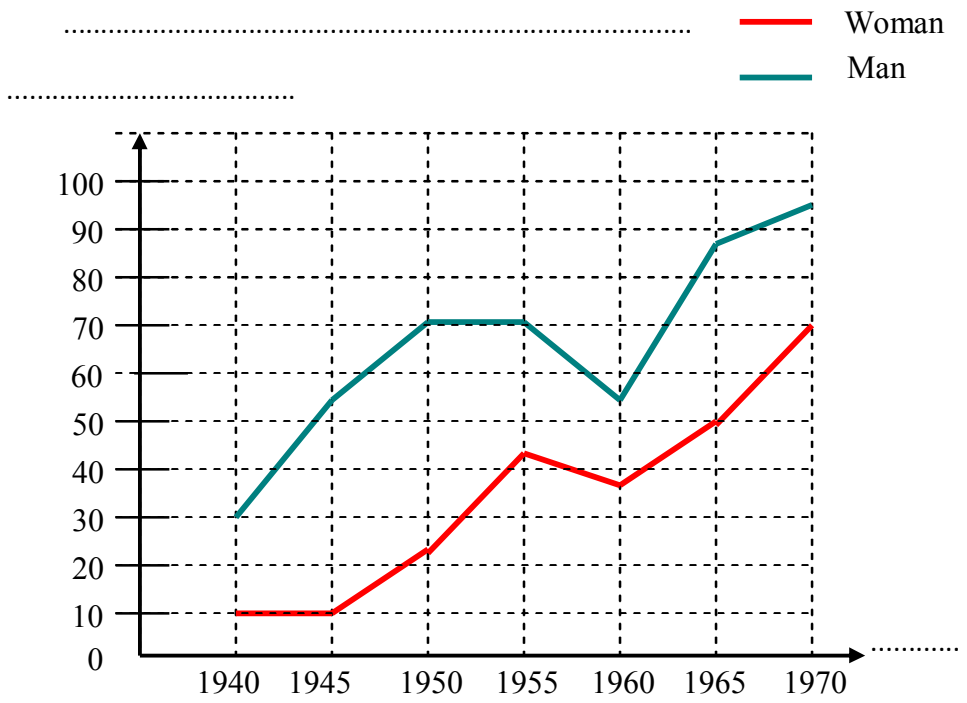
> *"I wrote the numbers given in the table. Two students have no sisters or brothers… Nine students have one, six students have 2 and one student have 3 sisters or brothers…"*

It seemed that the students interpreted the question in this way due to a possible misconception that interpreting a graph means repeating the information given to them, which might be because of the lack of knowledge of interpreting graphs.

4.2.4. Reading and Interpreting Line Graphs

The objectives "to interpret line graphs based on more than one criterion" and "to formulate predictions based on the data" were evaluated in the 4th question in pretest. The 4th question is given in Figure 4.4 below:

Ouestion 4:



The table above shows the changes of literacy ratios that belong to the population of woman and man in a country between the years 1940 and 1970. Accordingly,

a) Write the title and names of axes in the blanks given above.

b) Which years or between years is more than half of the woman's population literate?

c) Can the literacy ratios of woman and man in 1975 be guessed by using the data given? Explain your answer.

d) Interpret the graph.

Figure 4.4. The 4th Question in Pretest

The 4th question included four parts in which the students were expected to write the title and names of axes for a given line graph, read, and interpret it correctly. Hence, to investigate the students' typical errors and possible misconceptions, incorrect responses were analyzed and the frequency of each response was calculated. In the analysis process of 4th question, only the most common incorrect response types were examined to determine typical errors and possible misconceptions the students had.

The frequency of students' incorrect responses and examples of each response for part (a) in the 4th question is given in Table 4.11.

Table 4.11. The Frequency of Students' Incorrect Responses with Examples for Part (a) in the 4th Question

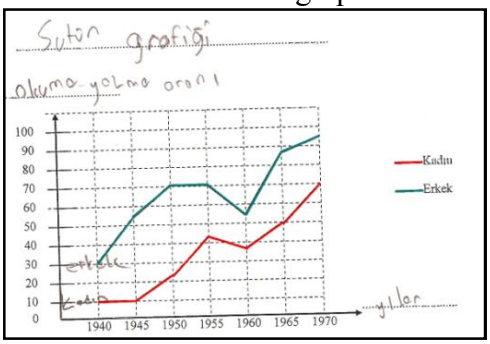
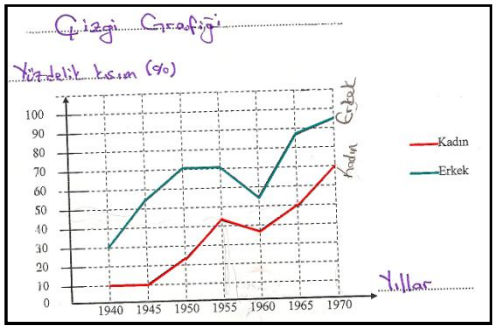
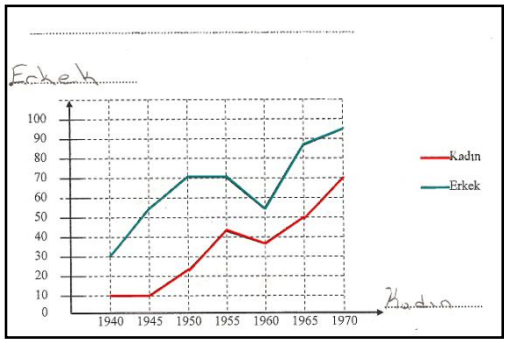
	Response Type	**Frequency of students for each response (f)**
Part a	Write an incorrect a title for the graph. 	**23**
	Write no title for the graph.	**7**
	Write an incorrect name for the vertical axis of the graph. 	**24**
	Write no name for the vertical axis of the graph.	**10**

Table 4.11. (Continued)

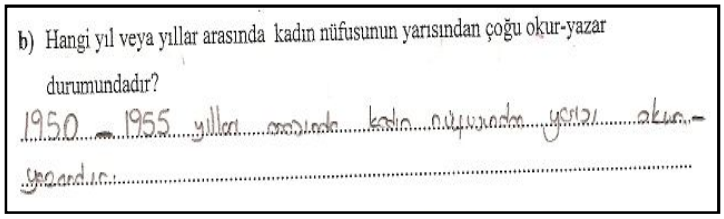
	Response Type	Frequency of students for each response (f)
Part a	Write an incorrect name for the horizontal axis of the graph. 	**3**
	Write no name for the horizontal axis of the graph.	**5**

In part (a), the analysis of results showed that the students wrote “line graph” or “bar graph” as the title of the line graph given in the question. It seemed that the students wrote such titles due to a possible misconception that the title of a graph was the type of it and this might be the result of their prior knowledge.

The analysis of students’ responses showed that the students generally could not write title or names of vertical or horizontal axis. In addition, the students’ responses showed that they wrote incorrect names for the vertical axis or horizontal axis such as “boys” and “girls”. Hence, that the students wrote incorrect responses for the title of the graph or the names of vertical axis or horizontal axis or they did not write any title or names for axes might be due to the typical errors made as a result of carelessness, having the lack of knowledge or having misconceptions.

Table 4.12 below presents the frequency of students’ incorrect responses and an example of these responses for part (b) of question 4.

Table 4.12. The Frequency of Students' Incorrect Responses with an Example for Part (b) in the 4th Question

Response Type		Frequency of students for each response (f)
Part b	Incorrect answer.  	**16**

In part (b), the students wrote different incorrect answers such as "more than half of the woman's population was literate between the years 1950 and 1955" or more than half of the woman's population was literate in the year 1970." The reason of these responses seemed to be their typical errors made as a result of carelessness, having the lack of knowledge, or having misconceptions.

Table 4.13 below presents the frequency of students' incorrect responses and examples of each response for part (c) of question 4.

Table 4.13. The Frequency of Students' Incorrect Responses with Examples for Part (c) in the 4th Question

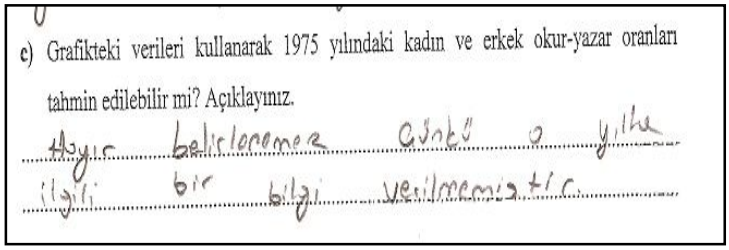
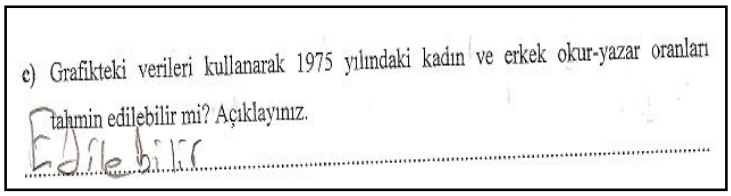
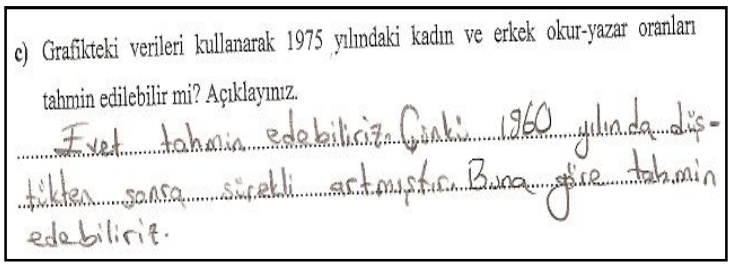
Response Type		Frequency of students for each response (f)
Part c	Correct answer with incorrect explanation.  	**7**

Table 4.13. (Continued)

	Response Type	Frequency of students for each response (f)
Part c	Incorrect answer without any explanation.  c) Grafikteki verileri kullanarak 1975 yılındaki kadın ve erkek okur-yazar oranları tahmin edilebilir mi? Açıklayınız. Edilebilir	13
	Incorrect answer with explanation.  c) Grafikteki verileri kullanarak 1975 yılındaki kadın ve erkek okur-yazar oranları tahmin edilebilir mi? Açıklayınız. Evet tahmin edebiliriz. Çünkü 1960 yılında düş-tükten sonra sürekli artmıştır. Buna göre tahmin edebiliriz.	39

In part (c), the students' responses showed that the literacy ratios of woman and man in 1975 could not be guessed by using the given data, because no information about that year was given. What is more, they claimed that it could be guessed since the literacy ratios always increased after 1960. It seemed that the students gave answers in these ways due to the possible misconceptions that when the information was not given in graphs, it could not be guessed or that the students focused on one point while reading and interpreting line graphs instead of thinking the whole graph. Hence, these might be the result of their prior knowledge. On the other hand, students also gave the answer "yes" as the situation "incorrect answer without any explanation." This might be that they might not have any idea about what the guessing meant.

Table 4.14 below presents the frequency of students' incorrect responses and an example of these responses for part (d) of question 4.

Table 4.14. The Frequency of Students' Incorrect Responses with Examples for Part (d) in the 4th Question

	Response Type	Frequency of students for each response (f)
Part d	Incorrect interpretation. 	**24**

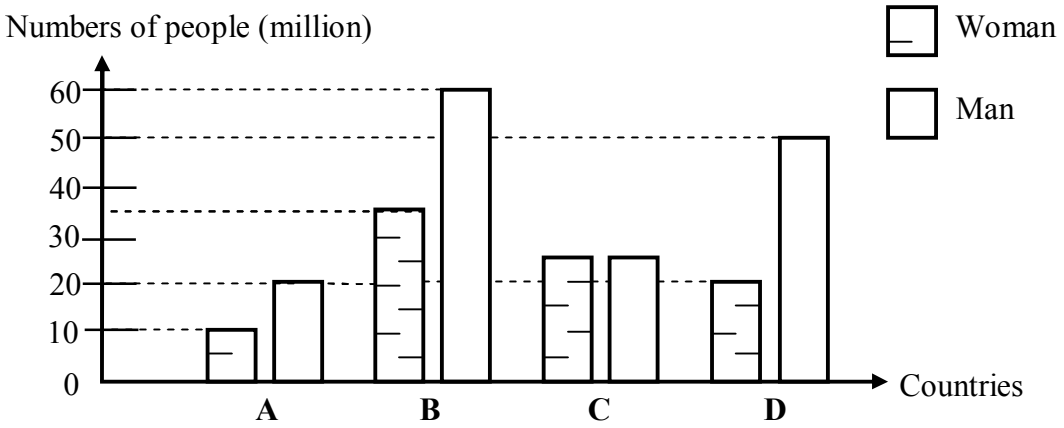
In part (d), many students did not interpret the graph and they said that the graph belonged to the literacy ratios of woman and man. It seemed that the students interpreted the question in this way due to a possible misconception that interpreting a graph means repeating the information given to them and this might be due to their prior knowledge.

4.2.5. Reading and Interpreting Bar Graphs

The objectives "to interpret bar graphs based on more than one criterion" and "to develop ideas for the real life situations by constructing and interpreting statistical representation forms" were evaluated in the 5th question in pretest. The 5th question is given in Figure 4.5 below:

Question 5:

Graph: Numbers of woman and man who drive a car according to the countries



The graph given above shows the numbers of the woman and man who drive a car in four different countries. According to this, fill in the blanks given below.

a) The difference between the total number of woman and the total number of man is…….. (Give an answer with numbers).

b) The country in which numbers of the woman and man are the most different is…….

c) The ratio of woman who drives a car is the most in the country…….

d) In the countries, ...,.....,....., numbers of woman driving a car is less than numbers of man driving a car. What can be the reasons of this situation? Explain.

Figure 4.5. The 5th Question in Pretest

The 5th question included four parts in which the students were expected to read and to interpret the bar graph given in the question correctly. Hence, to investigate the students' typical errors and possible misconceptions, incorrect responses were analyzed and the frequency of each response was calculated.

In the analysis process of 5th question, only the most common incorrect response types were examined to determine typical errors and possible misconceptions the students had.

The frequency of students' incorrect responses with an example of these responses for part (a) in the 5th question was given in Table 4.15.

Table 4.15. The Frequency of Students' Incorrect Responses with an Example for Part (a) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part a	Incorrect answer. a) Dört ülkedeki araba kullanan toplam kadın sayısı ile toplam erkek sayısı arasındaki fark ...fazla... dır. (Sayısal olarak belirtiniz.)	**44**

In part (a), in many cases, although the students were asked to write their answers in numbers, they gave their answers by using words and they said that the difference between the total number of woman and the total number of man was "great." Hence, this might be their typical errors made as a result of carelessness, having the lack of knowledge, or having misconception.

Table 4.16 below presents the frequency of students' incorrect responses and an example of these responses for part (b) of question 5.

Table 4.16. The Frequency of Students' Incorrect Responses with an Example for Part (b) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part b	Incorrect answer. b) Araba kullanan kadın ve erkek sayıları arasındaki farkın en fazla olduğu ülke B'dir.	**39**

In part (b), the most common students answer was that the country in which the numbers of the woman and man were the most different was B. It seemed that the students gave this answer due to a possible misconception of considering the height of the bars while reading the bar graphs, which might be the result of their prior knowledge.

Table 4.17 below presents the frequency of students' incorrect responses and an example of these responses for part (c) of question 5.

Table 4.17. The Frequency of Students' Incorrect Responses with an Example for Part (c) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part c	Incorrect answer. c) Araba kullanan kadınların oranı ...B.....ülkesinde en fazladır.	**60**

In part (c), the most common incorrect answer was that the ratio of woman who drove a car was the most in the country B although the correct answer was country C. This might be their typical errors made as a result of carelessness, having the lack of knowledge or having misconception.

Table 4.18 below presents the frequency of students' incorrect responses and an example of these responses for part (d) of question 5.

Table 4.18. The Frequency of Students' Incorrect Responses with an Example for Part (d) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part d	Incorrect answer without any explanation. d) ...C.....ülkelerindeki araba kullanan kadın sayısı araba kullanan erkek sayısından azdır. Bu durumun sebepleri neler olabilir? Açıklayınız.	**1**
	Incorrect answer with explanation.	**0**

In part (d), “the students’ incorrect answer without any explanation” was that in the country C, numbers of woman driving a car was less than numbers of man driving a car. It seemed that the students gave such response as a result of their typical errors made as a result of carelessness, having the lack of knowledge or having misconception.

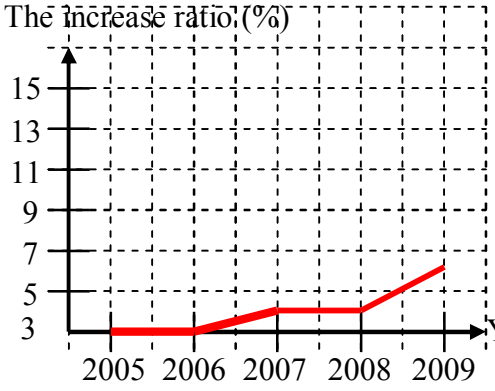
4.2.6. Explaining the Situations Line Graphs might Address Incorrect Interpretations

The objective “to explain the situations that line graphs, pictographs, or object graphs might address incorrect interpretations” was evaluated in the 6th question in pretest. The 6th question is given in Figure 4.6 below:

Question 6:

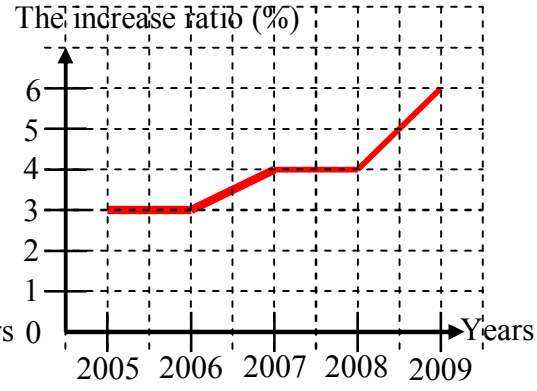
A

Graph: The increase ratios made for employees in between the years 2005 and 2009



B

Graph: The increase ratios made for employees in between the years 2005 and 2009



The increase ratios made by a private establishment to its employees are given in the graphs above. Accordingly,

a) Explain the differences between the graphs.

b) Which graph could be drawn by the employees? Explain your answer.

Figure 4.6. The 6th Question in Pretest

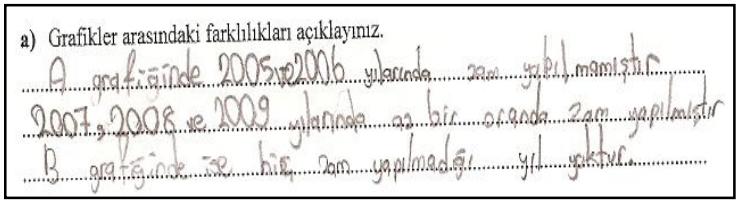
The 6th question included two parts one of which the students were expected to interpret the differences between the graphs correctly and the other was to express

and explain which graph could be drawn by the employees. Hence, to investigate the students' typical errors and possible misconceptions, incorrect responses in parts were analyzed and the frequency of each response was calculated.

In the analysis process of 6th question, only the most common incorrect response types were examined to determine typical errors and possible misconceptions the students had.

The frequency of students' incorrect responses and an example of these responses for part (a) in the 6th question is given in Table 4.19.

Table 4.19. The Frequency of Students' Incorrect Responses with an Example for Part (a) in the 6th Question

	Response Type	**Frequency of students for each response (f)**
Part a	Incorrect interpretation.  	**44**

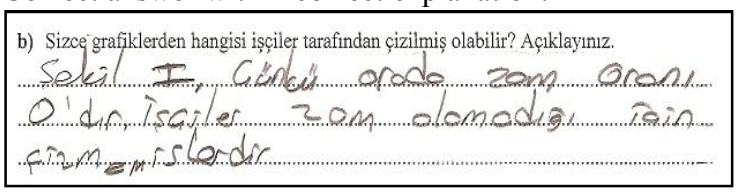
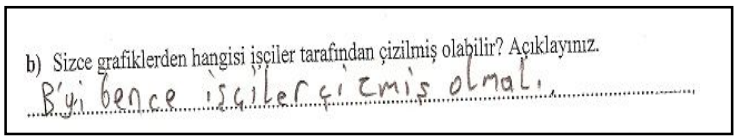
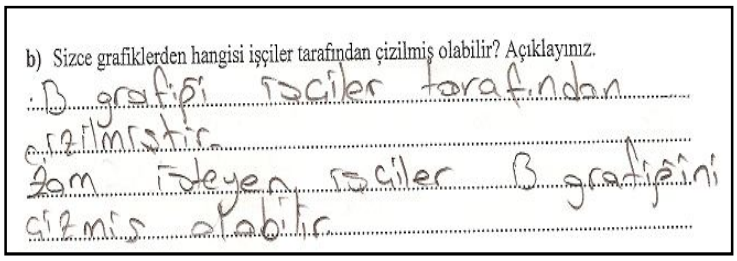
In part (a), the most common incorrect interpretation was that in graph A, while there was no increase ratios made by a private establishment to its employees in years 2005 and 2006, there were increase ratios made by a private establishment to its employees in years 2007, 2008, and 2009. However, in graph B, in all years, increase ratios were made by a private establishment to its employees. In the interview, when Student E was asked to explain his answer, he only repeated his response as the following:

> "*In graph A, in the years 2007, 2008, and 2009, there were increase ratios made to the employee, but there were no increase ratios in years 2005 and 2006.*"

It seemed that the students gave answer due to a possible misconception that in line graphs, the value on the horizontal axis as zero although the graphs started from a number different from zero and this might be the result of their prior knowledge.

Table 4.20 below presents the frequency of students' incorrect responses and examples of each response for part (b) of question 6.

Table 4.20. The Frequency of Students' Incorrect Responses with Examples for Part (b) in the 6th Question

	Response Type	**Frequency of students for each response (f)**
Part b	Correct answer with incorrect explanation.  	**8**
	Incorrect answer without any explanation.  	**8**
	Incorrect answer with explanation.  	**20**

In part (b), the students' responses showed that the graph A could be drawn by the employees, because there was no increase ratios made by a private establishment to its employees. In addition, the common answer the students gave was that the graph B could be drawn by the employees who wanted to increase ratios. It also seemed that the students gave answer due to a possible misconception that the value on the horizontal axis was zero although the graphs started from a number different

from zero and two graphs which show the same thing with different scales were different. Hence, this might be the due to their prior knowledge.

4.2.7. Summary of Pretest Results

The analysis of pretest results showed that the students had common possible misconceptions about use of line, bar and circle graphs, which might be the result of students' prior knowledge. The students' possible misconceptions about line graphs were that line graphs would be used to compare things between different groups and they were the most suitable type of graphs to show percentage ratios. Another possible misconception about bar graphs was that the percentage symbols were not used in bar graphs, but circle graphs were used in order to show the data in percentage. Also, only degrees were used in circle graphs. The ratios would not be showed in circle graphs was the possible misconception the students had about circle graphs.

According to the pretest results, the students had also possible misconceptions about constructing line and bar graphs, which might be due to their prior knowledge. The students wrote "line graph" or "bar graph" as the title of the graph. They drew bar graphs with a categorical vertical axis and with a quantitative horizontal axis by using vertical bars instead of horizontal bars. In addition, like bar graphs, they drew line graphs by using a vertical axis representing values of a categorical variable and a horizontal axis representing values of a quantitative variable. Moreover, in line graphs they did not join the points they determined on the graph according to the given data with straight lines. Furthermore, the students drew graphs with a horizontal axis for categorical variable and a vertical axis for quantitative variable did not put zero on the intersection point of axes, rather they identify zero up to the horizontal axis. What is more, while many students drew graphs by plotting the values of the variable in the exact same order as given in the table, there were students who plotted the values of the variable in numerical order with appropriate intervals and no space between identical values, by not taking into consideration of the distance between the starting point, zero, and the first value in the order.

The pretest results showed that the students' had typical errors which were about constructing line and bar graphs, which might be result of students' carelessness, having the lack of knowledge, or having misconceptions. Although the

correct type of graph in the second question in pretest was a bar graph, the students drew line graphs for the data given in two criteria. Also, there were many students who drew circle graphs for this question. In addition, the students wrote incorrect name for the vertical axis or they did not write any title or names for axes.

Pretest results also showed that the students' had possible misconceptions about reading and interpreting line and bar graphs. The students focused on one point while reading and interpreting line graphs instead of thinking the whole graph or they focused on the height of the bars while reading the bar graphs. In addition, when the information was not given in graphs, it could not be guessed. Furthermore, they interpreted graphs by repeating the information given to them. The analysis of students' responses also showed that they had typical errors about reading and interpreting line and bar graphs and they gave incorrect responses to the questions as a result of their carelessness, having the lack of knowledge or having misconceptions.

The analysis of pretest results also showed that the students had possible misconceptions about explaining the situations line graphs might address incorrect interpretations. The students thought that in line graphs, the value on the horizontal axis as zero although the graphs started from a number different from zero and two graphs which showed the same thing with different scales were different.

The students also had possible misconceptions about constructing and interpreting circle graphs as a result of their prior knowledge. In the third question, the students drew two circle graphs to show the data including two criteria. In addition, many students drew a circle graph by showing the data in two criteria as given in the table.

4.3. 7th-Grade Students' Typical Errors and Possible Misconceptions in Graphs Concept after the Regular Mathematics Instruction

7th-grade students' typical errors and possible misconceptions in the graphs concept after the regular mathematics instruction were investigated through the analysis of posttest results of the students. The posttest in the study was conducted with 71 7th-grade students after the instruction and it included six open-ended questions based on the 7th-grade objectives in the elementary mathematics curriculum that were reorganized for the pretest.

4.3.1. Use of Line, Bar and Circle Graphs

The objective "to explain which statistical representation form can be used for given data" was evaluated in the 1st question in posttest. The 1st question is given in Figure 4.7 below:

Question 1:

Table: Numbers of visitors who came to a country in 2008 and 2009

Intercommunication manner	**Years**	
	2008	**2009**
Seaway	3,5 million	2 million
Airway	6 million	5 million
Land route	2,5 million	1 million

Numbers of visitors who came to a country by seaway, airway or land route in years 2008 and 2009 are given in the table above. Accordingly,

a) Is it suitable to show the data given in the table by using a line graph? Explain your answer.

b) Is it suitable to show the data given in the table by using a bar graph? Explain your answer.

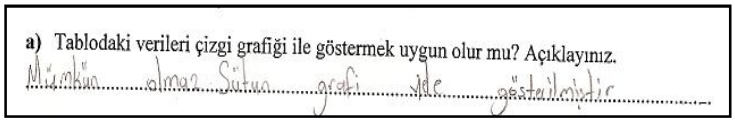
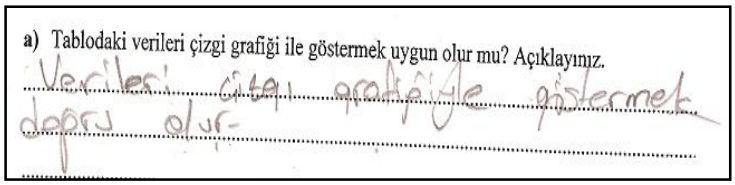
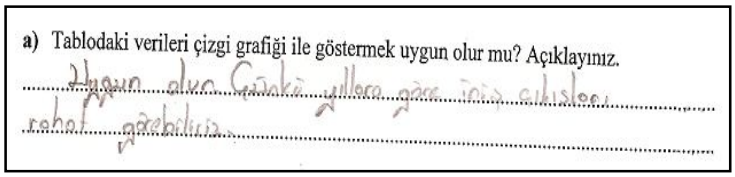
c) Is it suitable to show the data given in the table by using a circle graph? Explain your answer.

Figure 4.7. The 1st Question in Posttest

The 1st question included three parts in which the students were expected to give a short answer "yes" or "no" and to explain their answer in detail. Hence, the possible combinations of correct and incorrect responses for three parts and students' explanation were analyzed and the frequency of these combinations was calculated.

The analysis of the 1st question focused on only three situations in each part in which students' typical errors and possible misconceptions could be determined clearly: (i) correct answer with incorrect explanation, (ii) incorrect answer with explanation, and (iii) incorrect answer without any explanation. The frequency of correct and incorrect responses and examples of each response for part (a) in the 1st question is given in Table 4.21.

Table 4.21. The Frequency of Correct and Incorrect Responses with Examples for Part (a) in the 1st Question

	Response Type	Frequency of students for each response (f)
Part a	Correct answer with incorrect explanation.  	**13**
	Incorrect answer without any explanation.  	**3**
	Incorrect answer with explanation.  	**16**

The analysis of students' responses in posttest showed that although students' possible misconceptions in the pretest differed from those in the posttest, students' common misconceptions about the use of line, bar, and circle graphs were detected in both pretest and posttest.

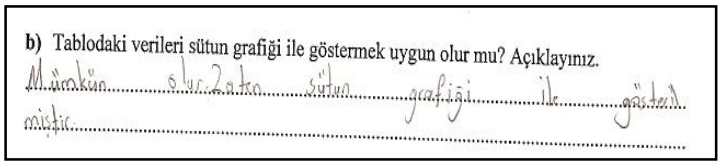
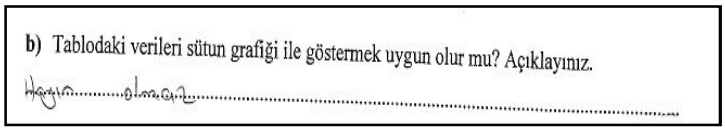
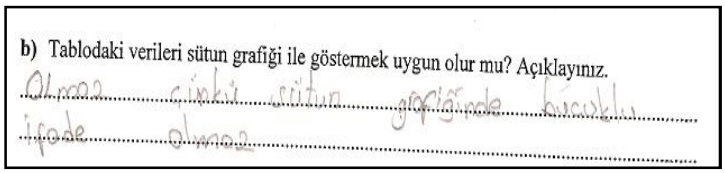
In part (a), the most common students' responses in the situations (i) and (ii) were that a line graph was not suitable to use for showing the numbers of visitors because it was already shown by using a bar graph and that line graph was suitable to show the data to see the increases and decreases clearly. Moreover, the students' explanations in the interview showed one more misconception. Student F explained that:

> *"In the table, both numbers of visitors in 2008 and 2009 were given. Line graphs are not used to show such kind of data. Bar graphs are used."*

These students' responses might be because of possible misconceptions that if all the information was given, any type of the graphs would be suitable to show the data, the data given in table should be given in bar graphs or only bar graphs were used to show the data in two criteria. The students also gave the answer "yes" without any explanation which might be the result of not knowing the differences between types of graphs exactly.

Table 4.22 below presents the frequency of students' correct and incorrect responses and examples of each response for part (b) of question 1.

Table 4.22. The Frequency of Correct and Incorrect Responses with Examples for Part (b) in the 1st Question

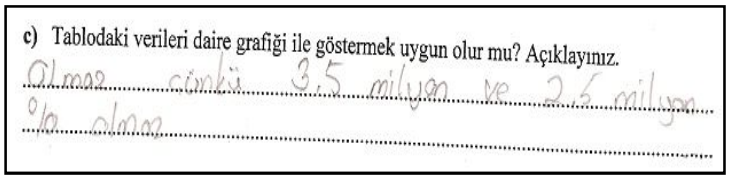
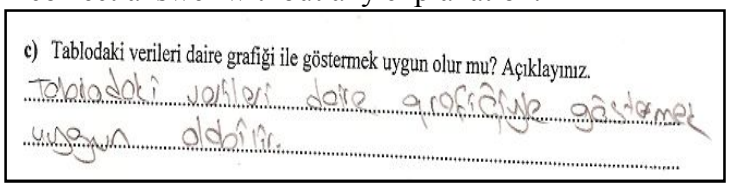
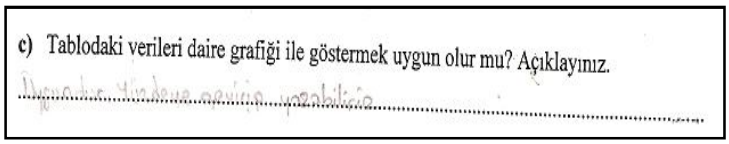
	Response Type	**Frequency of students for each response (f)**
Part b	Correct answer with incorrect explanation. 	**10**
	Incorrect answer without any explanation. 	**1**
	Incorrect answer with explanation. 	**11**

In part (b), students' "correct answers with incorrect explanation" showed that they had incorrect knowledge about what a bar graph was. They explained that a bar graph was suitable to show numbers of visitors came to a country by seaway, airway, or land route in years 2008 and 2009. Besides, numbers of visitors had been shown in a bar graph. In "incorrect answer with explanation" situation, the students' responses

stated that a bar graph was not suitable because numbers of visitors included decimal numbers and they were not used in bar graphs. It seemed that students' possible misconceptions were that the table and the bar graphs were the same and the decimal numbers were not used in bar graphs. The students, on the other hand, gave the answer "no" for the situation "incorrect answer without any explanation" and this might be because they did not have any idea about the use of bar graphs.

Table 4.23 below presents the frequency of students' correct and incorrect responses and examples of each response for part (c) of question 1.

Table 4.23. The Frequency of Correct and Incorrect Responses with Examples for Part (c) in the 1st Question

	Response Type	**Frequency of students for each response (f)**
Part c	Correct answer with incorrect explanation. 	**16**
	Incorrect answer without any explanation. 	**2**
	Incorrect answer with explanation. 	**23**

In part (c), an interesting answer "correct answer with incorrect explanation" was that numbers of visitors who came to a country by seaway, airway, or land route in years 2008 and 2009 included decimal numbers such as 2,5 million and 3,5 million and since they could not transform these values in percentages, a circle graph was not suitable to show numbers of visitors. The most common "incorrect answer

with explanation" was that a circle graph was suitable to show numbers of visitors by converting them into percentage. It seemed that the students answered the sub-questions in these ways due to a possible misconception that data including decimal numbers could not be converted into percentages or the circle graphs were used to show the data including two criteria. The students, on the other hand, gave the answer "yes" for the situation "incorrect answer without any explanation" and this might be because they did not have any idea about the property of circle graphs.

In order to understand the possible reasons of students' incorrect responses, the mathematics teacher's instruction about graphs was also observed in the study. In the instruction process, the teacher provided students the purpose of using line, bar, and circle graphs. She emphasized that while line graphs were used for tracking changes over short and long periods of time, bar graphs were utilized to see the numbers more clearly and compare things between different groups. Also, she gave an explanation that circle graphs were used for comparing the parts of a whole as the purpose of using circle graphs. During the instruction process, the teacher did not ask more questions about line, bar, and circle graphs. She asked only one question for each type of graphs. Hence, students' possible misconceptions about use of line, bar, and circle graphs might be the result of the teacher's instruction in which she did not provide detailed explanations about the use of these types of graphs to the students, she did not compare the purposes of using them, and she did not give much opportunities for the students to answer different questions as examples.

4.3.2. Constructing Line and Bar Graphs

The objective "to construct a graph based on more than one criterion" was evaluated in the 2nd question in posttest. The 2nd question is given in Figure 4.8 below:

Question 2:

Table: The first exam results of Mathematics and Turkish

	Mathematics	**Turkish**
Ayşegül	0	20
Ali	85	90
Yiğit	70	60
Esra	95	100
Uğur	40	55

The first Mathematics and Turkish exam results of five students are given in the table above. By using the information, draw a graph.

Figure 4.8. The 2nd Question in Posttest

In the 2nd question, the students were expected to choose the most suitable type of graph for data given in the table and draw it accurately. Students' answers were analyzed in five topics with possible responses under the topics such as type of graph, headings, axes, vertical axis, and horizontal axis. As a result, to investigate the students' typical errors and possible misconceptions, the possible responses were analyzed and the frequency of each response was calculated.

In the analysis process of 2nd question, only the most important response types were focused to determine the students' typical errors and possible misconceptions.

The frequency of students' incorrect responses and examples of each response for the topic "type of graph" in the 2nd question was given in Table 4.24.

Table 4.24. The Frequency of Students' Incorrect Responses with Examples for Type of Graph in the 2nd Question

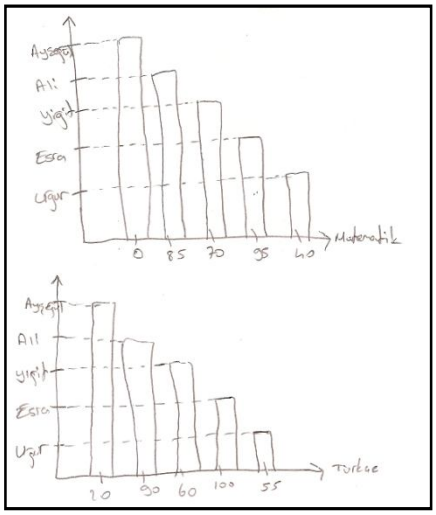
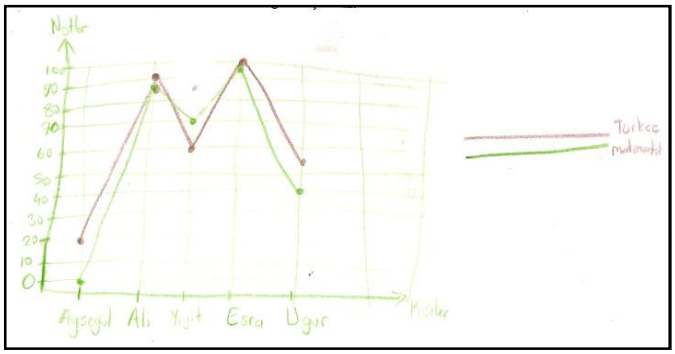
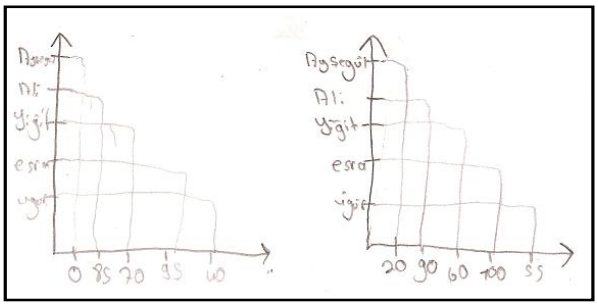
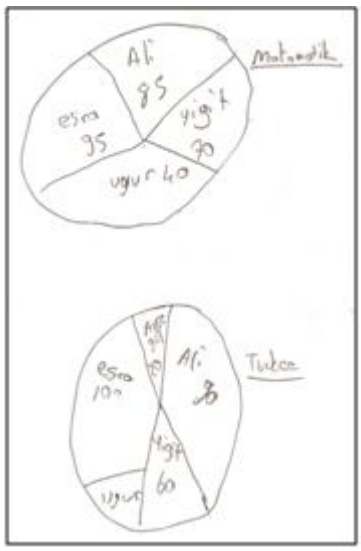
	Response Type	Frequency of students for each response (f)
Type of Graph	Draw more than one bar graph. 	**5**
	Draw a line graph. 	**6**
	Draw more than one line graph. 	**1**

Table 4.24. (Continued)

	Response Type	Frequency of students for each response (f)
Type of Graph	Draw a circle graph. 	**1**
	Draw more than one circle graph. 	**3**

The analysis of posttest results showed that the students had common possible misconceptions about constructing line and bar graphs in both pretest and posttest.

Under the topic, type of the graph, the results of 2nd question in posttest showed that while many students drew two bar graphs, there were students who drew a line graph. Also, the students drew a circle graph or two circle graphs to show the data given in the table.

The results also showed that the responses of students who drew one bar graph or two bar graphs were different in their choice of using axes of the graphs. Most of the students who chose to draw a bar graph to show the given data used vertical axis

for showing four sections and used horizontal axis for showing numbers of boys and girls in these sections. However, among these students some students drew vertical bars instead of horizontal bars with the possible misconception that bars in bar graphs would always be drawn vertically. In the instruction process, the teacher drew a bar graph with a categorical vertical axis and a quantitative horizontal axis in only one section, she did not give any other examples in other sections. Hence, that the teacher did not show different types of bar graphs in all sections might be the reason of students' drawing such kind of bar graphs.

Before the instruction, the students in the study had knowledge about construction and interpretation of line and bar graphs including data with one criterion. During the instruction, although the objective given in the MONE curriculum was related to forming a line graph according to more than one criterion, the teacher asked a question in which the students were wanted to draw a line graph by using the data including one criterion as an example of line graphs. She did not ask any more questions in which the students were wanted to draw a line graph for showing data in two criteria. Thus, that the students drew two line graphs to show the given data including two criteria might be the result of teacher's instruction.

In the teaching of circle graphs, the teacher also asked only one and the same question in which the students were wanted to draw a circle graph to each section. However, she did not mention whether a circle graph could be drawn to show data including more than one criterion or not. Hence, the teacher's instruction might also be the reason of students' tendency to draw one or more circle graphs in this question.

Table 4.25 below presents the frequency of students' incorrect responses and an example of these responses for the topic "headings" of question 2.

Table 4.25. The Frequency of Students' Incorrect Responses with Examples for Headings in the 2nd Question

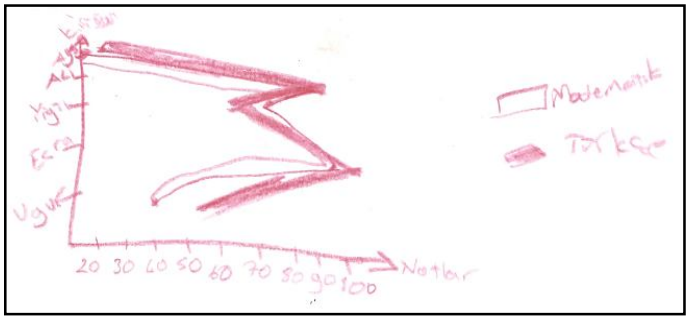
	Response Type	Frequency of students for each response (f)
Headings	Write an incorrect title for the graph. 	**2**
	Write no title for the graph.	**46**
	Write an incorrect name for the horizontal axis.	**0**
	Write no name for the horizontal axis.	**39**
	Write an incorrect name for the vertical axis.	**0**
	Write no name for the vertical axis.	**40**

Under the topic, headings, the students' results showed that they had an incorrect idea about what the title of a graph was. In the instruction process, although the teacher warned students not forget to write title and names of axes of the graphs and she controlled their graphs, they wrote "line graph", "bar graph" or "Table: The results of mathematics and Turkish exam results" as the title of the graph. It seemed that the students were likely to consider the title of a graph is the type of it and the table and the bar and line graphs as the same. Hence, these might be the result of their prior knowledge and forgetting the teachers' warnings about the topic.

The analysis of pretest results also showed that the students generally could not write title or names of vertical axis or horizontal axis. Hence, that the students did not write any title or names of axes might be due to the typical errors made as a result of carelessness, having the lack of knowledge, or having misconceptions.

Table 4.26 below presents the frequency of students' incorrect responses and examples of each response for the topic "axes" of question 2.

Table 4.26. The Frequency of Students' Incorrect Responses with Examples for Axes in the 2nd Question

	Response Type	Frequency of students for each response (f)
Axes	In line graph, use the horizontal axis for showing the results of first Mathematics and Turkish exams of five students and use the vertical axis for showing the names of these students. 	**1**
	In line graph, the points are not joined with straight lines.	**0**

Under the topic, axes, the results showed that there were differences in students' choice of using axes of the graphs. The results showed that there was a student who drew a line graph to show the given data used vertical axis for showing names of the students and used horizontal axis for showing the results of first Mathematics and Turkish exams. In the interview, Student F was asked questions about his responses such as why he chose a line graph to draw and why he drew a line graph with a vertical axis representing categorical variable and a horizontal axis representing quantitative variable. He did not express his response clearly and he explained it as the following:

> *"I chose a line graph because I wanted to make something different. Iummm… I saw bar graphs like that and I thought that I could draw a line graph in this way."*

In the instruction process, the teacher did not mention whether a line graph with a vertical axis representing categorical variable and a horizontal axis presenting

a quantitative variable could be drawn or not in any of the four sections. Hence, teacher's instruction also might cause that the students drew such line graphs in the posttest.

Table 4.27 below presents the frequency of students' incorrect responses and examples of each response for the topics "vertical axis" and "horizontal axis" of question 2.

Table 4.27. The Frequency of Students' Responses with Examples for Vertical and Horizontal Axes in the 2nd Question

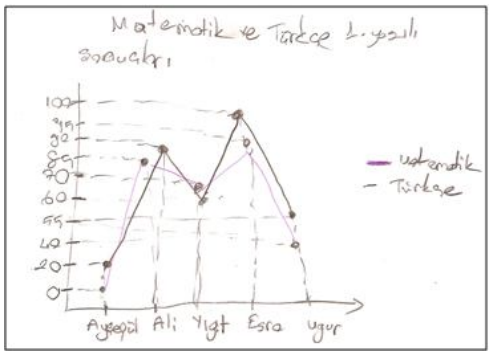
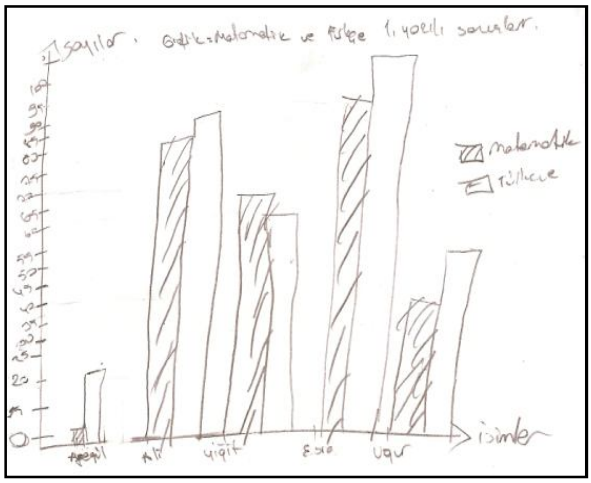
	Response Type	**Frequency of students for each response (f)**
Vertical Axis	Identify zero above the vertical axis. 	**38**
	In line or bar graphs, plot the values of the variable in vertical axis in numerical order with appropriate intervals and no space between identical values by not taking into consideration to the distance between the starting point, zero and the first value in the order. 	**4**

Table 4.27. (Continued)

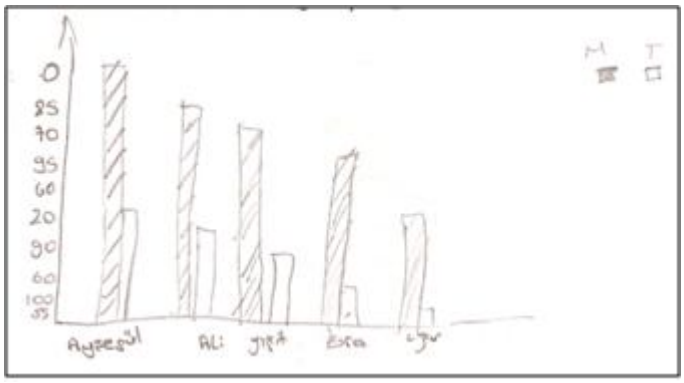
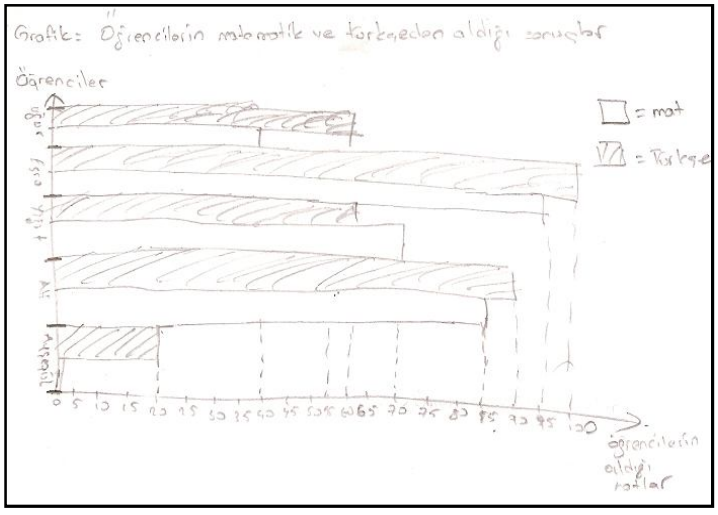
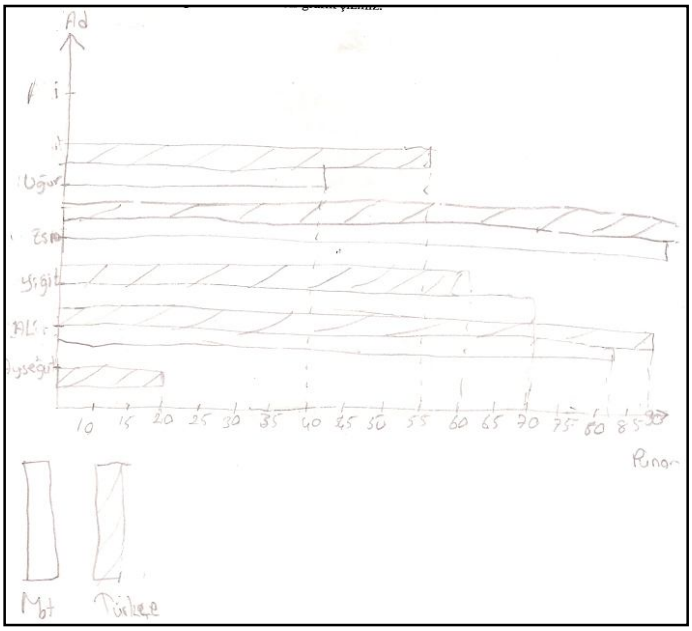
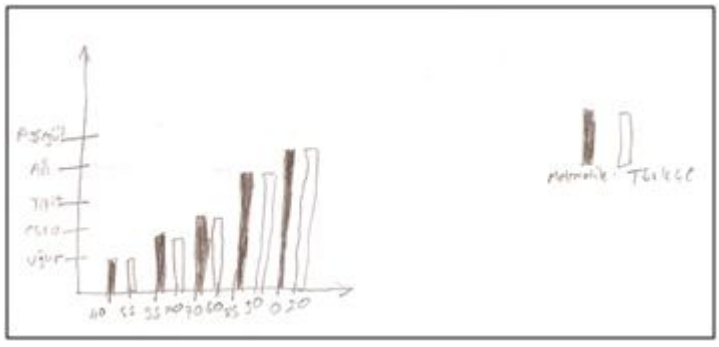
	Response Type	Frequency of students for each response (f)
Vertical Axis	In line or bar graphs, plot the individual values of the variable in vertical axis, often in the exact same order as given in the table. 	**29**
Horizontal Axis	Identify zero to the right of intersection point of both axes on the horizontal axis. 	**1**

Table 4.27. (Continued)

	Response Type	Frequency of students for each response (f)
	In line or bar graphs, plot the values of the variable in horizontal axis in numerical order with appropriate intervals and no space between identical values by not taking into consideration to the distance between the starting point, zero and the first value in the order. 	**2**
	In line or bar graphs, plot the individual values of the variable in vertical axis, often in the exact same order as given in the table. 	**2**

Under the topics, vertical and horizontal axes, the students drew graphs with a horizontal axis for showing names of five students and a vertical axis representing the results of their first Mathematics and Turkish examinations did not put zero on

the intersection point of axes. In other words, they identify zero up to the horizontal axis. In the interview, Student G explained her reason for why she identify zero up to the horizontal axis:

Researcher (R): What is the name of the intersection point of vertical and horizontal axis in the graph you drew?
Student E (E): It is the origin.
R: Why do you call it like that?
E: Iımmmm… I do not know. Our teacher said "It is origin."
R: Ok… Why did you identify zero up to the x-axis?
E: Ayşegül got zero from the exam, so I put zero up to the x-axis. Iımm… If I did not do this, Ayşegül did not have an exam result.

In the instruction process, though the teacher directed the student while drawing the graph on the board by asking questions about the construction of them when needed and emphasized the origin, this could not remove the students' possible misconception that the place of zero could be changed on the axes according to the given data due to the limited numbers of questions she asked to them.

Most of the students, on the other hand, drew graphs by plotting the values of the results of first Mathematics and Turkish examinations in the exact same order as given in the table. In the teacher's instruction, while one of the students was drawing the line graph on the board, he plotted the values of the variable in the exact same order on the line graph as given in the table. This might be due to the misconception she had as the result of the instruction provided in the previous grades. As a result, the teacher warned him by saying that values must be plotted in numerical order in equal intervals, but she did not explain the reason of it and she did not control how the other students were drawing their graphs as she only focused on the student's drawing on the board. Also, although there were students who plot the results of first Mathematics and Turkish examinations in numerical order with appropriate intervals and no space between identical values, they did not consider the distance between the starting point, zero and the first value in the order. It seemed that the students drew graphs in these ways due to the possible misconception of plotting the individual values of the variable in the exact same order as given in the table or plotting the

values of the variable in numerical order with appropriate intervals by only taking into consideration of the data given in the table. Hence, that the students drew graphs in the posttest in these ways due to their prior knowledge or teacher's instruction.

4.3.3. Constructing and Interpreting Circle Graphs

The objective "to construct and interpret circle graphs" was evaluated in the 3rd question in posttest. The 3rd question is given in Figure 4.9 below:

Question 3:

Table: Mathematics exam results of students

Results	Numbers of students
0	1
1	4
2	0
3	13
4	10
5	8

Mathematics exam results of students are given in the table above. Accordingly,

a) Draw a circle graph showing numbers of students by using the data given.

b) Interpret the graph.

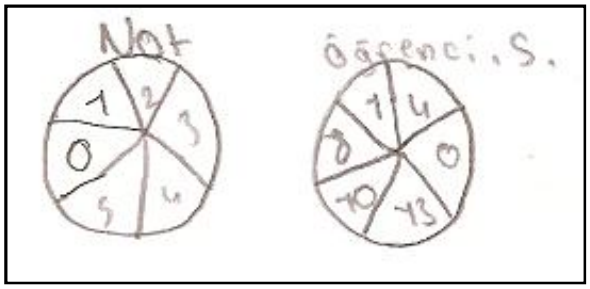
Figure 4.9. The 3rd Question in Posttest

The 3rd question included two parts in which students were expected to draw a circle graph to show the data given in the table accurately and to interpret it correctly. Hence, to investigate the students' typical errors and possible misconceptions, incorrect responses were analyzed and the frequency of each response was calculated.

In the analysis process of 3rd question, only the most common incorrect response types were examined to determine the students' typical errors and possible misconceptions.

The frequency of students' incorrect responses and examples of each response for part (a) in the 3rd question is given in Table 4.28.

Table 4.28. The Frequency of Students' Incorrect Responses with Examples for Part (a) in the 3rd Question

	Response Type	Frequency of students for each response (f)
Part a	Draw more than one circle graph. 	**2**
	Write an incorrect title for the circle graph.	**0**
	Write no title for the circle graph.	**37**
	Show only numbers of students in the circle graph as given in the table. 	**16**
	Show both numbers of students and Mathematics exam results of them in the circle graph as given in the table.	**0**

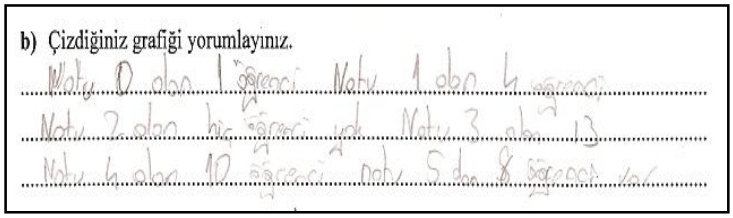
The analysis of posttest results showed that the students had common possible misconceptions about constructing and interpreting circle graphs in both pretest and posttest.

In the third question, although the students were asked to draw a circle graph showing only numbers of students, they drew two circle graphs one of which was used to show students' numbers and other was used for representing Mathematics exam results of these students. In addition, most of the students also did not convert

numbers of students given in the table into degrees and they showed the numbers of students directly in the circle graph as given in the table. It seemed that the students had possible misconceptions that circle graphs could be drawn to show the data in two criteria and showed the numbers of students directly in the circle graph as given in the table. Hence, that the students had possible misconceptions or errors might be due to the teacher's instruction in which the students were not given opportunities to answer more questions about circle graphs as examples.

Table 4.29 below presents the frequency of students' incorrect responses and an example of these responses for part (b) of question 3.

Table 4.29. The Frequency of Students' Incorrect Responses with an Example for Part (b) in the 3rd Question

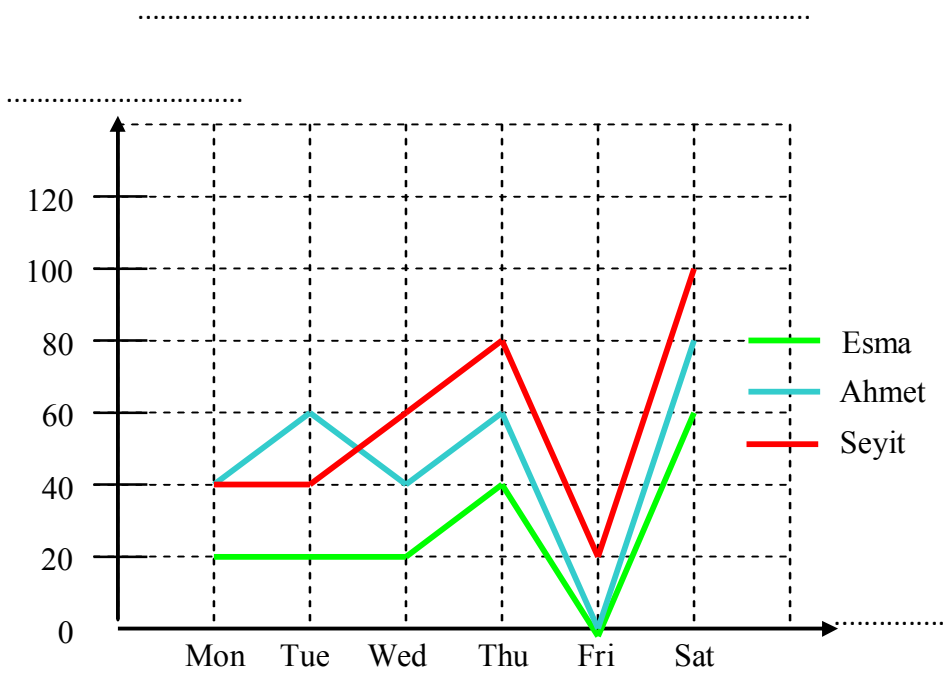
	Response Type	**Frequency of students for each response (f)**
Part b	Incorrect interpretation. 	**17**

In the situation "incorrect interpretation", many students did not interpret circle graphs, rather they stated the numbers of the students and their Mathematics examination results. It seemed that the students interpreted the question in this way due to a possible misconception that interpreting a graph means repeating the information given to them and this might be the result of the lack of the questions that were not provided by the teacher in the instruction process.

4.3.4. Reading and Interpreting Line Graphs

The objectives "to interpret line graphs based on more than one criterion." and "to formulate predictions based on the data" were evaluated in the 4th question in posttest. The 4th question is given in Figure 4.10 below:

Question 4:



Esma, Ahmet and Seyit have read the same book for a week. Numbers of pages they read in six days are given in the table above. Accordingly,

a) Write the title and the names of axes in the blanks given above.

b) Which days did Ahmet read more pages than his friends?

c) How many pages did Seyit read more pages than Ahmet in six days?

d) Can the numbers of pages which they read on Sunday be guessed by using the information given in the graph? Explain.

e) Interpret the graph.

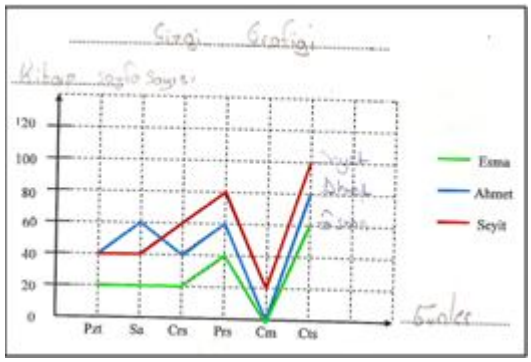
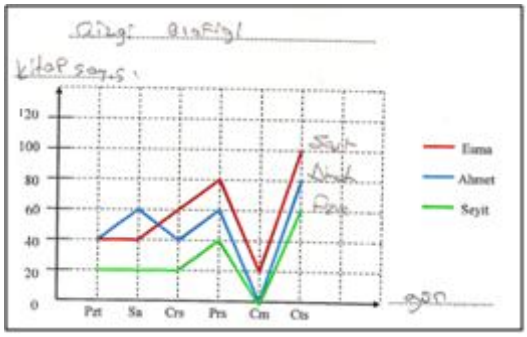
Figure 4.10. The 4th Question in Posttest

The 4th question included four parts in which the students were expected to write the title and names of axes for a given line graph and, read and interpret it correctly. Hence, to investigate students' typical errors and possible misconceptions, the incorrect responses were analyzed and the frequency of each response was calculated.

In the analysis process of second question, only incorrect response types were focused to determine the students' typical errors and possible misconceptions.

The frequency of students' incorrect responses and examples of each response for part (a) in the 4th question was given in Table 4.30.

Table 4.30. The Frequency of Students' Incorrect Responses with Examples for Part (a) in the 4th Question

	Response Type	Frequency of students for each response (f)
Part a	Write an incorrect title for the graph. 	**16**
	Write no title for the graph.	**9**
	Write an incorrect name for the vertical axis of the graph. 	**6**
	Write no name for the vertical axis of the graph.	**2**
	Write an incorrect name for the horizontal axis of the graph.	**0**
	Write no name for the horizontal axis of the graph.	**5**

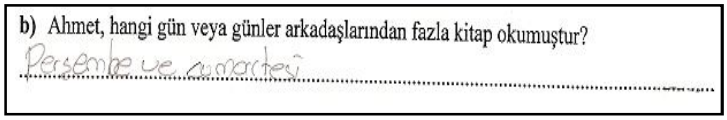
In part (a), the results showed that students wrote "line graph" as the title of the line graph given in the question. It seemed that the students wrote this title due to a possible misconception that the title of a graph would be the type of it and this might be the result of the teacher's instruction in which the students were not provided more questions as examples.

The analysis of students' responses showed that the students generally could not write title or names of vertical or horizontal axis. In addition, the students'

responses showed that they wrote incorrect name for the vertical axis such as "numbers of books" instead of "numbers of book pages." Hence, that the students wrote incorrect responses for the title of the graph or the name of vertical axis or they did not write any title or names for axes might be due to the typical errors made as a result of carelessness, having the lack of knowledge, and having misconceptions.

Table 4.31 below presents the frequency of students' incorrect responses and an example of these responses for part (b) of question 4.

Table 4.31. The Frequency of Students' Incorrect Responses with an Example for Part (b) in the 4th Question

	Response Type	**Frequency of students for each response (f)**
Part b	Incorrect answer. 	**38**

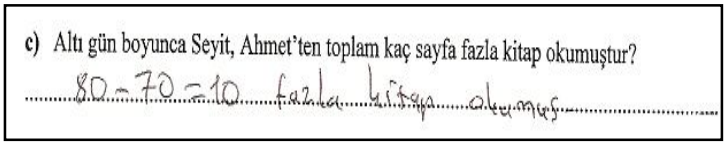
In part (b), students gave different incorrect answers such as "Ahmet read more pages than his friends on Thursday and Saturday" and "On Friday, Ahmet read more pages than his friends."

In the teacher's instruction process, the teacher did not fully follow the curriculum objectives. Although there are five objectives in the 7th-grade MONE curriculum about the graphs concept, her instruction was based on the first two objectives such as "to construct and interpret bar graphs and line graphs based on more than one criterion" and "to construct and interpret circle graphs." She did not consider the remaining objectives such as "to develop ideas for the real life situations by constructing and interpreting statistical representation forms," "to formulate predictions based on the data," and "to explain the situations that line graphs, pictographs, or object graphs might address incorrect interpretations." This influenced students' responses in the pretest and posttest which were prepared based on the objectives in the MONE curriculum. As a result, the regular classroom instruction of this teacher did not have any influence on some of the students' typical

errors and possible misconceptions about reading line and bar graphs and the students' prior knowledge had an effect on these errors and misconceptions.

Table 4.32 below presents the frequency of students' incorrect responses with an example of these responses for part (c) of question 4.

Table 4.32. The Frequency of Students' Incorrect Responses with an Example for Part (c) in the 4th Question

	Response Type	Frequency of students for each response (f)
Part c	Incorrect answer.  c) Altı gün boyunca Seyit, Ahmet'ten toplam kaç sayfa fazla kitap okumuştur? 80-70=10 fazla kitap okumuş.	**46**

In part (c), students gave incorrect answers such as "Seyit read 10 more pages than Ahmet in six days." The reason of this response also seemed to the students' typical errors made as a result of students' prior knowledge.

Table 4.33 below presents the frequency of students' incorrect responses and examples of each response for part (d) of question 4.

Table 4.33. The Frequency of Students' Incorrect Responses with Examples for Part (d) in the 4th Question

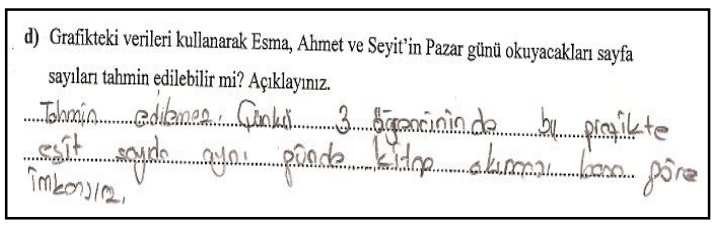
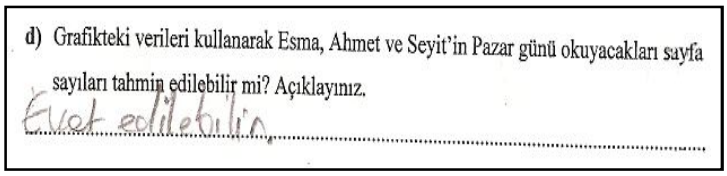
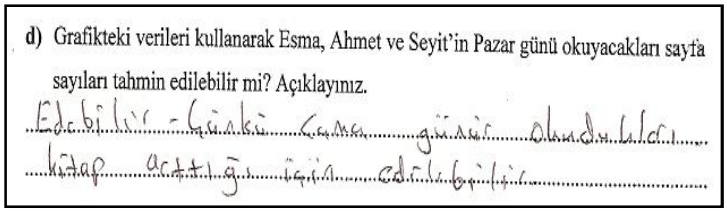
	Response Type	Frequency of students for each response (f)
Part d	Correct answer with incorrect explanation.  d) Grafikteki verileri kullanarak Esma, Ahmet ve Seyit'in Pazar günü okuyacakları sayfa sayıları tahmin edilebilir mi? Açıklayınız. Tahmin edilemez. Çünkü 3 öğrencinin de bu grafikte eşit sayıda aynı günde kitap okuması kesin pek imkansız.	**5**

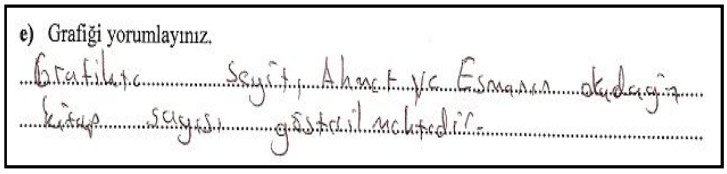
Table 4.33. (Continued)

	Response Type	Frequency of students for each response (f)
Part d	Incorrect answer without any explanation.  	**11**
	Incorrect answer with explanation.  	**26**

In part (d), the results showed that since numbers of pages Esma, Ahmet, and Seyit read increased on Friday, numbers of pages which they read on Sunday could be guessed. It seemed that students gave this answer due to a possible misconception of focusing on one point while reading and interpreting line graphs instead of thinking the graph as a whole and this might be result of their prior knowledge. The students also gave the answer "no" as an incorrect answer without any explanation. This might be because they did not have any knowledge about guessing.

Table 4.34 below presents the frequency of students' incorrect responses and an example of these responses for part (e) of question 4.

Table 4.34. The Frequency of Students' Incorrect Responses with an Example for Part (e) in the 4th Question

	Response Type	Frequency of students for each response (f)
Part e	Incorrect interpretation.  	**30**

In part (e), many students incorrectly interpreted the graph and they stated that the pages the friends read were shown in the graph. In the interview, Student H was asked to interpret line graph, but he could not interpret clearly and he only repeated his response in posttest as the following:

> *"In the graph, numbers of pages read by Seyit, Ahmet and Esma were given."*

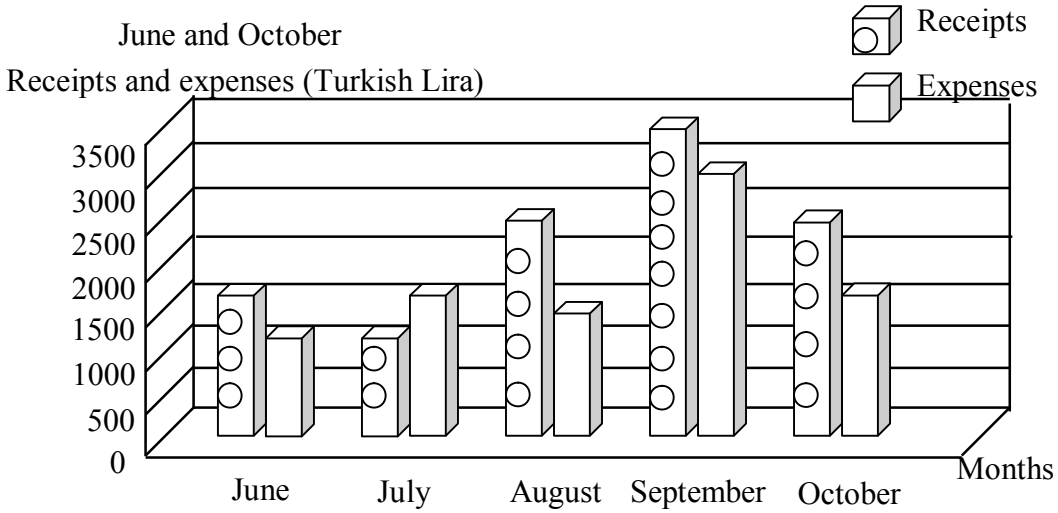
It seemed that the students interpreted line graph in this way due to a possible misconception that interpreting a graph meant repeating the information given by it and this might be the result of teacher's instruction in which the students were not provided much opportunities to answer more questions as examples.

4.3.5. Reading and Interpreting Bar Graphs

The objectives "to interpret bar graphs based on more than one criterion" and "to develop ideas for the real life situations by constructing and interpreting statistical representation forms" were evaluated in the 5th question in posttest. The 5th question is given in Figure 4.11 below:

Question 5:

Graph: The data of receipts and expenses in between the months



The state of receipts and expenses of a market owner for five months is shown in the graph above. According to this, fill in the blanks below:

a) The total amount of receipts is…….TL.

b) The total amount of expenses is ……....TL.

c) The most receipts were obtained in the month,……

d) The most expenses were obtained in the month,……

e) The market owner made the most profits in the month, ……..

f) The profits made in the months.....and.....were the same. The market owner made a loss in a month. What could be the reasons of this situation? Explain.

Figure 4.11. The 5th Question in Posttest

The 5th question included six sub-questions in which the students were expected to read and interpret the bar graph given in the question correctly. Hence, to investigate the students' typical errors and possible misconceptions, the incorrect responses were analyzed and the frequency of each response was calculated.

In the analysis process of 5th question, only the most important response types were focused to determine the students' typical errors and possible misconceptions.

The frequency of students' incorrect responses and examples of each response for part (a) in the 5th question was given in Table 4.35.

Table 4.35. The Frequency of Students' Incorrect Responses with an Example for Part (a) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part a	Incorrect answer. a) Toplam gelir..... 11000 ..... TL'dir.	**59**

In part (a), one of a students' incorrect answer was that the difference between the total amount of receipts was 11000 TL. It seemed that the students gave this answer due to their typical errors made as a result of carelessness and their prior knowledge.

Table 4.36 below presents the frequency of students' incorrect responses and an example of these responses for part (b) of question 5.

Table 4.36. The Frequency of Students' Incorrect Responses with an Example for Part (b) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part b	Incorrect answer. b) Toplam gider..... 8500 ..... TL'dir.	**51**

In part (b), the most common student incorrect answer was that total amount of expenses was 8500 TL. It also seemed that typical errors that might be made as a result of carelessness and their prior knowledge.

Table 4.37 below presents the frequency of students' incorrect responses and an example of these responses for part (c) of question 5.

Table 4.37. The Frequency of Students' Incorrect Responses with an Example for Part (c) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part c	Incorrect answer. c) En çok gelir 3000 ayında elde edilmiştir.	**7**

In part (c), the most common incorrect answer was giving the answer in numbers and they stated that the most of the receipts obtained in the month were 3000. Hence, that the student gave such a response because of typical errors made as a result of carelessness and their prior knowledge.

Table 4.38 below presents the frequency of students' incorrect responses and an example of these responses for part (d) of question 5.

Table 4.38. The Frequency of Students' Incorrect Responses with an Example for Part (d) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part d	Incorrect answer. d) En çok gider 2500 ayında gerçekleşmiştir.	**17**

In part (d), the students also wrote that July was the month in which the expenses were obtained the most or the most expenses were obtained in the month, and the value was 2500. It also seemed that the students gave this answer as due to their typical errors they might be made as a result of carelessness and their prior knowledge.

Table 4.39 below presents the frequency of students' incorrect responses and an example of these responses for part (d) of question 5.

Table 4.39. The Frequency of Students' Incorrect Responses with an Example for Part (e) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part e	Incorrect answer. e) Market sahibi en çok ....Eylül.....ayında kar etmiştir.	**31**

In part (e), the students gave an answer such as the market owner made the most profits in September. It seemed that the students had a possible misconception of focusing on the height of the bars while reading the bar graphs and this might be the result of their prior knowledge.

Table 4.40 below presents the frequency of students' incorrect responses and an example of these responses for part (f) of question 5.

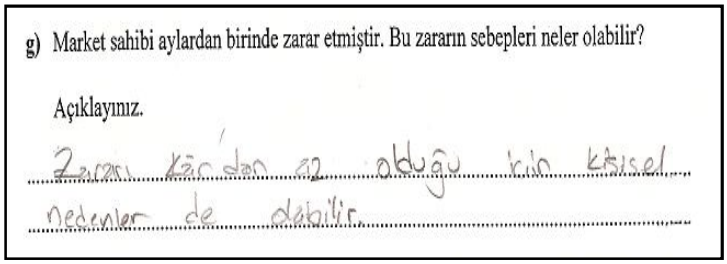
Table 4.40. The Frequency of Students' Incorrect Responses with an Example for Part (f) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part f	Incorrect answer. f) .....Haziran..... ile.....Temmuz....aylarında elde edilen karlar eşittir.	**58**

In part (f), the students also said that the profits made in the months June and July were the same. It seemed that students had typical errors made as a result of carelessness and their prior knowledge.

Table 4.41 below presents the frequency of students' incorrect responses and an example of these responses for part (g) of question 5.

Table 4.41. The Frequency of Students' Incorrect Responses with an Example for Part (g) in the 5th Question

	Response Type	Frequency of students for each response (f)
Part g	Incorrect interpretation.  g) Market sahibi aylardan birinde zarar etmiştir. Bu zararın sebepleri neler olabilir? Açıklayınız. Zarar kar dan az olduğu için kişisel nedenler de olabilir.	**11**

In part (g), students' incorrect interpretation was that since the total amount of deficits were less than the total number of the profits, there were personal problems. It seemed that the students gave answer as a result of the typical errors they had due to their carelessness and prior knowledge.

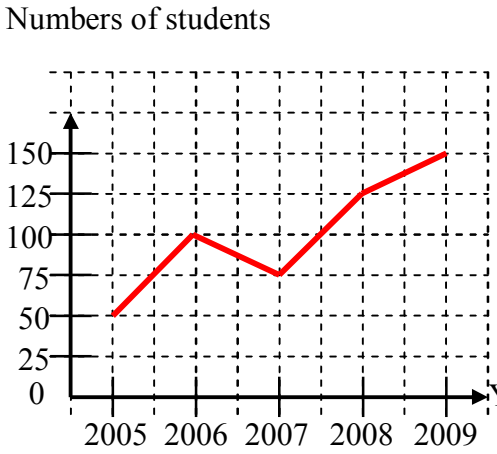
4.3.6. Explaining the Situations Line Graphs might Address Incorrect Interpretations

The objective "to explain the situations that line graphs, pictographs, or object graphs might address incorrect interpretations" was evaluated in the 6th question in posttest. The 6th question is given in Figure 4.12 below:

Question 6:

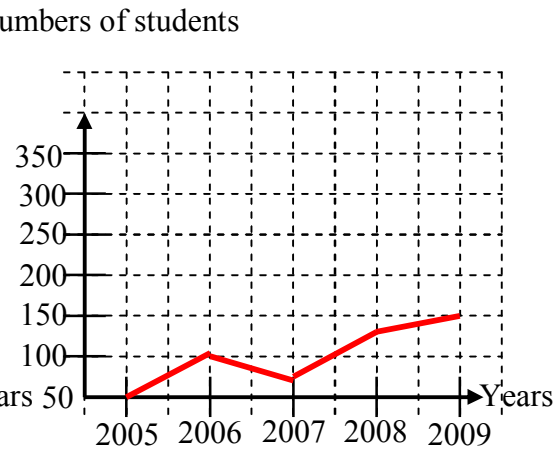
A

Graph: Numbers of students entered a university in between the years 2005 and 2009



B

Graph: Numbers of students entered a university in between the years 2005 and 2009



Numbers of students who entered the university in a test preparation center in 2005 and 2009 are given in the graphs above. Accordingly,

a) Explain the differences between the graphs.

b) Which graph should be used for the advertisement of the test preparation center? Explain your answer.

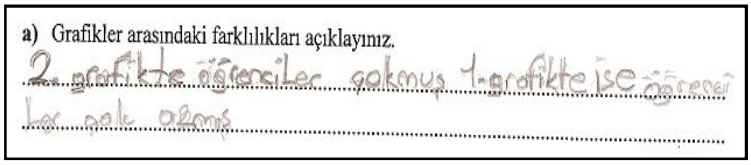
Figure 4.12. The 6th Question in Posttest

The 6th question included two parts in which the students were expected to interpret the differences between the graphs correctly and to state and explain which graph should be used for the advertisement of the test preparation center. Hence, to investigate the students' typical errors and possible misconceptions, incorrect response situations in parts were analyzed and the frequency of students was calculated.

In the analysis process of 6th question, only the most common incorrect response types were examined to determine typical errors and possible misconceptions the students had.

The frequency of students' incorrect responses and an example of these responses for part (a) in the 6th question is given in Table 4.42.

Table 4.42. The Frequency of Students' Incorrect Responses with an Example for Part (a) in the 6th Question

	Response Type	Frequency of students for each response (f)
Part a	Incorrect explanation.  	**38**

The analysis of posttest results showed that the students had common possible misconceptions about explaining the situations represented in line graphs in both pretest and posttest.

In part (a), the most common "incorrect explanation" was that numbers of students in graph B were more than those in graph A. Students' answers might address a possible misconception that two graphs with different scales were different and this might be the lack of questions in teacher' instruction.

Table 4.43 below presents the frequency of students' incorrect responses and examples of each response for part (b) of question 6.

Table 4.43. The Frequency of Students' Incorrect Responses with Examples for Part (b) in the 6th Question

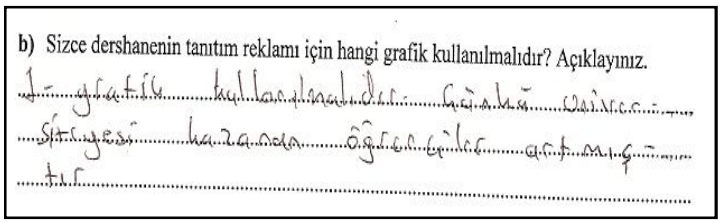
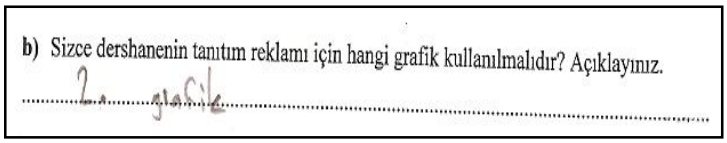
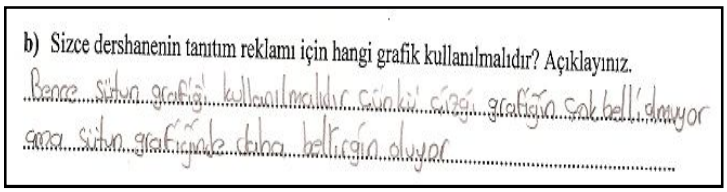
	Response Type	Frequency of students for each response (f)
Part b	Correct answer with incorrect explanation.  	**15**

Table 4.43. (Continued)

Response Type		Frequency of students for each response (f)
	Incorrect answer without any explanation.  	**5**
	Incorrect answer with explanation.  	**18**

In part (b), the students' responses showed that the graph A should be used for the advertisement of the test preparation center since number of students who entered a university between the years 2005 and 2009 increased in this graph. Students' answer might indicate a possible misconception that two graphs which show the same thing with different scales were different and this might be the lack of this kind of questions. Moreover, students' incorrect answer without any explanation was that the bar graph should be used for the advertisement of the test preparation center, because bar graphs were clearer than line graphs and hence, that the students gave such an answer might be due to typical errors made as a result of carelessness and their prior knowledge.

4.3.7. Summary of Posttest Results

The analysis of posttest results showed that the students had possible misconceptions about using, constructing, reading, and interpreting line, bar, and circle graphs after the regular mathematics instruction, which were parallel to those in pretest.

The students' possible misconceptions about use of bar graphs was that the table and the bar graphs were the same and only bar graphs were used to show the

data in two criteria. Another possible misconception the students had was that the data including decimal numbers could not be converted into percentage and the ratios given in percentage could not be showed by using bar graphs or the circle graphs were used to show the data including two criteria. Hence, that the students had possible misconceptions about use of line, bar, and circle graphs might be the result of the teacher's instruction in which they were not provided much opportunities to see the differences between the purpose of using line, bar, and circle graphs in sufficient questions.

According to the posttest results, the students had also possible misconceptions about constructing line and bar graphs. The students wrote "line graph", "bar graph" or the sentences beginning with "Table:…." as the title of the graph. They drew bar graphs by using a vertical axis representing values of a categorical variable and a horizontal axis representing values of a quantitative variable. Also, they drew line graphs with a categorical vertical axis and with a quantitative horizontal axis by using vertical bars instead of horizontal bars. Moreover, they did not join the points determined on the graph according to the given data with straight lines in line graphs. The students did not put zero on the intersection point of axes, rather they identify zero up to the horizontal axis of the graphs with a horizontal axis for categorical variable and a vertical axis for quantitative variable. On the contrary, the students drawing graphs with a categorical vertical axis and with a quantitative horizontal axis identify the value zero to the right of intersection point of the axes on the horizontal axis. On the other hand, there were students who drew graphs by plotting the values of the variable in the exact same order as given in the table while many students plotted the values of the variable in numerical order with appropriate intervals and no space between identical values, by not taking into consideration of the distance between the starting point (zero), and the first value in the order. The lack of questions in teacher's instruction might be result of these situations.

The posttest results also showed that the students' had typical errors about constructing line and bar graphs and these typical errors might be the result of their carelessness, having lack of knowledge, or having misconceptions. The students drew line graphs for the data given in two criteria in second question in posttest though the correct type of graph was a bar graph. Many students drew circle graphs

for this question. In addition, the students wrote incorrect name for the vertical axis or they did not write any title or names for axes.

Posttest results also showed that the students had possible misconceptions about reading and interpreting line and bar graphs. While reading and interpreting line graphs, the students focused on one point instead of thinking the whole graph or they focused on the height of the bars while they were reading the bar graphs. In addition, when the information was not given in graphs, it could not be guessed. They interpreted graphs by repeating the information given to them. The analysis of students' responses also showed that the students had typical errors about reading and interpreting line and bar graphs and they gave incorrect responses to the questions about them.

The analysis of posttest results showed that the students had common possible misconceptions about constructing and interpreting circle graphs. They drew circle graphs to show the data including two criteria and they interpreted circle graphs by repeating the information given to them. As a result, that the students had such kind of possible misconceptions probably as a result of the insufficiency of questions and in teacher's instruction.

Posttest results also showed that the students had possible misconceptions about explaining the situations represented in line graphs. The students thought that in line graphs, the value on the horizontal axis as zero although the graphs started from a number different from zero and two graphs which showed the same thing with different scales were different.

4.4. Teacher's Awareness of 7th-Grade Student' Typical Errors and Possible Misconceptions in Graphs Concept

The mathematics teacher's awareness of 7th-grade students' typical errors and possible misconceptions in graphs concept were investigated through the interview conducted by the teacher. The teacher was asked questions about pretest and posttest results of the students who had typical errors and possible misconceptions in graphs concept.

Misconception is defined as the students' perception of concepts differently than their definitions which are scientifically accepted (Keşan & Kaya, 2007). On the other hand, errors are defined wrong answers made as a result of carelessness, the

lack of knowledge or having misconceptions. Hence, the term "misconception" is used to address students' conceptions that construct a systematic pattern of errors (Smith, diSessa, & Roschelle, 1993) and all misconceptions are errors, but not all errors address misconceptions.

In the interview, the teacher was initially asked about the difference between the terms "misconception" and "error." She explained as follows:

> "*Not understanding the concepts or subjects was a misconception, but error was something like… an operation mistake. In error, the idea was formed correctly and the logic was also correct.*"

She also claimed that "*a misconception can sometimes cause error.*"

The questions in the interview were prepared based on the typical errors and possible misconceptions that the students had. The 1st question in the posttest in which the student's explanation about the circle graph was correct, but he had a possible misconception that a circle graph was suitable to show data in both one and two criteria. This question in Figure 4.13 was asked to the teacher.

Question 2:

Tablo: 2008-2009 yıllarında bir ülkeye gelen yabancı turist sayısı

Ulaşım şekli	Yıllar	
	2008	2009
Deniz yolu	3,5 milyon	2 milyon
Hava yolu	6 milyon	5 milyon
Kara yolu	2,5 milyon	1 milyon

Yukarıdaki tabloda, 2008-2009 yıllarında bir ülkeye deniz yolu, hava yolu ve kara yolu ile gelen yabancı turist sayısı verilmiştir. Buna göre,

c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

Evet olur. Daire grafiğinde aralar belirtilerek gösterilir.

Figure 4.13. The 2nd Question in the Interview

The teacher commented about the response as follows:

> "*The student's answer was incorrect. He knew that circle graphs were formed by using the ratios. His explanation was correct, but the answer was wrong. Iımmm…. he had a misconception.*"

The teacher was presented by the student's misconception given in Figure 4.14 for the 2nd question in the pretest. In this question, the student had two possible misconceptions of drawing a line graph with categorical vertical axis and with quantitative horizontal axis and plotting the values of variable in numerical order with appropriate intervals by not taking into consideration the distance between the starting point, zero and the 1st value in the order.

The teacher commented that the student's choice of graph type was incorrect and she explained that "*a bar graph with a categorical vertical axis and a quantitative horizontal axis can be drawn, but I did not see any line graphs like that.*" She claimed that student's naming of the axes was an error because "*Being a misconception means that he cannot do anything and he doesn't know the subject.*"

Question 3:

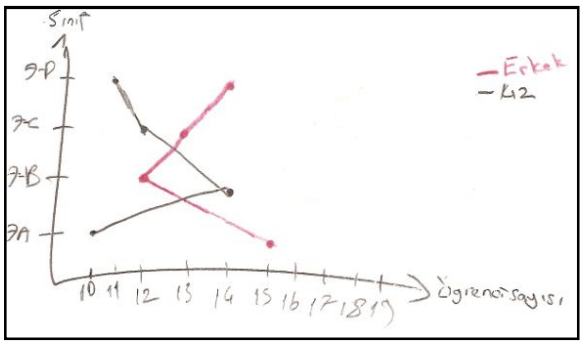


Figure 4.14. The 3rd Question in the Interview

When the measurement of vertical axis was pointed by the researcher and asked if that was a misconception or an error, the teacher expressed the following:

> *"It changes according to the student. If a student is successful, [I would say] he made an error. If he is a lazy student, it is a misconception… Iımmm… If he did it quickly, it was an error."*

The student response in Figure 4.15 for the 2nd question in posttest in which the student had a possible misconception of identifying the zero up to the x-axis in graphs with quantitative vertical axis and with categorical horizontal axis was presented to the teacher. The teacher claimed that although student's choice of the graph type was correct, his/her drawing was incorrect, which she addressed as a misconception.

Question 4:

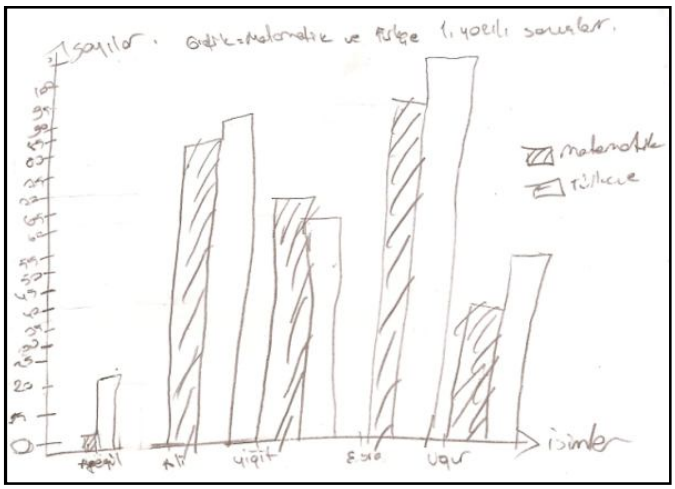
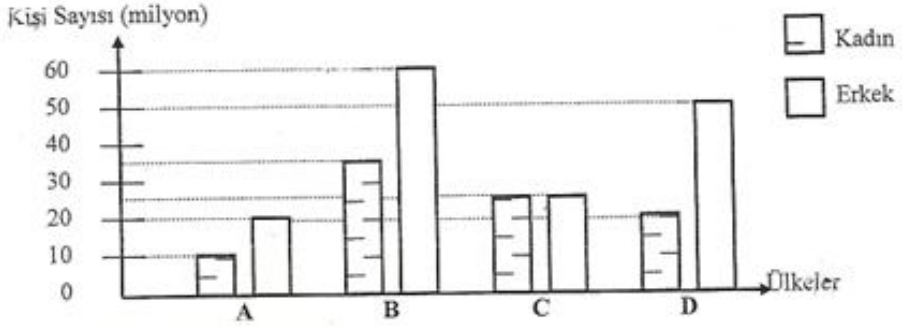


Figure 4.15. The 4th Question in the Interview

The correctness of the student' responses which were errors made as result of carelessness or the lack of knowledge or having misconceptions in Figure 4.16 for the 5th question in the pretest were asked to the teacher.

Question 5:

Grafik: Ülkelere göre araba kullanan kadın ve erkek sayısı



Yukarıdaki grafik, dört farklı ülkedeki araba kullanan kadın ve erkek sayılarını göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

b) Araba kullanan kadın ve erkek sayıları arasındaki farkın en fazla olduğu ülke .....B.....'dır.

c) Araba kullanan kadınların oranı .....B.....ülkesinde en fazladır.

Figure 4.16. The 5th Question in the Interview

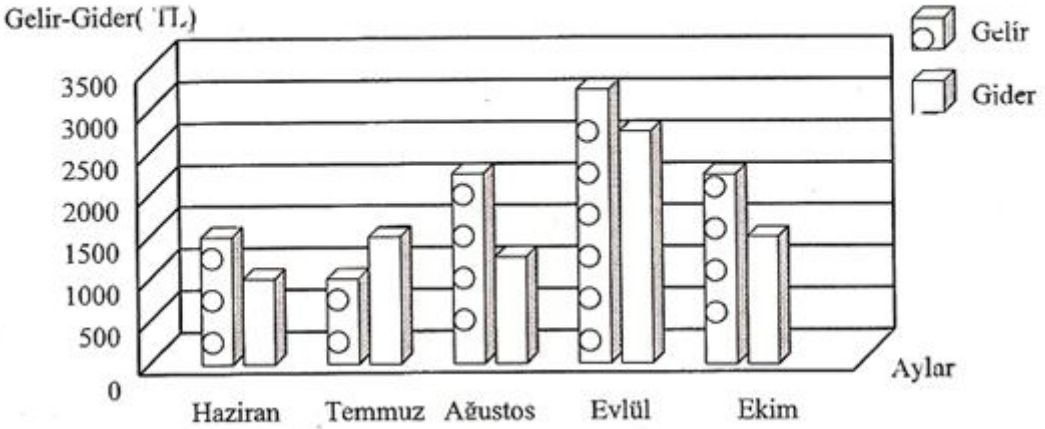
She claimed that the responses were incorrect and commented about the response was as follows:

> "*Iuuummm... He had a misconception… Oohhh no. He made an error because he might answer the questions quickly.*"

For the 5th question in the posttest, students' responses which were errors made as result of carelessness or the lack of knowledge or having misconceptions in Figure 4.17 were asked to the teacher. She commented that the student might have answered the questions quickly and so she/he made errors.

Question 6:

Grafik: Haziran-Ekim ayları arasında gelir-gider verileri



a) Toplam gelir.....11000..... TL'dir.

b) Toplam gider.....8500..... TL'dir.

c) En çok gelir.....3000.....ayında elde edilmiştir.

d) En çok gider.....Temmuz.....ayında gerçekleşmiştir.

e) Market sahibi en çok .....Eylül.....ayında kar etmiştir.

f) .....Haziran..... ile.....Temmuz....aylarında elde edilen karlar eşittir.

Figure 4.17. The 6th Question in the Interview

The interview with the teacher about students' responses showed that teacher's knowledge of students' typical errors and possible misconceptions were limited. She could not fully distinguish between students' errors and misconceptions and she first considered the students' achievement level in categorizing errors and misconceptions.

4.5. Summary of the Findings

In the study, the reliability analysis of pretest and posttest indicated that there was a considerable relationship between the test items within the pretest and posttest.

The result of data analysis showed that there were typical errors and possible misconceptions the students had before and after the regular mathematics instruction. Students' had possible misconceptions about the usage, construction, reading, and interpretation of line, bar, and circle graphs. However, the comparison of pretest and posttest results showed that while there were differences between the students' possible misconceptions in pretest and posttest, some misconceptions decreased or increased, or did not change from pretest to posttest. The frequency of possible misconceptions in pretest and posttest is given in Table 4.44.

Table 4.44. The Frequency of Possible Misconceptions in Pretest and Posttest

Possible Misconceptions	**The frequency of students in pretest (f)**	**The frequency of students in posttest (f)**
• Line graphs are used to compare things between different groups.	**3**	**0**
• Line graphs are the most suitable type of graphs to show percentage ratios.	**2**	**0**
• The data in percentage is only used in circle graphs.	**4**	**0**
• The ratios are not showed in circle graphs, only degrees are used in circle graphs.	**8**	**0**
• The table and the bar graphs are the same.	**0**	**3**
• Any type of the graphs is suitable to show the data when all the information is given.	**7**	**7**
• Only bar graphs are used to show the data in two criteria.	**0**	**8**
• The data including decimal numbers cannot be converted into percentage.	**0**	**2**
• Write "line graph", "bar graph" or the sentences beginning with "Table:…." as the title of the graph	**15**	**7**
• Draw bar graphs with a categorical vertical axis and with a quantitative horizontal axis by using vertical bars instead of horizontal bars.	**4**	**5**
• Draw line graphs by using a vertical axis representing values of a categorical variable and a horizontal axis representing values of a quantitative variable.	**3**	**1**
• In line graphs, fail to join the points determined on the graph according to the given data with straight lines.	**7**	**0**

Table 4.44. (Continued)

Possible Misconceptions	The frequency of students in pretest (f)	The frequency of students in posttest (f)
• Identify zero up to the horizontal axis of the graphs with a quantitative vertical axis and with a categorical horizontal axis.	**2**	**38**
• Identify zero to the right of intersection point of axes on the horizontal axis of the graphs with a categorical vertical axis and with a quantitative horizontal axis.	**0**	**1**
• Plot the values of the variable in the exact same order as given in the table.	**8**	**31**
• Plot the values of the variable in numerical order with appropriate intervals and no space between identical values by not taking into consideration of the distance between the starting point, zero and the first value in the order.	**25**	**6**
• Focus on one point while reading and interpreting line graphs instead of thinking the whole graph.	**12**	**18**
• Focus on the height of the bars while reading the bar graphs.	**18**	**29**
• When the information was not given in graphs, it could not be guessed.	**5**	**7**
• Interpret line graphs by repeating the information given.	**16**	**24**
• Draw circle graphs to show the data including two criteria.	**8**	**0**
• Interpret circle graphs by repeating the information given.	**14**	**17**
• In line graphs, the value on the horizontal axis as zero although the graphs started from a number different from zero.	**9**	**0**
• Two graphs which show the same thing with different scales were different.	**25**	**26**

The regular mathematics instruction had both a positive and negative effect on students' understanding of graphs concept. It might also indicate that while some of the students' errors or misconceptions were covered by the regular mathematics instruction, there were increased misconceptions or new misconceptions detected in posttest.

The interviews conducted with the selected students addressed that the students had also common possible misconceptions in graphs concept. The observation findings of teacher's instruction showed that the teacher did not fully discover and prevent students' possible misconceptions. She ignored the reasons behind students' questions or their responses to her questions and missed the opportunity to understand students' thinking in the graphs concept. The findings of the interview conducted with the teacher indicated that her knowledge of students' typical errors and possible misconceptions were limited. To categorize misconception and error, she initially considered the students' achievement level and she could not fully differentiate students' errors and misconceptions.

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

The main purpose of this study was to examine 7th-grade students' typical errors and possible misconceptions in graphs concept before and after the regular mathematics instruction. In this chapter, first, findings of the study will be summarized and then, the implications about the major findings will be discussed. Recommendations and implications for future research will also be presented.

5.1. Discussion

In this study, the comparison of pretest and posttest results showed that while students' typical errors and possible misconceptions about using, constructing, reading, and interpreting line, bar, and circle graphs appeared in the pretest decreased or increased or did not change in the posttest, there were new typical errors and possible misconceptions detected in the posttest. It seemed that the regular mathematics instruction of the mathematics teacher had a considerable effect on this situation. These typical errors and possible misconceptions will be mentioned below in detail.

5.1.1. Typical Errors and Possible Misconceptions about Use of Line, Bar and Circle Graphs

The analysis of students' responses in pretest and posttest showed that although students' misconceptions in the pretest differed from those in the posttest, students' common misconception about the use of line, bar, and circle graphs were detected in both pretest and posttest.

In the study, the teacher provided students the purpose of using line, bar, and circle graphs. She emphasized that while line graphs were used for tracking changes over short and long periods of time, bar graphs were utilized in order to compare things between different groups and see the numbers more clearly. Also, she gave an explanation that circle graphs were used for comparing the parts of a whole as the

purpose of using circle graphs. Although the analysis of pretest and posttest results showed that there were students' correct responses parallel to these explanations, different students' responses addressed possible misconceptions which were detected in pretest and posttest.

Before the instruction, the common misconception about line graphs was that line graphs would be used to compare things between different groups and they were the most suitable type of graphs for showing percentage ratios. Another misconception about bar graphs was that circle graphs were used to show the data in percentage although the percentage symbols were not used in bar graphs. Also, only degrees were used in circle graphs. The ratios would not be showed in circle graphs was the common misconception the students had about circle graphs.

The posttest results showed that after the instruction, the students had a misconception which was the table and the bar graphs were the same. In addition, the data including decimal numbers could not be converted into percentage and the ratios given in percentage could not be showed by using bar graphs were other common misconceptions the students had.

In the study, before the observation process, while the students had knowledge about line and bar graphs, they did not have any knowledge about the circle graphs. Therefore, students gave explanations in the pretest in these ways due to their prior knowledge. On the other hand, during the instruction process, the teacher did not ask more questions about line, bar, and circle graphs. She asked only one question for each type of graphs. It seemed that students' misconceptions might be the result of the teacher's instruction in which she did not provide detailed explanations about the use of line, bar, and circle graphs to the students, she did not compare the purposes of using them, and she did not give much opportunities for the students to answer different questions as examples.

The analysis of pretest and posttest results also showed that the frequency of students who generally tended to draw bar graphs to show the data including two criteria increased in the posttest. Their choice about the type of graph was correct for the data given to them, but when the students were asked why they chose to draw a bar graph, they said drawing a bar graph was easier. This referred to the common possible misconception about the use of line, bar, and circle graphs of the students in

both pretest and posttest that when all the information was given, any type of the graphs would be suitable to show the data.

5.1.2. Typical Errors and Possible Misconceptions about Constructing Line and Bar Graphs

The students have a tendency to reverse x and y coordinates on graphs (Kerslake, 1993). The pretest and posttest results showed that there was an increase in the frequency of students who drew bar graphs with a vertical axis used for a categorical variable and a horizontal axis utilized for a quantitative variable by drawing vertical bars instead of horizontal bars. In the instruction process, the teacher drew a bar graph with a categorical vertical axis and a quantitative horizontal axis in only one section, she did not give any more examples in other sections. Hence, that the teacher did not show different types of bar graphs in all sections might be the reason of the increase in the frequency of students who drew such kind of bar graphs.

When the students encounter new situations, they poorly transfer their knowledge on these situations (Kerslake, 1993). They tend to transfer their knowledge about more familiar representations to the newer representations while interpreting or generating them (Baker, Corbett, & Koedinger, 2001). In the study, there was a decrease in the frequency of the students who drew line graphs with a vertical axis representing categorical variable and a horizontal axis representing quantitative variable. In one section, the teacher gave an example of a bar graph with categorical vertical axis and with quantitative horizontal axis. However, she did not mention whether a line graph with a vertical axis representing categorical variable and a horizontal axis presenting a quantitative variable could be drawn or not in any of the four sections. Hence, teacher's instruction also might cause the students transfer their knowledge and the decrease in the frequency of students who drew such line graphs in the posttest. In addition, in the study, there was a decrease in the frequency of students who did not join the points they plotted on the graphs based on the data given. Since the teacher did not give more examples about line graphs, the possible reason of this situation might be that the students who learnt line graphs in previous years remembered what they knew about line graphs.

Since the students learnt different sets of representations in different grade levels (NCTM, 2000), the old representations encountered earlier levels are the important models for learning new representations. Before the instruction, the students in the study had knowledge about construction and interpretation of line and bar graphs including data with one criterion. During the instruction, as an example about bar graphs, the teacher asked the same question in which the students were wanted to draw a bar graph by using the data including two criteria in all sections. However, she did not ask such a question in teaching process of line graphs. In fact, although the objective given in the MONE curriculum was related to forming a line graph according to more than one criterion, she asked a question in which the students were wanted to draw a line graph by using the data including one criterion. Thus, that the students did not learn to draw line graphs including data in two criteria might cause them to draw only bar graphs to show such kind of data given in pretest and posttest, which could not be considered as a possible misconception.

The questions in pretest and posttest were prepared based on the 7th-grade curriculum objectives. Hence, in both tests, there was not any question about the histogram which the students will learn in the 8th-grade and scatterplots which do not take a place in Turkish mathematics curriculum. However, according to the research studies related to histogram and scatterplots, middle school students tended to apply their prior knowledge about the construction and interpretation of standard bar graphs while generating and interpreting histograms and scatterplots. The students drew representations that were equivalent to a bar graph though they chose the correct axes for the variables (Baker, Corbett, & Koedinger, 2002). In addition, understanding the relationship between raw and grouped representations of data is another problem that the students have (Bright & Friel, 1998). They tend to sense histograms as representations of raw data including bars each of which belongs to an individual observation rather than grouped data (Lee & Meletiou-Mavrotheris, 2003).

In the instruction process, the teacher warned students not forget to write title and names of axes of the graphs and she controlled their graphs. The decrease in the frequency of students who wrote “line graph”, “bar graph” as the title of the graph in the posttest might be the result of the emphasize the teacher put during the instruction.

Organization of numerical data is also a major obstacle for the students not only in middle school (Bright & Friel, 1998) but also in elementary school. Young children are unable to classify items appropriately according to the form, size, orientation, function, or type (Pasnak, Holt, Campbell, & McCutcheon, 1991). In addition, the students can reorganize and represent categorical data easier than numerical data (Nisbet, Jones, Thornton, Langrall, & Mooney, 2003). According to the pretest and posttest results, while the frequency of students who plotted the values of the variable in numerical order with appropriate intervals by only taking into consideration of the data given in the table decreased, there was an increase in the frequency of students plotted the individual values of the variable in the exact same order as given in the table. Hence, that the teacher did not ask more questions as examples might be the reason of the students' possible misconceptions on these situations.

In general, the students tend to sketch graphs that pass through the origin since they believe that all graphs pass through the origin. On the other hand, students have mistakes about the meaning of origin and they identify zero up to the horizontal axis (Capraro, Kulm, & Capra, 2005). In the study, the students were unaware of about the intersection of the vertical and horizontal axes and in the posttest, there was an increase in the frequency of students who identified zero up to the x-axis. In the instruction process, though the teacher directed the student while drawing the graph on the board by asking questions about the construction of them when needed by asking questions related to the name of axis on which students plot the numbers of visitors, whether the arrows should be put at the end of the axes or not, and emphasized the origin, this could not remove the students' possible misconceptions possibly due to the limited numbers of questions she asked to them.

5.1.3. Typical Errors and Possible Misconceptions about Reading and Interpreting Line and Bar Graphs

What is given in the graphs affect directly the students' understanding. The students in lower grades are not able to understand the abstract ideas of a graph and they understand better if they see the actual object or a picture of the object in the graph. In general, the younger students get confused in making connections between real objects and abstract representations (Friel, Curcio, & Bright, 2001). In the study,

since the participants were in grade 7, the questions in both pretest and posttest were prepared on the basis of three types of graphs, line, bar, and circle graphs. The analysis of pretest and posttest results showed that there were increases in the frequency of students in possible misconceptions about reading and interpreting line and bar graphs. While reading and interpreting graphs, the students focused on one point on the line graphs instead of having a general perspective and they paid attention on the height of the bars on bar graphs. The students also interpreted line graphs by repeating the information given by them. They thought that further issues could not be guessed unless the information was given in graphs. They believed that patterns must exist in a graph completely. They said that they could not give an answer since "it" was not on the graph and they also couldn't manage to tell "beyond the picture" (Pereira-Mendoza & Mellor, 1991). Hence, that the teacher did not provide any questions in which students could read graphs might be the reason of the students' possible misconceptions.

The pretest and posttest results also showed that the students had different misconceptions before and after the instruction about explaining the situations represented in line graphs. Students have problems in identifying the same data that is presented in different ways (Bright & Friel, 1998; Kerslake, 1981). Many students do not pay enough attention to the scale on vertical and horizontal axes in graphs. Because of thinking every tick mark on a scale marks a single unit, the students cannot read the graph with a different increment scale correctly (Dunham & Osborne, 1991). Especially, the young students who have a limited ability to count the increments of more than one unit misread graphs (Friel, Curcio, & Bright, 2001). When interpreting graphs, middle school students fail to understand how the appearance of the graph is affected when the scale is changed. They cannot realize the effect of scale on the proportions of a graph (Kerslake, 1981). In the study, before the instruction, the students thought that although the graphs started from a number different from zero, the value on the horizontal axis was zero. After the instruction, there was an increase in the frequency of students who thought that the two graphs which showed the same thing with different scales were different and the value on the graph with a larger scale was higher than the value on the others. Therefore, that the lack of questions in which the students could read graphs also might be the reason of the students' possible misconceptions.

5.1.4. Typical Errors and Possible Misconceptions about Constructing and Interpreting Circle Graphs

The students' responses in pretest and posttest showed that there were both increases and decreases in the frequency of the students in common misconceptions about constructing and interpreting circle graphs.

In the teaching of circle graphs, the teacher asked only one and the same question in which the students were wanted to draw a circle graph to each section. Although she did not mention whether a circle graph could be drawn to show data including more than one criterion or not, there was a decrease in the frequency of students who drew circle graphs including two criteria in the posttest. Hence, this might be the result of the students' tendency to draw circle graphs as in the example provided by the teacher in the instruction process. On the other hand, students tend to choose a circle graph omitting 0 as a categorical variable. (Capraro, Kulm, & Capra, 2005). That the lack of questions in the instruction process might be the reason of decreases in the frequency of students who drew circle graphs containing the data which included the value zero and interpreted the circle graphs by repeating the information given to them. Hence, it seemed that the regular mathematics instruction of the mathematics teacher had an important effect on the students' possible misconceptions.

5.1.5. The Influence of Regular Classroom Instruction on 7th-Grade Students' Typical Errors and Possible Misconceptions in Graphs Concept

Observation of teacher's instruction showed that she did not fully follow the curriculum objectives. Although there are five objectives in the 7th-grade MONE curriculum about the graphs concept, her instruction was based on the first two objectives such as "to construct and interpret bar graphs and line graphs based on more than one criterion" and "to construct and interpret circle graphs." She did not consider the remaining objectives such as "to develop ideas for the real life situations by constructing and interpreting statistical representation forms," "to formulate predictions based on the data," and "to explain the situations that line graphs, pictographs, or object graphs might address incorrect interpretations." This influenced students' responses in the pretest and posttest which were prepared based on the objectives in the MONE curriculum. As a result, the regular classroom

instruction of this teacher did not have any influence on some of the students' typical errors and possible misconceptions about reading and interpreting line and bar graphs and the students' prior knowledge had an effect on these misconceptions. Teachers' decisions on planning are not always based on a specification of objectives in a logical way and teachers may not always consider the objectives while planning (Zahoric, 1970, as cited in Yinger, 1980). Considering the relationship between the changes in teacher's planning and their classroom teaching behavior (Hogan, Rabinowitz, & Craven, 2003; Leinhardt & Greeno, 1986), quality instruction is more likely to occur when the teachers make a detailed and quality lesson plans by focusing on the curriculum (Li, 2007). The observations also showed that the teacher's instruction differed in the four sections that she taught from time to time. While she mentioned some important points in some of the sections, she did not talk about them in other sections. She also did not provide explanation for some of the student responses which might have caused certain misconceptions during the instruction. It seemed that the teacher in this study did not make a good planning on the basis of curriculum objectives and this influenced the effectiveness of regular classroom instruction on students' understanding of the concept and their misconceptions. Lack of effective planning also seemed to have caused her instruction which considerably differed in the four sections.

In the study, the teacher provided the students with the connections between the graphs and the real world examples by asking questions about the use of graphs in daily life to the students and giving more examples. However, she did not make any connections between the graphs and other topics, which would be very important for the students to provide the conceptual and meaningful understanding. This might indicate that the teacher lacked sufficient content knowledge in mathematics, which influenced her regular classroom instruction (Ball, 1991) in a negative way and so her students' learning. Therefore, it might be speculated that teacher's insufficient regular classroom instruction in graphs concept resulted in several common misconceptions in the posttest.

The teacher did not provide an effective learning environment in which the students were given opportunities to share and discuss their ideas with each other and she did not encourage them to work collaboratively. Students' mathematical learning could be enhanced when they are given opportunities to explain and compare their

thinking with the teacher and the other students in the classroom within a discussion environment (Askew et al., 1997; Wood, 1988) where effective questioning between the teacher and the students occur in addition to paper-and-pencil tasks (Watson & Mason, 1998). If the teacher in this study could have provided an effective discussion environment especially when the students' questions addressed a possible misconception, they would reexamine their thinking and could have reached a self-correction (Anghileri, 2000).

The teacher in this study did not use any material such as graph paper, colored pencils, compass, and scissors or technology while teaching the graphs. While use of technology was limited with lack of classroom and school facilities, no visible limitation to use materials were detected. However, the teacher did not use any worksheets or hands on materials during the regular mathematics instruction of graphs concept which could have addressed certain student misconceptions before they were formed.

5.2. Recommendations

Misconceptions are the major obstacles for a meaningful learning (Keşan & Kaya, 2007) and students' misconceptions should not be underestimated. If the planning of an instruction starts by the existing and possible future misconceptions of students, effective planning could be conducted on the basis of the students' needs and the curriculum. The findings of the study revealed the importance of student questioning in addition to teacher questioning. Questioning and students' possible questions should be an important part of the mathematics teaching practices in the schools since both would contribute to the learning of mathematics by addressing certain misconception in the beginning, during, and at the end of the instruction on the mathematical concepts. This study showed that even experienced teachers would ineffectively plan lessons and lack of effective planning resulted in certain misconceptions, and did not help students in removing many others. Therefore, the need for effective planning and the need to effectively evaluate students' questions should be communicated to the teachers in order to increase students' learning in the mathematics classrooms.

Based on the findings of the current study, it can be suggested that the teachers should provide a meaningful learning environment for their students in which they

would provide connections between the mathematical concepts and different subject areas, and between the mathematics concepts and the real world examples. The teachers should emphasize students' interaction and participation in each lesson and they should encourage students to explain their ideas, discuss, and work with the other students and the teacher. In addition, the teachers should give meaningful tasks and provide activities in which the students are more likely to be transparent in their thinking. They should use materials and technology to make the content more understandable for the students.

Graphs have an important role in not only conceptual understanding but also solving problems in the analysis of mathematical problems (Özgün-Koca, 2008). Hence, the teachers should be expert in the graphs concept to provide a learning environment in which the students learn graphs concept in a conceptual and meaningful way. In their instruction process, the teachers should make connections between the graphs and other subjects, and between the graphs and the real world. Also, they should transfer to the students not only the purposes of different types of graphs correctly but also the differences between them in detail. Furthermore, they should provide sufficient tasks and activities about constructing, reading, and interpreting of graphs according to the students' needs.

The study showed that inservice and preservice training of teachers should address the importance of effective planning in the mathematics classroom. Providing diverse experiences to the students in terms of questions, materials, and approaches could eliminate many misconceptions in mathematics and these could be achieved through effective planning.

5.3. Implications for Further Research

This study was based on 7th-grade students' typical errors and possible misconceptions before and after the regular mathematics instruction. The current study focused on the regular mathematics instruction. The participants were not exposed to a special treatment. Hence, the findings of this study can be triangulated through involving different research designs involving the application of an actual treatment for the participants. Furthermore, this study was concerned with only the typical errors and possible misconceptions of the 7th-grade students. Other studies can be conducted with the students in the other grade levels and the results of this

study can be compared with the findings of the studies conducted in the other grade levels. In addition, the findings of this study revealed that there seems to be a need for assessing the inservice and preservice training of teachers which address the importance of effective planning in the mathematics classroom.

Lastly, as the data for this study were gathered from Afyonkarahisar, other studies can be conducted in other cities to compare the findings of this study.

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APPENDICES

APPENDIX A
PERMISSION OBTAINED FROM MIDDLE EAST TECHNICAL UNIVERSITY

1956

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Middle East Technical University

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06/04/2010

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AFYONKARAHİSAR VALİLİĞİNE
(İl Milli Eğitim Müdürlüğü)

Üniversitemiz İlköğretim Fen ve Matematik Eğitimi Anabilim Dalı Yüksek Lisans Programı öğrencisi Tuğba Tortop'un, 2009– 2010 eğitim-öğretim yılı II. döneminde "*7. Sınıf Öğrencilerinin Grafikleri Okuma, Yorumlama ve Oluşturma ile İlgili Oldukları Kavram Yanılgıları ve Matematik Öğretiminin Bu Kavram Yanılgılarına Etkisi*" başlıklı çalışmasına ilişkin olarak ekli listede belirtilen Afyonkarahisar ilinde bulunan Milli Eğitim Bakanlığına bağlı ilköğretim okullarında öğrenim gören öğrenci ve görev yapan öğretmenlerden yaklaşık 150 kişiyle görüşme yapması ve belirtilen ilköğretim okullarında gözlem yapması için öğrencinin isteği doğrultusunda görevlendirilmesi Etik Komite onayı ile uygun görülmüştür.

Uygulamanın yapılabilmesi için gereğini izninize sunarım.

Saygılarımla.

Prof. Dr. Çiğdem Erçelebi
Rektör Yardımcısı

Ekler:
1-Öğrencinin dilekçesi
2-Danışmanın dilekçesi
3-Okul listesi
4-Anketler

APPENDIX B

PERMISSION OBTAINED FROM MINISTRY OF EDUCATION

FORM-2

T.C.
MİLLÎ EĞİTİM BAKANLIĞI
Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı
ARAŞTIRMA DEĞERLENDİRME FORMU

ARAŞTIRMA SAHİBİNİN	
Adı Soyadı	Tuğba TORTOP
Kurumu / Üniversitesi	Orta Doğu Teknik Üniversitesi Sosyal Bilimler Enstitüsü İlköğretim Fen ve Matematik Eğitimi Anabilim Dalı
Araştırma yapılacak iller	Afyonkarahisar
Araştırma yapılacak eğitim kurumu ve kademesi	Hacı Ahmet Özsoy İlköğretim Okulu ve Fatih İlköğretim Okulu
Araştırmanın konusu	7. Sınıf Öğrencilerinin Grafikleri Okuma, Yorumlama ve Oluşturma İle İlgili Oldukları Kavram Yanılgıları ve Matematik Öğreniminin Bu Kavram Yanılgılarına Etkisi
Üniversite / Kurum onayı	Var
Araştırma/proje/ödev/tez önerisi	Var
Veri toplama araçları	Var
Görüş istenilecek Birim/Birimler	

KOMİSYON GÖRÜŞÜ

"7. Sınıf Öğrencilerinin Grafikleri Okuma, Yorumlama ve Oluşturma İle İlgili Oldukları Kavram Yanılgıları ve Matematik Öğreniminin Bu Kavram Yanılgılarına Etkisi" İle İlgili Tez Çalışması; "Milli Eğitim Bakanlığı Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı" tarafından 28.02.2007 tarih ve B.08.4.EGD.0.33.03.311–311/1084 sayılı bakanlık onayı ile yayınlanan "Milli Eğitim Bakanlığına Bağlı Okul ve Kurumlarda Yapılacak Araştırma ve Araştırma Desteğine Yönelik İzin ve Uygulama Yönergesi" doğrultusunda görüşülmüş olup, çalışmalar tamamlandıktan sonra araştırma sonuçlarının birer örneğinin İl Milli Eğitim Müdürlüğüne teslim edilmesi şartıyla, komisyon tarafından uygun görülmüştür.

Komisyon kararı	Oybirliği ile alınmıştır.
Muhalif üyenin Adı ve Soyadı:	

K O M İ S Y O N
28/04/2010

Komisyon Başkanı
Musa DİNÇER

ÜYE
Murat KONTBİLEK

ÜYE
Murat EMİRİK

EĞİTİME %100 DESTEK — DANIŞMA 444 0 632 HATTI
İl Milli Eğitim Müdürlüğü — Kültür – Spor Bölümü
Tel : 0 272 213 76 03 / 127 — E-posta : arge03@meb.gov.tr
Fax : 0 272 213 76 05 — Web : http://afyon.meb.gov.tr
Yazılarımıza verilecek cevaplarda yazımızın ilgisinin mutlaka belirtilmesi

T.C.
AFYONKARAHİSAR VALİLİĞİ
Milli Eğitim Müdürlüğü

Sayı : B.08.4.MEM.4.03.00.06–040 / 29.04.2010* 12767
Konu : Araştırma İzni

VALİLİK MAKAMINA

İlgi : 06/04/2010 tarih ve B.30.2.ODT.72.00.00/1420-2513 sayılı Araştırma İzni konulu yazısı.

Orta Doğu Teknik Üniversitesi Sosyal Bilimler Enstitüsü İlköğretim Fen ve Matematik Eğitimi Anabilim Dalı Yüksek Lisans Öğrencisi Tuğba TORTOP'ın **"7. Sınıf Öğrencilerinin Grafikleri Okuma, Yorumlama ve Oluşturma İle İlgili Oldukları Kavram Yanılgıları ve Matematik Öğreniminin Bu Kavram Yanılgılarına Etkisi"** konulu anket uygulamak istemektedir. Çalışmalar tamamlandıktan sonra tez çalışmasının bir örneğinin İl Milli Eğitim Müdürlüğüne teslim edilmesi şartıyla, Müdürlüğümüz Araştırma ve Değerlendirme Komisyonu tarafından araştırma yapması uygun görülmektedir.

Makamınızca da uygun görüldüğü takdirde tensiplerinize arz ederim.

Hidayet YILDIRIM
İl Milli Eğitim Müdürü

OLUR
24../4../2010

Gökhan Veli KİŞİOĞLU
Vali a.
Vali Yardımcısı

EKLER:
1-Araştırma Değerlendirme Formu (1 Sayfa)

EĞİTİMDE REFORM Daha güzel gelecek! EĞİTİME %100 DESTEK DANIŞMA 444 0 632 HATTI
İl Milli Eğitim Müdürlüğü Kültür – Spor Bölümü
Tel : 0 272 213 76 03 / 127 E-posta : arge03@meb.gov.tr
Fax : 0 272 213 76 05 Web : http://afyon.meb.gov.tr
Yazılarımıza verilecek cevaplarda yazımızın ilgisinin mutlaka belirtilmesi

APPENDIX C

THE FIRST FORMS OF ACHIEVEMENT TESTS

Ad-Soyad :
Sınıf :
Numara :

SORULAR (ÖN SINAV)

Soru 1:

Tablo: Bölgelerin orman oranları

Bölgeler	Orman Oranı (%)
Akdeniz Bölgesi	24
Doğu Anadolu Bölgesi	11
Ege Bölgesi	17
Güneydoğu Anadolu Bölgesi	3
İç Anadolu Bölgesi	7
Karadeniz Bölgesi	25
Marmara Bölgesi	13

Yukarıdaki tabloda, Türkiye'deki ormanların bölgelere düşen oranları verilmiştir. Buna göre,

a) Tablodaki verileri çizgi grafiği ile göstermek uygun olur mu? Açıklayınız.

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b) Tablodaki verileri sütun grafiği ile göstermek uygun olur mu? Açıklayınız.

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c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

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1

Soru 2:

Tablo: Afyonkarahisar iline ait bir haftalık hava tahmin durumu

Gün	Sıcaklık (°C)	
	Gündüz	Gece
Pazartesi	13	5
Salı	13	5
Çarşamba	12	3
Perşembe	11	2
Cuma	11	3
Cumartesi	9	2
Pazar	6	3

Yukarıdaki tabloda, Afyonkarahisar iline ait bir haftalık hava tahmin durumu verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

2

Soru 3:

Tablo: 7.sınıf şubelerine ait kız ve erkek öğrenci sayısı

	Kız	**Erkek**
7-A	10	15
7-B	14	12
7-C	12	13
7-D	11	14

Yukarıdaki tabloda, bir okuldaki 7.sınıf şubelerine ait kız ve erkek öğrenci sayıları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

3

Soru 4:

Tablo: Öğrencilerin kardeş sayıları

Kardeş sayısı	Öğrenci sayısı
0	2
1	9
2	6
3	1

Yukarıdaki tabloda, bir sınıftaki öğrencilerin kardeş sayıları verilmiştir. Buna göre,

a) Verilen bilgileri kullanarak bir daire grafiği çiziniz.

b) Çizdiğiniz grafiği yorumlayınız.

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Soru 5:

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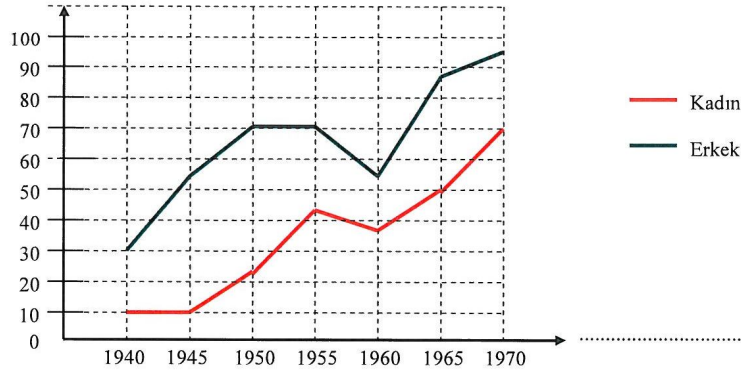

.....

Yukarıdaki grafik, bir ülkedeki 1940-1970 yılları arasındaki kadın ve erkek nüfusuna ait okuma-yazma oranının değişimini göstermektedir. Buna göre,

a) Grafiğin başlığını ve eksen isimlerini yukarıda belirtilen boşluklara yazınız.

b) Hangi yılda kadın nüfusunun yarısından çoğu okur-yazar durumundadır?

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.....

c) Grafikteki verileri kullanarak 1975 yılındaki kadın ve erkek okur-yazar oranları tahmin edilebilir mi? Açıklayınız.

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d) Grafiği yorumlayınız.

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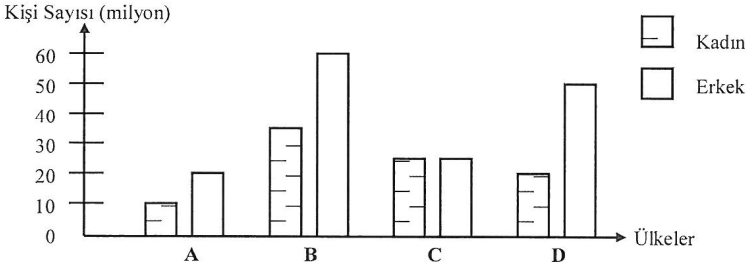
5

Soru 6:

Grafik: Ülkelere göre araba kullanan kadın erkek sayıları



Yukarıdaki grafik, dört farklı ülkedeki araba kullanan kadın ve erkek sayılarını göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

a) Dört ülkedeki araba kullanan toplam kadın sayısı ile toplam erkek sayısı arasındaki fark.....'dır.

b) Araba kullanan kadın ve erkek sayıları arasındaki farkın en fazla olduğu ülke .....'dır.

c) Araba kullanan kadınların oranı .....ülkesinde en fazladır.

d) ....., ..., ...ülkelerindeki araba kullanan kadın sayısı araba kullanan erkek sayısından azdır. Bu durumun sebepleri neler olabilir? Açıklayınız.

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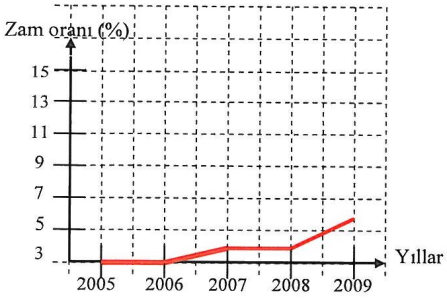
6

Soru 7:

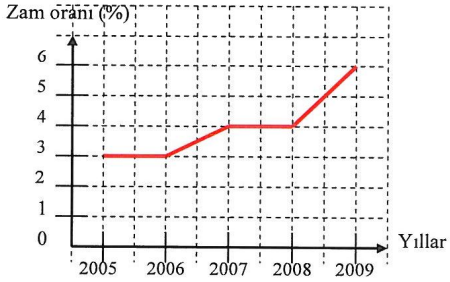
A

Grafik: 2005-2009 yılları arasında işçilere yapılan zam oranları



B

Grafik: 2005-2009 yılları arasında işçilere yapılan zam oranları



Yukarıdaki grafiklerde, özel bir kuruluşun 2005-2009 yılları arasında işçilerine yaptığı zam oranları verilmektedir. Buna göre,

a) Grafikler arasındaki farklılıkları açıklayınız.

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b) Sizce grafiklerden hangisi işçiler tarafından çizilmiş olabilir? Açıklayınız.

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7

Ad-Soyad :
Sınıf :
Numara :

SORULAR (SON SINAV)

Soru 1:

Tablo: 2008-2009 yıllarında bir ülkeye gelen yabancı turist sayısı

Ulaşım şekli	Yıllar	
	2008	2009
Deniz yolu	3,5 milyon	2 milyon
Hava yolu	6 milyon	5 milyon
Kara yolu	2,5 milyon	1 milyon

Yukarıdaki tabloda, 2008-2009 yıllarında bir ülkeye deniz yolu, hava yolu ve kara yolu ile gelen yabancı turist sayısı verilmiştir. Buna göre,

a) Tablodaki verileri çizgi grafiği ile göstermek uygun olur mu? Açıklayınız.

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b) Tablodaki verileri sütun grafiği ile göstermek uygun olur mu? Açıklayınız.

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c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

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Soru 2:

Tablo: Kır ve kent nüfus oranları

Yıl	Nüfus oranı (%)	
	Kır	Kent
1970	80	20
1975	75	25
1980	70	30
1985	55	45
1990	50	50

Yukarıdaki tabloda, bir ülkedeki 1970-1990 yılları arasındaki kır ve kent nüfus oranları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

2

Soru 3:

Tablo: Matematik ve Türkçe 1.yazılı sonuçları

	Matematik	**Türkçe**
Ayşegül	0	20
Ali	85	90
Yiğit	70	60
Esra	95	100
Uğur	40	55

Yukarıdaki tabloda, beş kişinin Matematik ve Türkçe derslerine ait birinci yazılı sonuçları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

3

Soru 4:

Tablo: Öğrencilerin matematik notları

Not	Öğrenci Sayısı
0	1
1	4
2	0
3	13
4	10
5	8

Yukarıdaki tabloda, bir sınıftaki öğrencilerin matematik dersinden almış oldukları notlar verilmiştir. Buna göre,

a) Verilen bilgileri kullanarak bir daire grafiği çiziniz.

b) Çizdiğiniz grafiği yorumlayınız.

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Soru 5:

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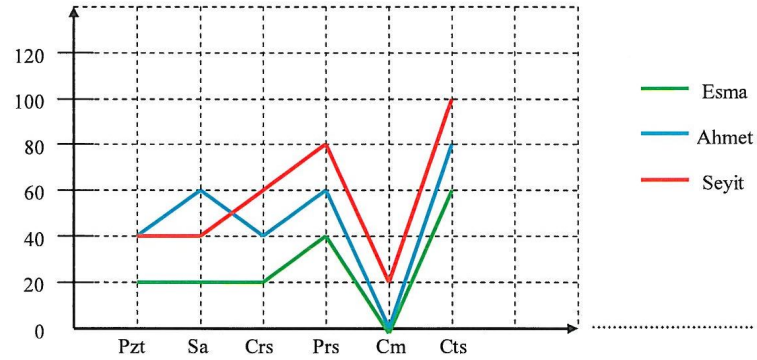

.....

Esma, Ahmet ve Seyit altı gün boyunca aynı kitabı okumuşlardır. Her gün kaç sayfa kitap okudukları yukarıdaki grafikte gösterilmektedir. Buna göre,

a) Grafiğin başlığını ve eksen isimlerini yukarıda belirtilen boşluklara yazınız.

b) Ahmet, hangi gün veya günler arkadaşlarından fazla kitap okumuştur?

.....

.....

c) Altı gün boyunca Seyit, Ahmet'ten toplam kaç sayfa fazla kitap okumuştur?

.....

.....

d) Grafikteki verileri kullanarak Esma, Ahmet ve Seyit'in Pazar günü okuyacakları sayfa sayıları tahmin edilebilir mi? Açıklayınız.

.....

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e) Grafiği yorumlayınız.

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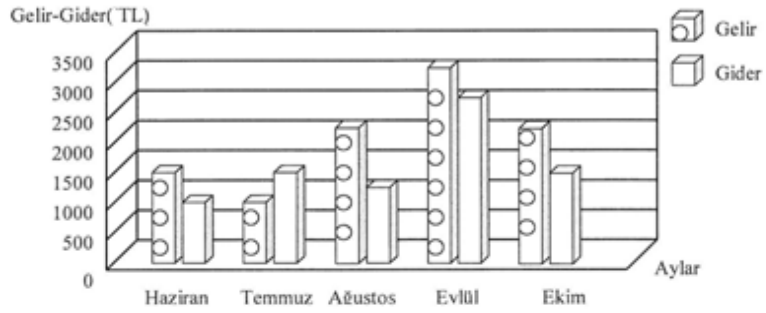
5

Soru 6:

Grafik: Haziran-Ekim ayları arasında gelir-gider verileri



Yukarıdaki grafik bir market sahibinin beş aylık gelir-gider durumunu göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

a) Toplam gelir..... TL'dir.

b) Toplam gider..... TL'dir.

c) En çok gelir.....ayında elde edilmiştir.

d) En çok gider.....ayında gerçekleşmiştir.

e) Market sahibi en çok .....ayında kar etmiştir.

f) ..... ile.....aylarında elde edilen karlar eşittir.

g) Market sahibi aylardan birinde zarar etmiştir. Bu zararın sebepleri neler olabilir? Açıklayınız.

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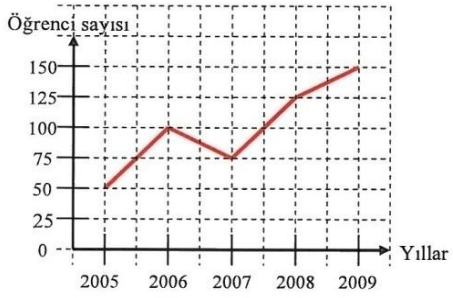
6

Soru 7:

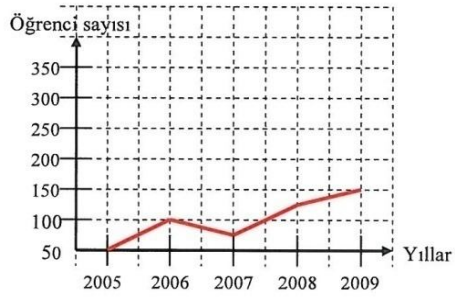
A

Grafik: 2005-2009 yılları arasında üniversiteyi kazanan öğrenci sayıları



B

Grafik: 2005-2009 yılları arasında üniversiteyi kazanan öğrenci sayıları



Yukarıdaki grafiklerde, bir dershanedeki 2005-2009 yılları arasında üniversiteyi kazanan öğrenci sayıları verilmiştir. Buna göre,

a) Grafikler arasındaki farklılıkları açıklayınız.

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b) Sizce dershanenin tanıtım reklamı için hangi grafik kullanılmalıdır? Açıklayınız.

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7

APPENDIX D

THE PILOTED FORM OF PRETEST

Ad-Soyad :
Sınıf :
Numara :

SORULAR (ÖN SINAV)

Soru 1:

Tablo: Bölgelerin orman oranları

Bölgeler	Orman Oranı (%)
Akdeniz Bölgesi	24
Doğu Anadolu Bölgesi	11
Ege Bölgesi	17
Güneydoğu Anadolu Bölgesi	3
İç Anadolu Bölgesi	7
Karadeniz Bölgesi	25
Marmara Bölgesi	13

Yukarıdaki tabloda, Türkiye'deki ormanların bölgelere düşen oranları verilmiştir. Buna göre,

a) Tablodaki verileri çizgi grafiği ile göstermek uygun olur mu? Açıklayınız.

.....

.....

b) Tablodaki verileri sütun grafiği ile göstermek uygun olur mu? Açıklayınız.

.....

.....

c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

.....

.....

d) Yukarıdaki soruya ait şıklar yeterince açık mı? Anlamakta zorlandığınız kısım varsa belirtiniz.

.....

.....

1

Soru 2:

Tablo: Afyonkarahisar iline ait bir haftalık hava tahmin durumu

Gün	Sıcaklık (°C)	
	Gündüz	Gece
Pazartesi	13	5
Salı	13	5
Çarşamba	12	3
Perşembe	11	2
Cuma	11	3
Cumartesi	9	2
Pazar	6	3

Yukarıdaki tabloda, Afyonkarahisar iline ait bir haftalık hava tahmin durumu verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

a) Yukarıdaki soru yeterince açık mı? Anlamakta zorlandığımız kısım varsa belirtiniz.

.....

.....

2

Soru 3:

Tablo: 7.sınıf şubelerine ait kız ve erkek öğrenci sayısı

	Kız	Erkek
7-A	10	15
7-B	14	12
7-C	12	13
7-D	11	14

Yukarıdaki tabloda, bir okuldaki 7.sınıf şubelerine ait kız ve erkek öğrenci sayıları verilmektedir.

a) Verilen bilgileri kullanarak bir grafik çiziniz.

b) Yukarıdaki soru yeterince açık mı? Anlamakta zorlandığınız kısım varsa belirtiniz.

.....

.....

3

Soru 4:

Tablo: Öğrencilerin kardeş sayıları

Kardeş sayısı	Öğrenci sayısı
0	2
1	9
2	6
3	1

Yukarıdaki tabloda, bir sınıftaki öğrencilerin kardeş sayıları verilmiştir. Buna göre,

a) Verilen bilgileri kullanarak bir daire grafiği çiziniz.

b) Çizdiğiniz grafiği yorumlayınız.

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c) Yukarıdaki soruya ait şıklar yeterince açık mı? Anlamakta zorlandığınız kısım varsa belirtiniz.

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4

Soru 5:

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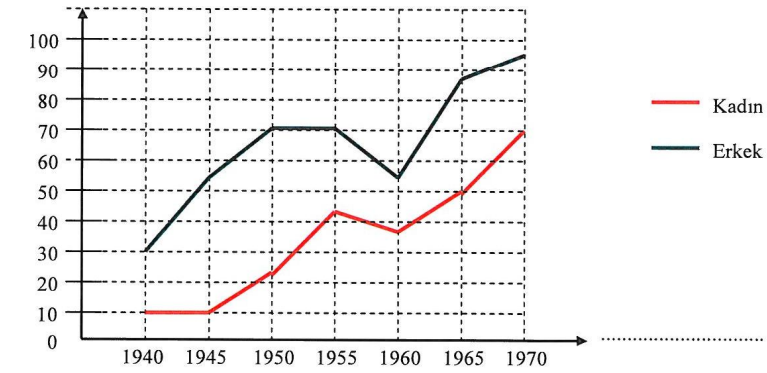

.....

Yukarıdaki grafik, bir ülkedeki 1940-1970 yılları arasındaki kadın ve erkek nüfusuna ait okuma-yazma oranının değişimini göstermektedir. Buna göre,

a) Grafiğin başlığını ve eksen isimlerini yukarıda belirtilen boşluklara yazınız.

b) Hangi yıllarda kadın nüfusunun yarısından çoğu okur-yazar durumundadır?

.....

.....

c) Grafikteki verileri kullanarak 1975 yılındaki kadın ve erkek okur-yazar oranları tahmin edilebilir mi? Açıklayınız.

.....

.....

d) Grafiği yorumlayınız.

.....

.....

e) Yukarıdaki soruya ait şıklar yeterince açık mı? Anlamakta zorlandığınız kısım varsa belirtiniz.

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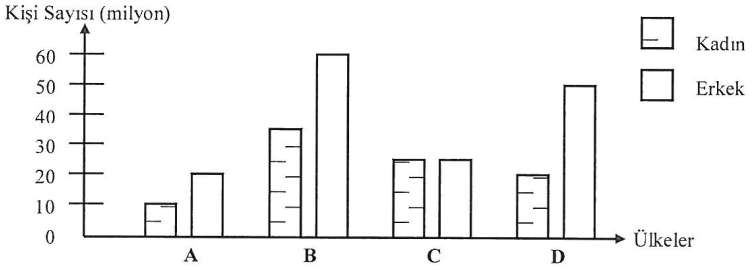
5

Soru 6:

Grafik: Ülkelere göre araba kullanan kadın erkek sayıları



Yukarıdaki grafik, dört farklı ülkedeki araba kullanan kadın ve erkek sayılarını göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

a) Dört ülkedeki araba kullanan toplam kadın sayısı ile toplam erkek sayısı arasındaki fark.....'dır.

b) Araba kullanan kadın ve erkek sayıları arasındaki farkın en fazla olduğu ülke .....'dır.

c) Araba kullanan kadınların oranı .....ülkesinde en fazladır.

d) ....., ..., ...ülkelerindeki araba kullanan kadın sayısı araba kullanan erkek sayısından azdır. Bu durumun sebepleri neler olabilir? Açıklayınız.

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e) Yukarıdaki soruya ait şıklar yeterince açık mı? Anlamakta zorlandığınız kısım varsa belirtiniz.

.....
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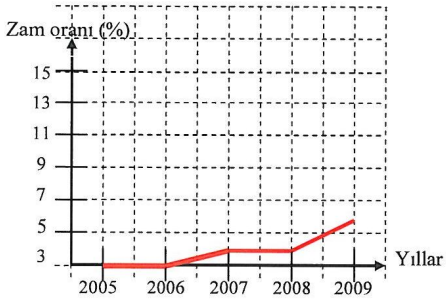
6

Soru 7:

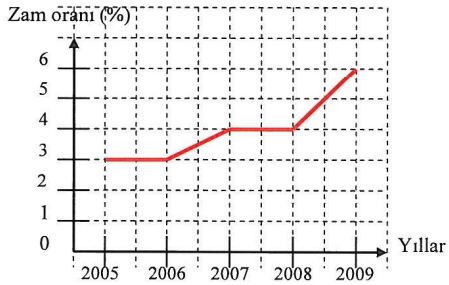
A

Grafik: 2005-2009 yılları arasında işçilere yapılan zam oranları



B

Grafik: 2005-2009 yılları arasında işçilere yapılan zam oranları



Yukarıdaki grafiklerde, özel bir kuruluşun 2005-2009 yılları arasında işçilerine yaptığı zam oranları verilmektedir. Buna göre,

a) Grafikler arasındaki farklılıkları açıklayınız.

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b) Sizce grafiklerden hangisi işçiler tarafından çizilmiş olabilir? Açıklayınız.

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c) Yukarıdaki soruya ait şıklar yeterince açık mı? Anlamakta zorlandığınız kısım varsa belirtiniz.

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7

APPENDIX E

THE LAST FORM OF PRETEST

Ad-Soyad :
Sınıf :
Numara :

SORULAR (ÖN SINAV)

Soru 1:

Tablo: Bölgelerin orman oranları

Bölgeler	Orman Oranı (%)
Akdeniz Bölgesi	24
Doğu Anadolu Bölgesi	11
Ege Bölgesi	17
Güneydoğu Anadolu Bölgesi	3
İç Anadolu Bölgesi	7
Karadeniz Bölgesi	25
Marmara Bölgesi	13

Yukarıdaki tabloda, Türkiye'deki ormanların bölgelere düşen oranları verilmiştir. Buna göre,

a) Tablodaki verileri çizgi grafiği ile göstermek uygun olur mu? Açıklayınız.

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b) Tablodaki verileri sütun grafiği ile göstermek uygun olur mu? Açıklayınız.

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c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

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1

Soru 2:

Tablo: 7.sınıf şubelerine ait kız ve erkek öğrenci sayısı

	Kız	Erkek
7-A	10	15
7-B	14	12
7-C	12	13
7-D	11	14

Yukarıdaki tabloda, bir okuldaki 7.sınıf şubelerine ait kız ve erkek öğrenci sayıları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

2

Soru 3:

Tablo: Öğrencilerin kardeş sayıları

Kardeş sayısı	Öğrenci sayısı
0	2
1	9
2	6
3	1

Yukarıdaki tabloda, bir sınıftaki öğrencilerin kardeş sayıları verilmiştir. Buna göre,

a) Verilen bilgileri kullanarak öğrenci sayısını gösteren bir daire grafiği çiziniz.

b) Çizdiğiniz grafiği yorumlayınız.

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Soru 4:

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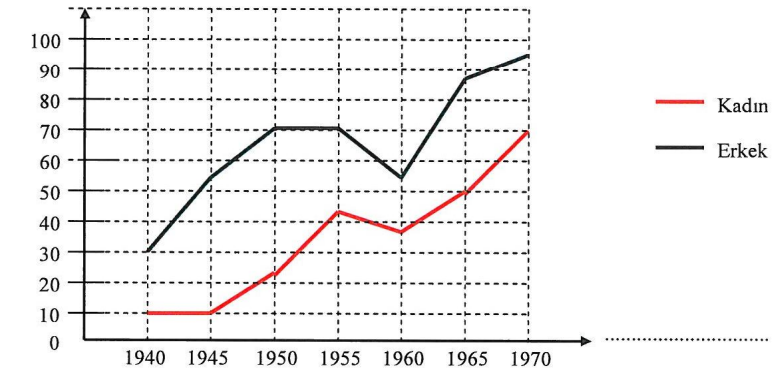

Yukarıdaki grafik, bir ülkedeki 1940-1970 yılları arasındaki kadın ve erkek nüfusuna ait okuma-yazma oranının değişimini göstermektedir. Buna göre,

a) Grafiğin başlığını ve eksen isimlerini yukarıda belirtilen boşluklara yazınız.

b) Hangi yıl veya yıllar arasında kadın nüfusunun yarısından çoğu okur-yazar durumundadır?

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c) Grafikteki verileri kullanarak 1975 yılındaki kadın ve erkek okur-yazar oranları tahmin edilebilir mi? Açıklayınız.

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d) Grafiği yorumlayınız.

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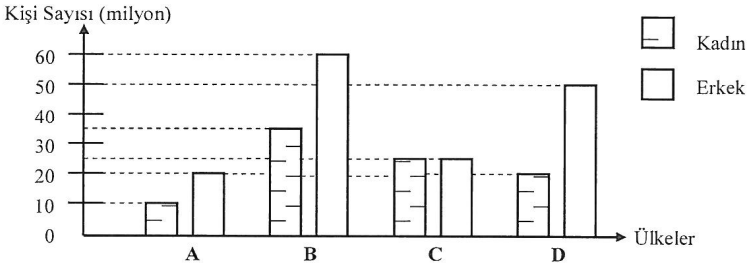
4

Soru 5:

Grafik: Ülkelere göre araba kullanan kadın erkek sayıları



Yukarıdaki grafik, dört farklı ülkedeki araba kullanan kadın ve erkek sayılarını göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

a) Dört ülkedeki araba kullanan toplam kadın sayısı ile toplam erkek sayısı arasındaki fark.....'dır. (Sayısal olarak belirtiniz.)

b) Araba kullanan kadın ve erkek sayıları arasındaki farkın en fazla olduğu ülke .....'dır.

c) Araba kullanan kadınların oranı .....ülkesinde en fazladır.

d) ....., ..., ...ülkelerindeki araba kullanan kadın sayısı araba kullanan erkek sayısından azdır. Bu durumun sebepleri neler olabilir? Açıklayınız.

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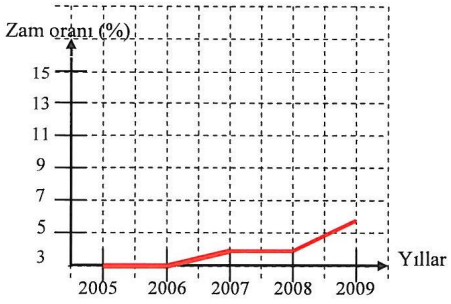
Soru 6:

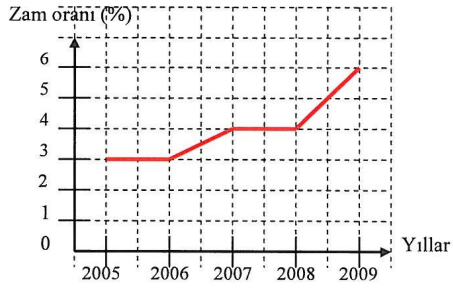
A

Grafik: 2005-2009 yılları arasında işçilere yapılan zam oranları



B

Grafik: 2005-2009 yılları arasında işçilere yapılan zam oranları



Yukarıdaki grafiklerde, özel bir kuruluşun 2005-2009 yılları arasında işçilerine yaptığı zam oranları verilmektedir. Buna göre,

a) Grafikler arasındaki farklılıkları açıklayınız.

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b) Sizce grafiklerden hangisi işçiler tarafından çizilmiş olabilir? Açıklayınız.

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6

APPENDIX F

THE RUBRIC OF PRETEST

Questions	Answers and Explanations	Scores
1st Question Part a (Line Graphs)	Write "No, it is not suitable to show the data given in the table by using a line graph" as the correct answer without any explanation for the response.	1+0
	Write "No, it is not suitable to show the data given in the table by using a line graph, because line graphs are used for tracking changes over short and long periods of time" as both correct answer and correct explanation for the response.	1+1
	Write "No, it is not suitable to show the data given in the table by using a line graph" as the correct answer and write an incorrect explanation which is not parallel to the purpose of using line graphs (Line graphs are used for tracking changes over short and long periods of time) for the response.	1+0
	Write "Yes, it is suitable to show the data given in the table by using a line graph" as the incorrect answer without any explanation for the response.	0+0
	Write "Yes, it is suitable to show the data given in the table by using a line graph" as the incorrect answer and write an incorrect explanation which is not parallel to the purpose of using line graphs (Line graphs are used for tracking changes over short and long periods of time) for the response.	0+0
1st Question Part b (Bar Graphs)	Write "Yes, it is suitable to show the data given in the table by using a bar graph" as the correct answer without any explanation for the response.	1+0
	Write "Yes, it is suitable to show the data given in the table by using a bar graph, because bar graphs are used to compare things between different groups in order to see the numbers more clearly" as both correct answer and correct explanation for the response.	1+1
	Write "Yes, it is suitable to show the data given in the table by using a bar graph" as the correct answer and write an incorrect explanation which is not parallel to the purpose of using bar graphs (Bar graphs are used to compare things between different groups to see the numbers more clearly) for the response.	1+0
	Write "No, it is not suitable to show the data given in the table by using a bar graph" as the incorrect answer without any explanation for the response.	0+0
	Write "No, it is suitable to show the data given in the table by using a bar graph" as the incorrect answer and write an incorrect explanation which is not parallel to the purpose of using bar graphs (Bar graphs are used to compare things between different groups to see the numbers more clearly) for the response.	0+0

1st Question Part c (Circle Graphs)	Write "Yes, it is suitable to show the data given in the table by using a circle graph" as the correct answer without any explanation for the response.	**1+0**
	Write "Yes, it is suitable to show the data given in the table by using a circle graph, because circle graphs are used for comparing the parts of a whole" as both correct answer and correct explanation for the response.	**1+1**
	Write "Yes, it is suitable to show the data given in the table by using a circle graph" as the correct answer and write an incorrect explanation which is not parallel to the purpose of using circle graphs (Circle graphs are used for comparing the parts of a whole) for the response.	**1+0**
	Write "No, it is not suitable to show the data given in the table by using a circle graph" as the incorrect answer without any explanation for the response.	**0+0**
	Write "No, it is suitable to show the data given in the table by using a circle graph" as the incorrect answer and write an incorrect explanation which is not parallel to the purpose of using circle graphs (Circle graphs are used for comparing the parts of a whole) for the response.	**0+0**
2nd Question	Draw a bar graph.	**1**
	Write "Numbers of girls and boys in 7th-grade sections" as the correct title of the graph.	**1**
	Write "Numbers of girls and boys" as the correct name of quantitative axis.	**1**
	Write "Sections" as the correct name of categorical axis.	**1**
	Show which variables are represented by bars in the graph.	**1**
	Identify zero in the intersection point of axes.	**1**
	Plot the values of the variable in numerical order with appropriate intervals in quantitative axis.	**1**
	Put an arrow to the end of vertical axis.	**1**
	Put an arrow to the end of horizontal axis.	**1**
3rd Question	Draw a circle graph.	**1**
	Write "Numbers of students" as the correct title of the circle graph.	**1**
	Convert numbers of students given in the table into degrees.	**1**
	Show degrees of students' numbers in the circle graph.	**1**
	Interpret the circle graph correctly. For instance, say that there are totally 18 students in the classroom, there is only one student who has the greatest numbers of sisters or brothers, or there are 2 students who have the least number of sisters or brothers...	**1**

4th Question	Write "The changes of literacy ratios that belong to the population of woman and man in a country between the years 1940 and 1970" as the correct title of the graph.	**1**
	Write "The literacy ratios" as the correct name of quantitative axis.	**1**
	Write "Years" as the correct name of categorical axis.	**1**
	Write "More than half of the woman population is literate between the years 1965 and 1970" as the correct answer for the response.	**1**
	Write "No, the literacy ratios of woman and man in 1975 cannot be guessed by using the data given, because in the graph, the literacy ratios of woman and man do not increase or decrease continuously" as the correct answer and correct interpretation for the response.	**1+1**
	Write "No, the literacy ratios of woman and man in 1975 cannot be guessed by using the data given" as the correct answer without any interpretation for the response.	**1+0**
	Write "No, the literacy ratios of woman and man in 1975 cannot be guessed by using the data given" as the correct answer and write an incorrect explanation which is not parallel to the correct explanation (In the graph, the literacy ratios of woman and man do not increase or decrease continuously) for the response.	**1+0**
	Interpret the line graph correctly. For instance, say that the literacy ratios of man is higher than the literacy ratios of woman between the years 1940 and 1970, the literacy ratios of woman did not change between the years 1940 and 1945, the literacy ratios of man did not change between the years 1950 and 1955, both the literacy ratios of woman and man decreased between the years 1955 and 1960.	**1**
5th Question	Write "The difference between the total number of woman and the total number of man is 65 million" as the correct answer for the response.	**1**
	Write "The country in which numbers of the woman and man are the most different is D" as the correct answer for the response.	**1**
	Write "The ratio of woman who drives a car is the most in the country C" as the correct answer for the response.	**1**
	Write "A" as one part of the answer.	**1**
	Write "B" as one part of the answer.	**1**
	Write "D" as one part of the answer.	**1**
	Write the correct reasons of the situation in which numbers of woman driving a car is less than numbers of man driving a car. For instance, say that the man work, but much of the woman are housewife, the woman are reluctant to drive a car not to have an accident...	**1**

6th Question	Explain the differences between the graphs correctly. For instance, the graph A starts from 3 while graph B starts from 0. While the interval between the values in graph A is 2, the interval between the values in graph B is 1.	**1**
	Write "The graph A could be drawn by the employees, because they want to show how the increase ratios made by the private establishment to them is less" as the correct answer and correct interpretation for the response.	**1+1**
	Write "The graph A could be drawn by the employees" as the correct answer without any explanation for the response.	**1+0**
	Write "The graph A could be drawn by the employees, because in graph A, it can be seen as the increase ratios made by the private establishment to the employees is less" as the correct answer and write an incorrect explanation which is not parallel to the correct explanation (In graph A, it can be seen as the increase ratios made by the private establishment to the employees is less) for the response.	**1+0**

APPENDIX G

THE LAST FORM OF POSTTEST

Ad-Soyad :
Sınıf :
Numara :

SORULAR (SON SINAV)

Soru 1:

Tablo: 2008-2009 yıllarında bir ülkeye gelen yabancı turist sayısı

Ulaşım şekli	Yıllar	
	2008	2009
Deniz yolu	3,5 milyon	2 milyon
Hava yolu	6 milyon	5 milyon
Kara yolu	2,5 milyon	1 milyon

Yukarıdaki tabloda, 2008-2009 yıllarında bir ülkeye deniz yolu, hava yolu ve kara yolu ile gelen yabancı turist sayısı verilmiştir. Buna göre,

a) Tablodaki verileri çizgi grafiği ile göstermek uygun olur mu? Açıklayınız.

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b) Tablodaki verileri sütun grafiği ile göstermek uygun olur mu? Açıklayınız.

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c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

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1

Soru 2:

Tablo: Matematik ve Türkçe 1.yazılı sonuçları

	Matematik	**Türkçe**
Ayşegül	0	20
Ali	85	90
Yiğit	70	60
Esra	95	100
Uğur	40	55

Yukarıdaki tabloda, beş kişinin Matematik ve Türkçe derslerine ait birinci yazılı sonuçları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

2

Soru 3:

Tablo: Öğrencilerin matematik notları

Not	Öğrenci Sayısı
0	1
1	4
2	0
3	13
4	10
5	8

Yukarıdaki tabloda, bir sınıftaki öğrencilerin matematik dersinden almış oldukları notlar verilmiştir. Buna göre,

a) Verilen bilgileri kullanarak öğrenci sayısını gösteren bir daire grafiği çiziniz.

b) Çizdiğiniz grafiği yorumlayınız.

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Soru 4:

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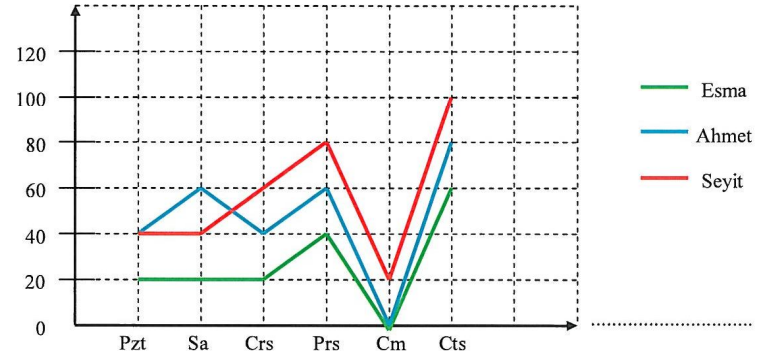

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Esma, Ahmet ve Seyit altı gün boyunca aynı kitabı okumuşlardır. Her gün kaç sayfa kitap okudukları yukarıdaki grafikte gösterilmektedir. Buna göre,

a) Grafiğin başlığını ve eksen isimlerini yukarıda belirtilen boşluklara yazınız.

b) Ahmet, hangi gün veya günler arkadaşlarından fazla kitap okumuştur?

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c) Altı gün boyunca Seyit, Ahmet'ten toplam kaç sayfa fazla kitap okumuştur?

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d) Grafikteki verileri kullanarak Esma, Ahmet ve Seyit'in Pazar günü okuyacakları sayfa sayıları tahmin edilebilir mi? Açıklayınız.

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e) Grafiği yorumlayınız.

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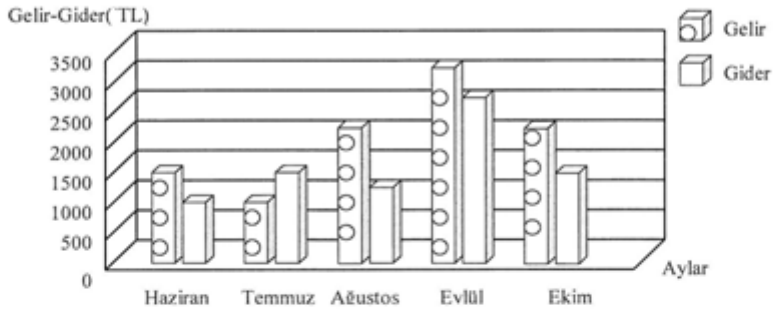
Soru 5:

Grafik: Haziran-Ekim ayları arasında gelir-gider verileri



Yukarıdaki grafik bir market sahibinin beş aylık gelir-gider durumunu göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

a) Toplam gelir..... TL'dir.

b) Toplam gider..... TL'dir.

c) En çok gelir.....ayında elde edilmiştir.

d) En çok gider.....ayında gerçekleşmiştir.

e) Market sahibi en çok .....ayında kar etmiştir.

f) ..... ile.....aylarında elde edilen karlar eşittir.

g) Market sahibi aylardan birinde zarar etmiştir. Bu zararın sebepleri neler olabilir? Açıklayınız.

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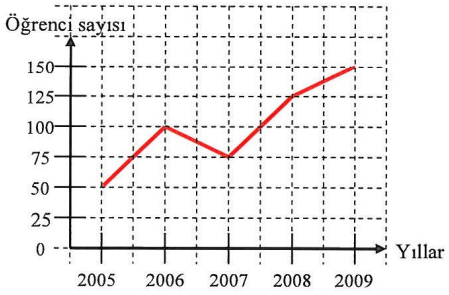
Soru 6:

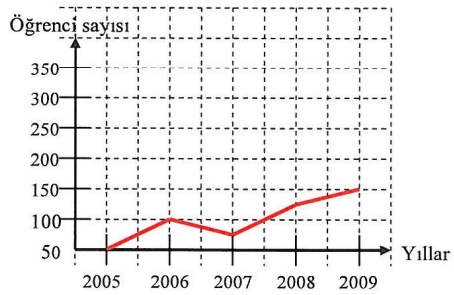
A

Grafik: 2005-2009 yılları arasında üniversiteyi kazanan öğrenci sayıları



B

Grafik: 2005-2009 yılları arasında üniversiteyi kazanan öğrenci sayıları



Yukarıdaki grafiklerde, bir dershanedeki 2005-2009 yılları arasında üniversiteyi kazanan öğrenci sayıları verilmiştir. Buna göre,

a) Grafikler arasındaki farklılıkları açıklayınız.

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b) Sizce dershanenin tanıtım reklamı için hangi grafik kullanılmalıdır? Açıklayınız.

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6

APPENDIX H

THE RUBRIC OF POSTTEST

Questions	Answers and Explanations	Scores
1st Question Part a (Line Graphs)	Write "No, it is not suitable to show the data given in the table by using a line graph" as the correct answer without any explanation for the response.	1+0
	Write "No, it is not suitable to show the data given in the table by using a line graph, because line graphs are used for tracking changes over short and long periods of time" as both correct answer and correct explanation for the response.	1+1
	Write "No, it is not suitable to show the data given in the table by using a line graph" as the correct answer and write an incorrect explanation which is not parallel to the purpose of using line graphs (Line graphs are used for tracking changes over short and long periods of time) for the response.	1+0
	Write "Yes, it is suitable to show the data given in the table by using a line graph" as the incorrect answer without any explanation for the response.	0+0
	Write "Yes, it is suitable to show the data given in the table by using a line graph" as the incorrect answer and write an incorrect explanation which is not parallel to the purpose of using line graphs (Line graphs are used for tracking changes over short and long periods of time) for the response.	0+0
1st Question Part b (Bar Graphs)	Write "Yes, it is suitable to show the data given in the table by using a bar graph" as the correct answer without any explanation for the response.	1+0
	Write "Yes, it is suitable to show the data given in the table by using a bar graph, because bar graphs are used to compare things between different groups to see the numbers more clearly and they can be used to show the data more than one criterion" as both correct answer and correct explanation for the response.	1+1
	Write "Yes, it is suitable to show the data given in the table by using a bar graph" as the correct answer and write an incorrect explanation which is not parallel to the purpose of using bar graphs (Bar graphs are used to see compare things between different groups to see the numbers more clearly and they can be used to show the data more than one criterion) for the response.	1+0
	Write "No, it is not suitable to show the data given in the table by using a bar graph" as the incorrect answer without any explanation for the response.	0+0
	Write "No, it is suitable to show the data given in the table by using a bar graph" as the incorrect answer and write an incorrect explanation which is not parallel to the purpose of using bar graphs (Bar graphs are used to see compare things between different groups to see the numbers more clearly and they can be used to show the data more than one criterion) for the response.	0+0

1st Question Part c (Circle Graphs)	Write "No, it is not suitable to show the data given in the table by using a circle graph" as the correct answer without any explanation for the response.	**1+0**
	Write "No, it is not suitable to show the data given in the table by using a circle graph, because circle graphs are used for comparing the parts of a whole, but they cannot be used to show data more than one criterion" as both correct answer and correct explanation for the response.	**1+1**
	Write "No, it is not suitable to show the data given in the table by using a circle graph" as the correct answer and write an incorrect explanation which is not parallel to the purpose of using circle graphs (Circle graphs are used for comparing the parts of a whole, but they cannot be used to show data more than one criterion) for the response.	**1+0**
	Write "Yes, it is suitable to show the data given in the table by using a circle graph" as the incorrect answer without any explanation for the response.	**0+0**
	Write "Yes, it is suitable to show the data given in the table by using a circle graph" as the incorrect answer and write an incorrect explanation which is not parallel to the purpose of using circle graphs (Circle graphs are used for comparing the parts of a whole, but they cannot be used to show data more than one criterion) for the response.	**0+0**
2nd Question	Draw a bar graph.	**1**
	Write "The first exam results of Mathematics and Turkish" as the correct title of the graph.	**1**
	Write "Exam results" as the correct name of quantitative axis.	**1**
	Write "Students' name" as the correct name of categorical axis.	**1**
	Show which variables are represented by bars in the graph.	**1**
	Identify zero in the intersection point of axes.	**1**
	Plot the values of the variable in numerical order with appropriate interval in quantitative axis.	**1**
	Put an arrow to the end of vertical axis.	**1**
	Put an arrow to the end of horizontal axis.	**1**
3rd Question	Draw a circle graph.	**1**
	Write "Mathematics exam results of students" as the correct title of the circle graph.	**1**
	Convert numbers of students given in the table into degrees.	**1**
	Show degrees of students' numbers in the circle graph.	**1**
	Interpret the circle graph correctly. For instance, say that there are totally 36 students in the classroom…	**1**

4th Question	Write "Numbers of pages Esma, Ahmet and Seyit read in six days" as the correct title of the graph.	1
	Write "Number of pages" as the correct name of quantitative axis.	1
	Write "Days" as the correct name of categorical axis.	1
	Write "Ahmet read more pages than his friends on Tuesday" as the correct answer for the response.	1
	Write "Seyit read 60 more pages than Ahmet in six days" as the correct answer for the response.	1
	Write "No, numbers of pages which the students read on Sunday cannot be guessed by using the information given in the graph, because in the graph, numbers of pages which they read in six days do not increase or decrease continuously" as the correct answer and correct interpretation for the response.	1+1
	Write "No, numbers of pages which the students read on Sunday cannot be guessed by using the information given in the graph" as the correct answer without any interpretation for the response.	1+0
	Write "No, numbers of pages which the students read on Sunday cannot be guessed by using the information given in the graph" as the correct answer and write an incorrect explanation which is not parallel to the correct explanation (In the graph, numbers of pages which they read in six days do not increase or decrease continuously) for the response.	1+0
	Interpret the line graph correctly. For instance, say that Esma read the least number of pages among them, Ahmet and Seyit read the same numbers of pages on Tuesday…	1
5th Question	Write "The total amount of receipts is 10250 TL" as the correct answer for the response.	1
	Write "The total amount of expenses is 8000 TL" as the correct answer for the response.	1
	Write "The most receipts were obtained in the month, September" as the correct answer for the response.	1
	Write "The most expenses were obtained in the month, September" as the correct answer for the response.	1
	Write "The market owner made the most profits in the month, August" as the correct answer for the response.	1
	Write "The profits made in the months, June and September were the same" as one part of the answer.	1
	Write the correct reasons of the situation in which the market owner made a loss in a month. For instance, say that since the month is July, the people can go to the holiday, another market can be opened near this market…	1

6th Question	Explain the differences between the graphs correctly. For instance, the graph A starts from 0 while graph B starts from 50. While the interval between the values in graph A is 25, the interval between the values in graph B is 50.	**1**
	Write "The graph A should be used for the advertisement of the test preparation center, because in graph A, it can be seen as there are more students who entered a university" as the correct answer and correct interpretation for the response.	**1+1**
	Write "The graph A should be used for the advertisement of the test preparation center" as the correct answer without any explanation for the response.	**1+0**
	Write "The graph A should be used for the advertisement of the test preparation center, because in graph A, it can be seen as there are more students who entered a university" as the correct answer and write an incorrect explanation which is not parallel to the correct explanation (In graph A, it can be seen as there are more students who entered a university) for the response.	**1+0**

APPENDIX I

AN EXAMPLE OF INTERVIEW PROTOCOLS USED IN STUDENT INTERVIEW

SORULAR

Soru 1:

Aşağıda daha önce sana sorulan bir soruyu ve bu soruya ait şıklara vermiş olduğun cevapları görmektesin.

- Neden o cevapları yazdığını ve nasıl düşündüğünü açıklar mısın?

a)

b)

c)

Tablo: 2008-2009 yıllarında bir ülkeye gelen yabancı turist sayısı

Ulaşım şekli	Yıllar	
	2008	2009
Deniz yolu	3,5 milyon	2 milyon
Hava yolu	6 milyon	5 milyon
Kara yolu	2,5 milyon	1 milyon

Yukarıdaki tabloda, 2008-2009 yıllarında bir ülkeye deniz yolu, hava yolu ve kara yolu ile gelen yabancı turist sayısı verilmiştir. Buna göre,

a) Tablodaki verileri çizgi grafiği ile göstermek uygun olur mu? Açıklayınız.

Hayır. Çünkü: Bu grafiği sütun grafiğinde göstermek için çünkü 2 tane veri var.

b) Tablodaki verileri sütun grafiği ile göstermek uygun olur mu? Açıklayınız.

Evet. Çünkü: 2 veriyle kullanılan tek grafik sütun grafiği olduğu için.

c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

Olamaz. Çünkü: Neyin ne aldığını ve 2008-2009 yıllarının kaç milyon kişi olduğunu anlayamayız.

Soru 2:

Aşağıda daha önce sana sorulan bir soruyu ve bu soruya yönelik çizdiğin sütun grafiğini görmektesin.

- Neden sütun grafiğini tercih ettiğini açıklar mısın?

- Çizdiğin grafiği tekrardan inceleyerek eksiklerin olup olmadığını söyler misin?

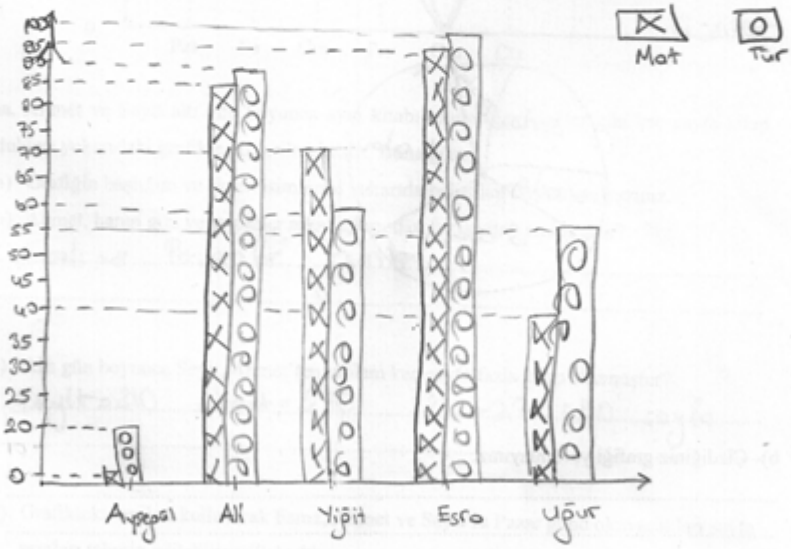
- "0" değerini neden x ekseninin üst kısmına yerleştirdiğini açıklar mısın?

- x ve y eksenlerinin kesişim noktası neyi göstermektedir?

Tablo: Matematik ve Türkçe 1.yazılı sonuçları

	Matematik	Türkçe
Ayşegül	0	20
Ali	85	90
Yiğit	70	60
Esra	95	100
Uğur	40	55

Yukarıdaki tabloda, beş kişinin matematik ve türkçe derslerine ait birinci yazılı sonuçları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.



Soru 3:

Aşağıda daha önce sana sorulan bir soruyu ve bu soruya ait şıklara vermiş olduğun cevapları görmektesin.

a) Bu şıkkı neden boş bıraktın? Verilen bilgilere göre grafikte ne anlatılıyor? x ve y eksenleri neyi gösteriyor?

- b, c ve d şıklarına neden o cevapları yazdığını ve nasıl düşündüğünü açıklar mısın?

b)

c)

d)

Yukarıdaki grafik, bir ülkedeki 1940-1970 yılları arasındaki kadın ve erkek nüfusuna ait okuma-yazma oranının değişimini göstermektedir. Buna göre,

a) Grafiğin başlığını ve eksen isimlerini yukarıda belirtilen boşluklara yazınız.

b) Hangi yıl veya yıllar arasında kadın nüfusunun yarısından çoğu okur-yazar durumundadır?

1955-1960

c) Grafikteki verileri kullanarak 1975 yılındaki kadın ve erkek okur-yazar oranları tahmin edilebilir mi? Açıklayınız.

Edilir. Çünkü: Okur-yazar oranı gittikçe artmış.

d) Grafiği yorumlayınız.

Erkek okur-yazar durumu kadınlardan fazladır.

Soru 4:

Aşağıda daha önce sana sorulan bir soruyu ve bu soruya ait şıklara vermiş olduğun cevapları görmektesin.

- Neden o cevapları yazdığını ve nasıl düşündüğünü açıklar mısın?

a)

b)

c)

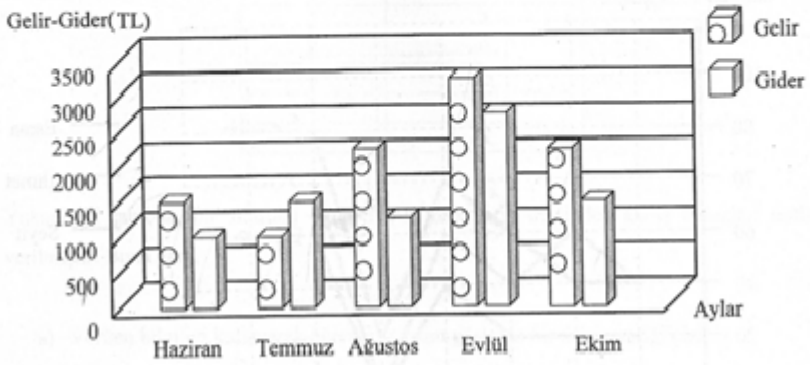
d)

e)

f)

g)

Grafik: Haziran-Ekim ayları arasında gelir-gider verileri



Yukarıdaki grafik bir market sahibinin beş aylık gelir-gider durumunu göstermektedir.

Buna göre aşağıdaki boşlukları doldurunuz.

a) Toplam gelir.....10.000..... TL'dir. 3000 + 2.000 + 2000 + 1250 + 750 = 10.000

b) Toplam gider.....6.800..... TL'dir. 750 + 1250 + 1000 + 2500 + 1250 = 6800

c) En çok gelir.....Ağustos.....ayında elde edilmiştir.

d) En çok gider.....Temmuz.....ayında gerçekleşmiştir.

e) Market sahibi en çok .....Ağustos.....ayında kar etmiştir.

f) .....Ağustos..... ile.....Ekim.....aylarında elde edilen karlar eşittir.

g) Market sahibi aylardan birinde zarar etmiştir. Bu zararın sebepleri neler olabilir?

Açıklayınız.

Temmuz ayında zarar yapmıştır ama neden yaptığını bilmiyor

APPENDIX K

INTERVIEW PROTOCOL OF TEACHER INTERVIEW

SORULAR

Soru 1:

"Kavram yanılgısı" ile "hata" arasındaki fark nedir?

.....

.....

.....

.....

.....

Soru 2:

Aşağıda daha önce öğrencilere uygulanan yazılı sınavlardan alınmış bir soruyu ve bir öğrencinin bu soruya vermiş olduğu cevabı görmektesiniz.

- Soruyu inceleyerek öğrenci cevabının doğru olup olmadığını açıklayınız.

- Öğrenci cevabı incelendiğinde öğrenci için ne söylenebilir? Kavram yanılgısına mı sahiptir yoksa hata mı yapmaktadır? Açıklayınız.

Soru:

Tablo: 2008-2009 yıllarında bir ülkeye gelen yabancı turist sayısı

Ulaşım şekli	Yıllar	
	2008	**2009**
Deniz yolu	3,5 milyon	2 milyon
Hava yolu	6 milyon	5 milyon
Kara yolu	2,5 milyon	1 milyon

Yukarıdaki tabloda, 2008-2009 yıllarında bir ülkeye deniz yolu, hava yolu ve kara yolu ile gelen yabancı turist sayısı verilmiştir. Buna göre, tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

Cevap:

c) Tablodaki verileri daire grafiği ile göstermek uygun olur mu? Açıklayınız.

Evet olur. Daire grafiğinde oranlar belirtilerek gösterilir.

Soru 3:

Aşağıda grafik çizimiyle ilgili bir soruyu ve bu soruya yönelik bir öğrencinin çizmiş olduğu çizgi grafiğini görmektesiniz.

- Öğrencinin grafik türü seçimi ve grafik çiziminin doğru olup olmadığını açıklayınız.

- Grafiğin eksenlerinin isimlendirilmesi ile ilgili öğrenci için ne söylenebilir? Kavram yanılgısına mı sahiptir yoksa hata mı yapmaktadır? Açıklayınız.

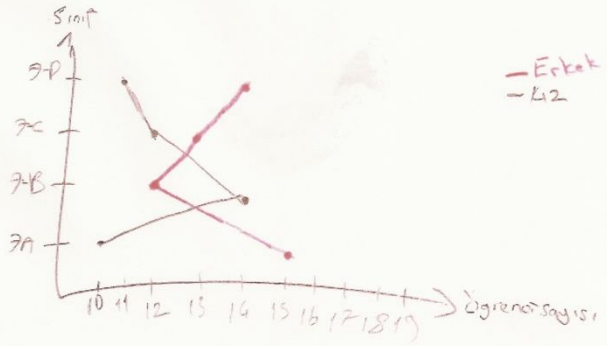
Soru:

Tablo: 7.sınıf şubelerine ait kız ve erkek öğrenci sayısı

	Kız	Erkek
7-A	10	15
7-B	14	12
7-C	12	13
7-D	11	14

Yukarıdaki tabloda, bir okuldaki 7.sınıf şubelerine ait kız ve erkek öğrenci sayıları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

Cevap:



Soru 4:

Aşağıda grafik çizimiyle ilgili bir soruyu ve bu soruya yönelik bir öğrencinin çizmiş olduğu sütun grafiğini görmektesiniz.

- Öğrencinin grafik türü seçimi ve grafik çiziminin doğru olup olmadığını açıklayınız.

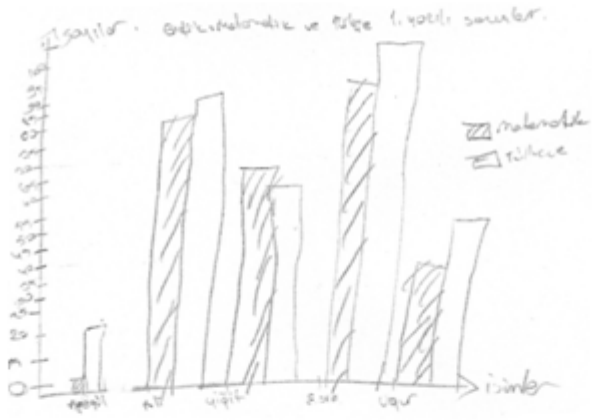
Soru:

Tablo: Matematik ve Türkçe 1.yazılı sonuçları

	Matematik	**Türkçe**
Ayşegül	0	20
Ali	85	90
Yiğit	70	60
Esra	95	100
Uğur	40	55

Yukarıdaki tabloda, beş kişinin Matematik ve Türkçe derslerine ait birinci yazılı sonuçları verilmektedir. Verilen bilgileri kullanarak bir grafik çiziniz.

Cevap:



Soru 5:

Aşağıda sütun grafiğinin yorumlanması ile ilgili bir soruyu ve bu soruya ait şıklara öğrencinin vermiş olduğu cevapları görmektesiniz.

- Öğrenci cevaplarının doğru olup olmadığını açıklayınız.

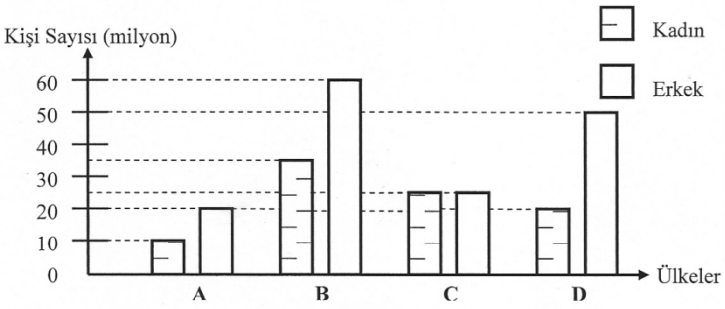
a)

b)

- Öğrenci cevapları incelendiğinde öğrenci için ne söylenebilir? Kavram yanılgısına mı sahiptir yoksa hata mı yapmaktadır? Açıklayınız.

Soru:

Grafik: Ülkelere göre araba kullanan kadın erkek sayıları



Yukarıdaki grafik, dört farklı ülkedeki araba kullanan kadın ve erkek sayılarını göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

Cevap:

b) Araba kullanan kadın ve erkek sayıları arasındaki farkın en fazla olduğu ülke B'dir.

c) Araba kullanan kadınların oranı B ülkesinde en fazladır.

Soru 6:

Aşağıda sütun grafiğinin yorumlanması ile ilgili bir soruyu ve bu soruya ait şıklara farklı öğrenci cevaplarını görmektesiniz.

- Cevapların doğru olup olmadığını açıklayınız.

a)

b)

c)

d)

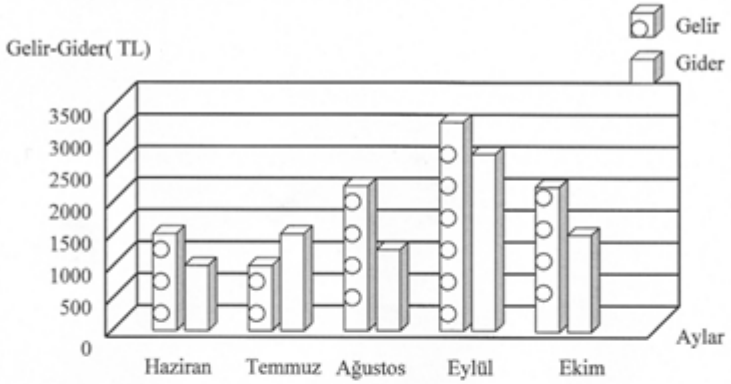
e)

f)

- Cevapları incelendiğinde öğrenciler için ne söylenebilir? Kavram yanılgısına mı sahiptirler yoksa hata mı yapmaktadırlar? Açıklayınız.

Soru:

Grafik: Haziran-Ekim ayları arasında gelir-gider verileri



Yukarıdaki grafik bir market sahibinin beş aylık gelir-gider durumunu göstermektedir. Buna göre aşağıdaki boşlukları doldurunuz.

Cevap:

a) Toplam gelir.....11000..... TL'dir.

b) Toplam gider.....8500..... TL'dir.

c) En çok gelir.....3000.....ayında elde edilmiştir.

d) En çok gider.....Temmuz.....ayında gerçekleşmiştir.

e) Market sahibi en çok .....Eylül.....ayında kar etmiştir.

f) .....Haziran..... ile.....Temmuz.....aylarında elde edilen karlar eşittir.