AN INVESTIGATION OF 7TH GRADE STUDENTS' LEVEL OF UNDERSTANDING IN THE STATISTICAL INVESTIGATION PROCESS

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Approval of the Graduate School of Social Sciences

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

AN INVESTIGATION OF 7TH GRADE STUDENTS' LEVEL OF UNDERSTANDING IN THE STATISTICAL INVESTIGATION PROCESS

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The aim of the present study was to investigate seventh grade students' level of understanding in the statistical investigation process when they are given real data sets. More specifically, seventh grade students' level of understanding in all the components of the statistical investigation process, which are posing a statistical investigation question, collecting data, analyzing data, and interpreting results.

The participants of the study were 121 seventh grade students from one public middle school. Data was collected via the Statistical Investigation Process Questionnaire (SIPQ) during the spring semester of the 2017-2018 academic year. To address the research questions, students' answers were analyzed through the item based in-depth analysis.

The findings of the study revealed that levels of understanding of the students were generally high in posing a statistical investigation question. Similarly, students' levels of understanding were the highest in posing a survey question, but their levels of understanding were the lowest in deciding on the data sources. On the other hand,

students' levels of understanding in analyzing data were low. In other words, students had difficulty in choosing a graph suitable for both data type and the aim of the given scenarios like comparing two different data sets. Besides, the graphs of students were problematic in terms of their structural features such as labeling the coordinates, numerating the axes and connecting paired orders with lines. The findings further indicated that students' levels of understanding were at intermediate level and advanced level while interpreting results. In other words, students integrated the presented information or they extended, predicted or inferred from the presented information.

Keywords: Statistical Investigation Process, Posing Statistical Investigation Question, Collecting Data, Analyzing Data, Interpreting Data

ÖZ

YEDİNCİ SINIF ÖĞRENCİLERİNİN İSTATİSTİKSEL ARAŞTIRMA SÜRECİNİ ANLAMLANDIRMALARININ İNCELENMESİ

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Bu çalışmanın amacı ortaokul yedinci sınıf öğrencilerinin istatistiksel araştırma sürecini anlamlandırmalarını incelemektir. Bu bağlamda, bu çalışma yedinci sınıf öğrencilerine gerçek veri kümeleri vererek istatistiksel araştırma sürecini oluşturan problemi belirleme, veri toplama, veriyi analiz etme ve sonuçları yorumlama aşamalarının her birindeki anlama seviyelerini belirlemektir.

Çalışmaya 121 devlet okulu öğrencisi katılmıştır. Veriler İstatistiksel Araştırma Süreci Testi (İAST) aracılığıyla 2017-2018 öğretim yılı bahar döneminde toplanmıştır. Öğrencilerin istatistiksel araştırma sürecini anlamlandırmalarının belirlenmesi için öğrencilerin hazırlanan teste verdiği cevaplar derinlemesine incelenmiştir.

Çalışmanın sonuçları öğrencilerin istatistiksel araştırma sorusu oluşturma seviyelerinin genel olarak yüksek olduğunu göstermiştir. Öte yandan, öğrencilerin araştırma sürecinde en başarılı oldukları kısım anket sorusu oluşturma iken en çok zorlandıkları ve en yabancı oldukları kısmın veri toplama yöntemine karar vermek

olduğu görülmüştür. Bu durum öğrencilerin ‘anket’ kavramını bilmeseler de anket sorusu oluşturabildiklerini göstermiştir. Ayrıca, öğrencilerin verileri analiz etme seviyelerinin düşük olduğu görülmüştür. Diğer bir deyişle, öğrencilerin hem veri türüne hem de karşılaştırma yapmak gibi verilen durumların amacına uygun grafik türünü seçmekte zorlandıkları görülmüştür. Bunun yanı sıra, grafiklerin çiziminde eksen isimlerinin yazılmaması, eksenlerin yanlış numaralandırılması ve sıralı ikilileri yanlış çizgilerle birleştirilmesi gibi hatalar yaptıkları gözlemlenmiştir. Son olarak, öğrencilerin sonuçları yorumlama seviyelerinin genel olarak orta veya ileri düzey olduğu görülmüştür. Diğer bir deyişle öğrencilerin grafikte verilen bilgileri bütün olarak ele alan ya da grafikte açıkça verilmeyen ilişkilere değinen yorumlar yaptıkları görülmüştür.

Anahtar kelimeler: İstatistiksel Araştırma Süreci, Araştırma Sorusu Oluşturma, Veri Toplama, Veri Analizi, Veri Yorumlama

To my parents

Adem ÖZ & Güldane ÖZ

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LIST OF ABREVIATIONS

GAISE Guidelines and Assessment for Statistics Education Report

IAST Istatistiksel Araştırma süreci Testi

MoNE Ministry of National Education

NCTM National Council of Teachers of Mathematics

SIPQ Statistical Investigation Process Quationnaire

CHAPTER 1

INTRODUCTION

Quantitative information is everywhere (Ben-Zvi & Garfield, 2004) and people encounter numbers and statistical information every day. Indeed, they are confronted with statistical information from different areas ranging from economy to education, from movies to sports, from food to medicine, and from public opinion to social behavior in newspapers and other media (Franklin et al., 2005). To put it differently, individuals encounter statistical information everywhere in their daily lives and an informed citizen should be able to understand this information and then be able to make decisions based on that understanding (Towsend, 2006). At this point, the statistics discipline gives to individuals the tools and ideas to use for the aim of reacting intelligently to the quantitative information in the world (Garfield & Ben-Zvi, 2008).

Statistics has become increasingly important in society that relies more and more on information and demands for statistical capabilities through industry, government and education (MacGillivray & Pereira-Mendoza, 2011). In other words, to access to more and more data increases the importance of statistics discipline in decision-making for all levels of citizenry (Reading, 2011). Developing statistical skills and thinking across all levels of education has a core importance in this century (MacGillivary& Pereira-Mendoza, 2011).

When the related literature is examined it is seen that statistics is explained as follows:

> Statistics has some claim to being a fundamental method of inquiry, a general way of thinking that is more important than any of the specific techniques that make up the discipline (Moore, 1990, p. 134).

As Moore stated, statistics is a practical subject dedicated to gathering and processing data with a view to making inferences which often extend beyond the data (Holmes, 1997). At the heart of statistics, the process of inquiry is located (Wild, 1994). In other words, statistics is defined as an inquiry process trying to find out about the real world by collecting and then making sense of data (Wild, 1994). Therefore, to understand the purpose and logic of statistical investigations is explained as the first goal of learning of statistics (Gal & Garfield, 1997). Students should understand both why statistical investigations are conducted and the big ideas that underlie statistical inquiries which include the omnipresent nature of variation and the use of numerical summaries and visual displays of data (Gal & Garfield, 1997). In parallel with this goal, to understand the process of statistical investigations is another important goal of statistics lessons (Gal & Garfield, 1997). Students should formulate a question, plan a study, collect, organize, analyze and display data, interpret and present findings and discuss conclusions (Gal & Garfield, 1997). Depending on the importance of statistical investigation in statistics discipline, most countries' curricula including the National Council of Teachers of Mathematics (NCTM) include statistical inquiry or investigations in national curriculum and curriculum standards (Makar & Fielding-Wells, 2011).

Curriculum standards of NCTM (2000) include statistical inquiry or investigations in instructional programs from pre-kindergarten through grade 12. The 'Data Analysis and Probability' standard of NCTM (2000) recommends that students formulate questions that can be answered using data. Also, students should learn how to collect data, organize data and display data in graphs or table to answer their questions. Moreover, they should select and use appropriate statistical methods to analyze data. Indeed, they should learn to make inferences and draw conclusions form data. Lastly, they should understand and apply basic concepts of probability in relation to statistics. Similarly, the mathematics curriculum in Turkey includes a content domain named 'data analysis' that is one of the five content domains in the curriculum. In the Turkish curriculum, the purpose is to ensure that students should be able to form research questions, collect appropriate data, represent and analyze the collected data using

measures of central tendency and spread and lastly interpret the results obtained by the end of the grade eight. Interpreting statistics in real life contexts and making decisions according to those interpretations were also emphasized in the Turkish curriculum (MoNE, 2018).

In line with the importance of statistical investigation process in the curricula, statisticians and statistics educators increasingly emphasize that all stages of statistical investigation process should be included in statistics education (MacGillivray & Pereira-Mendoza 2011). Students should design investigations, formulate research questions, collect data using observations, surveys and experiment, describe and compare data sets and prose and justify conclusions and predictions based on data as a part of their statistics education (Batanero, Burrill, & Reading, 2011). Indeed, the whole empirical enquiry cycle- understanding the contextual situation, formulating problems, defining variables, determining methods of measurement, designing methods of data collection, collecting data, and so forth should be a fundamental learning experience (Garfield & Ben-Zvi, 2008). Although it is suggested that more emphasis should be given to the investigative process (Moore, 1997), the focus in school statistics is on calculations, procedures, and graphs (Sorto, 2006). Indeed, making graphs is the end point instead of focusing on all the investigation process in the lessons (Heaton & Mickelson, 2002). For this reason, it is uncertain to which extent statistical investigations are implemented successfully in the schools (Makar & Fielding-Wells, 2011). Therefore, it is important to examine to what extent the students understand the whole statistical investigation process. Therefore, students' understanding of the whole statistical investigation process is focused on this study.

Beyond its place in curricula, the statistical investigation process has been an important topic in the area of research for many years. Various studies regarding students' capabilities to undertake the statistical investigation process (Burgess, 2001; Chick, 2000; Chick & Watson, 2001; English, 2014; English & Watson, 2015; Watson & English, 2015; Watson & English, 2017) exist in the related literature. Some studies investigated the students' capacities to pose an initial meaningful

statistical question for a given context (Watson and English, 2016). Some studies focused on students' capabilities of posing survey questions for an investigation (English, 2014). Some studies examined students' capabilities of collecting data themselves (English & Watson, 2015; Watson & English, 2016). Some examined students' capabilities to represent and analyze data to draw conclusion (Burgess, 2001; Burgess, 2002; Chick, 2000; Chick & Watson, 2001, Hotmanoğlu, 2014; Memnun, 2013). However, few studies combine all aspects of the statistical investigation process in one study (Güven et al., 2015; Watson & English, 2017). Therefore, in the present study, all aspects of the process are combined in order to gain more insight into students' capabilities and understanding in the statistical investigation process.

Therefore, the aim of this study is to examine the seventh grade students' level of understanding in the statistical investigation process. Ministry of National Education (MoNE, 2018), stated in the curriculum, for the seventh grade that students should be able to pose statistical investigation questions which are both summary and comparison questions which require gathering data, organizing data by making graphs such as bar graphs, line plots and pie charts, and interpreting the data to seventh grade. Moreover, students need to pay attention to the statistical investigation process when they collect their own data or when they use provided data sets (Friel, O'Connor, Mamer, 2006). Indeed, statistical concepts are best understood in the context of real data sets (Cobb, 1992). It is believed that giving real data sets gives opportunity to students to implement the statistical investigation process in the line with all these objectives. Therefore, the purpose of the present study is to analyze the level of understanding of seventh grade students in the statistical investigation process when they are given real data sets.

1.1. Problem Statement

The purpose of the study is to examine seventh grade students' level of understanding in the statistical investigation process when they are given real data sets. In this

respect, the following research question and its sub-question directed the current study:

1. What is the nature of seventh grade students'understanding of statistical investigation process?
   1.1. What levels of understanding do 7th grade students show in the formulating questions component of the statistical investigation process?
   1.2. What levels of understanding do 7th grade students show in the collecting data component of the statistical investigation process?
   1.3. What levels of understanding do 7th grade students show in the analyzing data component of the statistical investigation process?
   1.4. What levels of understanding do 7th grade students show in the interpreting results component of the statistical investigation process?

1.2. Definition of Important Terms

In this section, the definitions of the main terms in this study are provided for the clarity of the research questions.

Statistical investigation process: The investigative cycle '*describes the procedures a statistician works through and what the statisticians thinks about in order to learn more in the context sphere'* (Wild & Pfannkuch, 2004, p. 41).

In this study, the statistical investigation process involves four components that are formulating questions, collecting data, analyzing data, and interpreting results (Franklin et al., 2005).

Formulating questions component: This component includes clarifying the problem at hand and formulating questions that can be answered with data (Franklin, et al., 2005).

In this study, formulating question component refers to posing a statistical investigation question appropriate for the given data sets in the items.

Collecting data component: This component includes designing a plan to collect appropriate data and employing the plan to collect data (Franklin, et al., 2005).

In this study, collecting data component refers to deciding on the data sources of the given data sets in the items and posing survey questions.

Analyzing data component: This component includes selecting appropriate graphical and numerical methods and using these methods to analyze data (Franklin, et al., 2005).

In this study, analyzing the data component refers to selecting appropriate graphs for the given data sets and constructing them.

Interpreting results component: This component includes interpreting the analysis and relating the interpretation to the original question (Franklin, et al, 2005).

In this study, interpreting results component refers to drawing conclusions from the analysis.

Real data set: Real data sets provide a context to a statistical problem so that students have opportunity to reflect upon their data work with the data (Neumann, Hood, & Neumann, 2013).

In this study, real data set refers to data sets from real life context.

1.3. Significance of the Study

The statistics discipline gains more importance in decision-making for all levels of citizenry as a result of an increasingly data rich society (Reading, 2011). Consequently, statistics instruction at all educational levels is attracting more students and drawing more attention (Garfield & Ben-Zvi, 2008). Indeed, the fundamental learning experience of statistics is the whole empirical enquiry cycle from understanding the contextual situation, formulating problems, defining

variables, determining methods of measurement, to designing methods of data collection, collecting data, and so forth (Garfield & Ben-Zvi, 2008). As a result, many countries included statistical inquiry or investigations in their national curriculum and curriculum standards (Makar & Fielding-Wells, 2011). However, it is uncertain to which extent statistical investigations are implemented successfully in the schools (Makar & Fielding-Wells, 2011). Therefore, it is important to examine to what extent students understand the whole statistical investigation process.

Similarly in Turkey, elementary mathematics curriculum was updated in 2018 by the Ministry of National Education. The curriculum focused on the four components of statistical investigation: posing questions, collecting data, analyzing data, and interpreting results in different grade levels in the 'Data Analysis' learning domain. However, limited research was conducted to understand to which extent the objectives in curriculum were achieved by students by focusing on the whole statistical investigation process. Therefore, it is considered important to examine to what extent students achieved the objectives of the curriculum. As a result, this study is significant to present students' achievement of the objectives through the statistical investigation process.

There are research studies in the literature, examining students' understanding, capacities or skills in the statistical investigation process (Bush, Karp, Albanese, & Dillon, 2015; Chick, 2000; Chick & Watson, 2001; English, 2014; Fielding-Wells, 2010; Heaton & Mickelson, 2002; Watson & English, 2015; Watson & English, 2016; Watson & English, 2017). In these studies, although students underwent all the statistical investigation process, the focus was on some components of the process rather than all the components. The focus was especially on analyzing data and interpreting results (Burgess, 2001; Chick, 2000; Chick & Watson, 2001; Enisoğlu, 2014; Hotmanoğlu, 2014; Memnun, 2013). On the other hand, in the current study, students' understanding in all components of the statistical investigation process is examined. In this way, it would be possible to understand students' understanding of the statistical investigation process as a whole.

When examining the related literature in Turkey, it was seen that there is limited research on the investigation of students' experiences and understanding in the statistical investigation process (Güven, Öztürk & Özmen 2015; Hacısalihoğlu-Karadeniz, 2016). They examined the experiences and difficulties of students during the statistical investigation process. Different from these studies, the current study investigated the understanding level of students during the statistical investigation process when they were given real data sets. Hence, this study is significant since it has the potential to make an important contribution to the existing Turkish literature by revealing students' level of understanding of the statistical investigation process. In the studies of Güven et al. (2015), the students were required to study in groups and each group studied different problem situations. Familiarity with the problem situations in daily life affected process of posing research questions and collecting data about it. On the other hand, it was seen that some students guessed some data values randomly without making any research. Therefore, it was considered important to give real data sets to students to prevent guessing and making them to study with the same questions to prevent bias of context on the results of the study. As a result, this study is significant in that by giving the same data sets to all students, students' levels of understanding in the statistical investigation process could be examined by preventing bias of context. On the other hand, understanding of students in the statistical investigative process was examined through multiple choice tasks in some studies (Hacısalihoğlu-Karadeniz, 2016). However, to reveal students' understanding and questioning abilities better, open-ended tasks should be used (Watson, 1997). This study is significant in that through open-ended tasks, students' understanding in the statistical investigation process could be examined in detail.

On the other hand, there are not many comprehensive studies regarding students' understanding in the statistical investigation process in the accessible literature in Turkey (Güven et al., 2015). Therefore, considering the fact that there are a limited number of studies related to statistical investigation process in the related Turkish literature, this study investigated levels of understanding of seventh grade students in the statistical investigation process. By also attaching four different data sets

including different types of data, the results of such a study are expected to provide distinctive and valuable information regarding whether students could formulate statistical investigation problem to given situation, construct an appropriate graph to type of data and aim of situation and interpret the result in the given situations.

This study is also significant in terms of giving information to in-service teachers about the level of understanding of seventh grade students during the statistical investigation process. The results of the study can help teachers to gain an insight into middle school students' possible understanding while posing a statistical investigation question or survey question, constructing graphs and interpreting results. If the teachers are aware these understanding, they could prepare their lessons in a way to overcome lack of their understanding and enhance students' understanding.

Moreover, teacher educators can also benefit from the findings of the study. More specifically, while investigating students' understanding pre-service middle school mathematics teachers can be informed about middle school students' possible errors and difficulties regarding the statistical investigation process. In this way, since pre-service teachers will be aware of the defined errors and difficulties, they can make appropriate teaching plans to eliminate the errors and to prevent the difficulties in their future lessons.

In addition to teachers and teacher educators, the present study could provide valuable information to curriculum developers and textbook writers in the development of tasks that are necessary to teach conducting the statistical investigation process. The results of this study could be important in the revision of the current curricula and the development of textbooks taking into account students' strengths and weaknesses during the statistical investigation process which this study focused on.

CHAPTER 2

LITERATURE REVIEW

The aim of this study is to examine students' level of understanding in the statistical investigation process when they are given real data sets. For this purpose, review of the related literature is presented in this chapter. Based on the aims of the study, the chapter consists of three sections: the statistical investigation process frameworks, the features of the statistical investigation process components, the studies conducted on the statistical investigation process. At the end of the chapter, a summary of these three sections is presented.

2.1 Theoretical Frameworks of the Statistical Investigation Process

The main purpose of statistical investigation is learning in the context domain of a real problem (Wild & Pfannkuch, 1999). Statistical investigation process tries to abstract and solve a statistical problem grounded in a larger 'real' problem (Wild & Pfannkuch, 1999). In other words, the investigative cycle '*describes the procedures a statistician works through and what the statisticians thinks about in order to learn more in the context sphere'* (Wild & Pfannkuch, 2004, p. 41). As a result, statistical investigation cycle acts as a framework to build and develop statistical problem solving (Fielding-Wells, 2010). In other words, statistical problem solving is an investigation process that consists of components, each acknowledging the omnipresence of variability (Franklin, et al, 2005). In this section the main theoretical frameworks regarding the statistical investigation cycle will be summarized.

2.1.1 The PPDAC Investigative Cycle

Wild and Pfannkuch (1999) developed a statistical thinking model that is built upon the empirical enquiry cycle, historical and statistical literature in order to define how people think within the statistics discipline. Their purpose was to investigate complex thought processes involved in solving real world problems using statistics with a view to improve such problem solving. As a result, their statistical thinking framework evolved from their study of statisticians carrying out statistical investigations. The statistical framework consists of four dimensions which are the investigative cycle, types of thinking, the interrogative cycle, and dispositions. The first dimension of their statistical thinking model is investigative cycle which shows what a person does and thinks about during the course of a statistical investigation. The investigative cycle consists of five components which are problem, plan, data, analysis, and conclusions as shown in Figure 2.1.

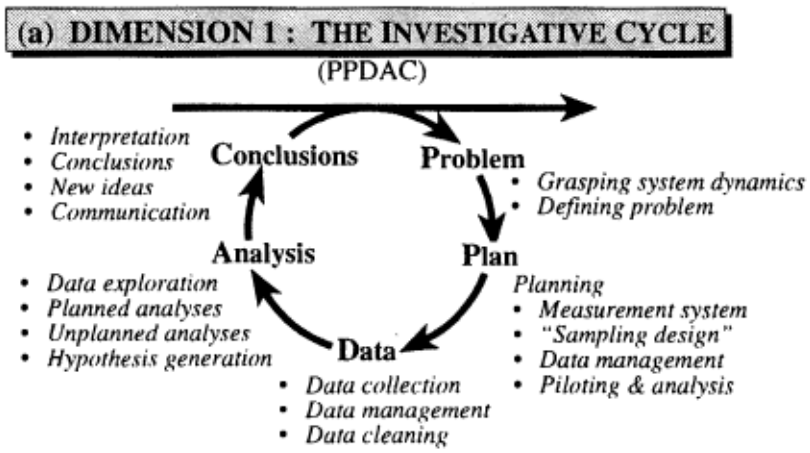


Figure 2.1 A four-dimensional framework for statistical thinking in empirical enquiry (From 'Statistical Thinking in Empirical Enquiry' by C. J. Wild and M. Pfannkuch, 1999, International Statistical Review, 67, p.226)

The problem component includes the deconstruction, negotiation and refining of a problem in conjunction with context familiarization. The plan component includes the identification of the needed data to answer the problem. Also, it is necessary to think about effective data collection, recording and analysis of data in the plan component. The data component includes the data collection, recording and cleaning processes. The analysis component involves organizing and manipulating data to identify trends or patterns in order to provide evidence to the problem. The conclusion component includes reflecting upon the evidence from the analysis component and linking it to the initial problem with the aim of providing an answer to that problem.

2.1.2 The Statistical Investigation Process of Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report (GAISE Report)

Franklin et al. (2005) developed a framework that was intended to complement the recommendations of the NCTM *Principles and Standards* which provides a conceptual structure for statistics education and gives a coherent picture of the overall curriculum. The statistical investigation process consists of four components as (a) formulate questions, (b) collect data, (c) analyze data, and (d) interpret results. In this framework, all the components of the statistical investigation process emphasize the omnipresence of variability. In the *formulating questions* component, students clarify the problem and formulate questions that could be answered with data by noticing anticipating variability. In the *collecting data* component, students design a plan to collect appropriate data and employ the plan by noticing acknowledging variability. The *collecting data* component includes 'plan' and 'data' stages of the PPDAC investigative cycle. In the *analyzing the data* component, students select appropriate graphical and numerical methods to analyze the data by noticing accounting variability. In the *interpreting results* component, students interpret the analysis and relate the interpretation to the original question by allowing for variability.

In spite of its similarities with the PPDAC investigative cycle in terms of components, this framework evolved for the school students, while the PPDAC investigative cycle of Wild and Pfannkuch (1999) evolved for statisticians.

2.1.3 Data-Handling Cycle

The description of the data-handling cycle that featured in the UK National School Curriculum since at least the mid-1970s (Holmes, 1997) has become the Plan, Collect, Process, Discuss (PCPD) cycle. The cycle is at the heart of the extensive pedagogies and resources produced by the Royal Statistical Society's Centre for Statistical Education (MacGillivary& Pereira-Mendoza, 2011). This cycle evolved for students similar to framework of the GAISE Report (2007). This cycle consists of four stages which are (a) specify the problem and plan, (b) collect data, (c) process and represent data and (d) interpret and discuss as presented below (Marriott, Davies, & Gibson, 2009):

Figure 2.2 Data-Handling Cycle (From Teaching, Learning and Assessing Statistical Problem Solving by J. Marriott, N. Davies & L. Gibson, 2009, *Journal of Statistics Education,* 17(1), p.2)

In this cycle, ‘planning’ is included in the first stage ‘specify the problem and plan’ different from the PPDAC cycle and GAISE report. This stage is related to formulating questions in terms of the data needed, and considering what inferences can be drawn from the data; deciding what data to collect (including sample size and data format) and what statistical analysis is needed. Collecting data stage is related to collecting data from a variety of suitable sources, including experiments and surveys, and primary and secondary sources. Processing and representing the data stage is related to turning the raw data into usable information that gives insight into the problem. Interpreting and discussing the results stage is related to answering the initial question by drawing conclusions from the data. Different from the GAISE Report, the stages of PCPD are cyclic because it may be necessary to refine the initial approach to solve a problem and repeat the process over and over again.

2.1.4 PCAI Modeling Cycle

The PCAI model has been proposed as a structuring device in order to help learners to organize their statistical investigation (Graham, 2006).

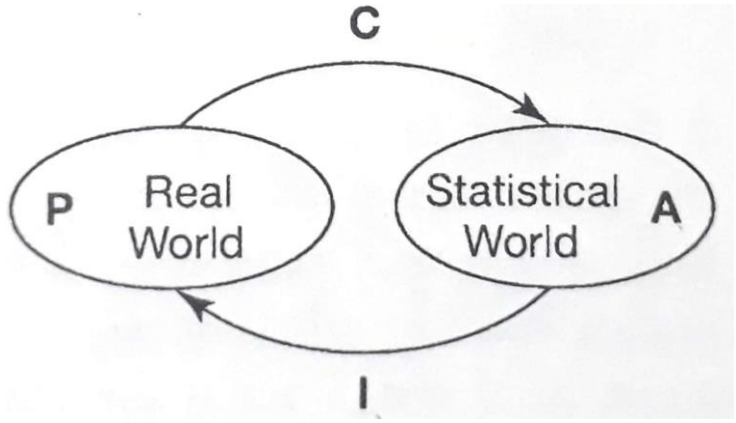


Figure 2.3 The PCAI Modeling Cycle (From Statistical Investigation, A. Graham, 2006 p.208)

The cycle consists of four stages which are posing questions, collecting the data, analyzing the data, and interpreting the results (Graham, 2006) similar to the GAISE Report. Graham (2006) stated that every statistical investigation starts with a question. Collecting data stage is related to deciding which data sources are useful for the research question. Conducting experiments or applying a questionnaire and choosing a sample for primary data sources and knowing where to look for secondary data are the aspects of this stage. Analyzing the data stage is related to determine which statistical elements such as data summaries, graphs and so on were used, considering the nature of the data and the aim of the enquiry. Interpreting the results stage is related to connecting the analysis to the initial question by representing the finding to others. The PCAI cycle is cyclic similar to the PCPD cycle.

2.1.5 The Stages of Statistical Investigation

Chatfield (1995) listed the steps of an idealized statistical investigation as (a) formulate the problem, (b) collect the data, (c) analyze data, (d) use resources and (e) communication. At formulating the problem step, the problem is formulated in statistical terms after clearly understanding the physical background to the situation under study. At collecting the data step, the question how 'good' data is collected to draw valid conclusions is answered. Therefore, the methods of collecting data and sampling size issues are considered at this step. At analyzing the data step, the features of data are described using tables, graphs and summary statistics. Then 'definitive' analysis and 'inferential' analysis are made. At using resources step which is different from other frameworks, computer and library are used. The choice of computer and its accompanying software is crucial because statistical analyses are carried out using computer. Although statisticians cannot be expected to 'know everything', they must know how to locate appropriate reference material and be able to understand it. A library is the most important source of knowledge and used wisely to overcome statistical problems. At communication step, interpretation of analyses

is made and results are communicated so that the findings can be understood by both statisticians and non-statisticians.

When the frameworks mentioned above are examined, it seen that four or five steps cycles have been prepared for statistical investigations and there are not big differences between them. Basically, all of them contain components such as posing a problem, planning and collecting data, analyzing the data and interpreting the analysis. All of them state that the statistical investigation process is non-linear and involves going back and forth between various phases. In spite of all the similarities, the focus of *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report* (Franklin et al., 2005) is exactly on school level to complement the recommendations of the NCTM for instructional programs from pre-kindergarten through grade 12. Therefore, in this study, four components of the statistical investigation process of GAISE outlined were used. In the next section, the features of the components of the statistical investigation process are explained.

2.2 Studies Related to the Features of the Components of the Statistical Investigation Process

In this section, the studies related to the features of the components of the statistical investigation process are examined.

2.2.1 The Features of the Formulating Question Component

Problem posing has long been recognized as a critically important intellectual activity in scientific investigation since researchable questions are required to carry out investigations (Chin & Kayalvizhi, 2002). Indeed, the formulation of an interesting problem is often more important than its solution (Einstein & Infeld, 1938). Therefore, in this part, the features of a statistical investigation question are examined.

Makar and Fielding-Wells (2011) summarized the literature to identify the key issues of the statistical investigation process. They stated that the problem-posing phase serves as the driving focus for investigation; hence, statistical investigative questions need to be interesting, challenging, ill-structured and ambiguous. Moreover, they should be statistical in nature, required to gather and interpret data to be answered (Makar & Fielding-Wells, 2011). Indeed, Franklin and Garfield (2006, p.350) expained what a statistical question is by stating that *'the formulation of a statistic question requires an understanding of the difference between a question that anticipates a deterministic answer and a question that anticipates an answer based on data that vary.'*

Similarly, Makar (2008) stated that authentic questions are ill-structured in inquiry and contain ambiguities which need to be resolved during the inquiry process. Inquiry problems require a number of skills: generating curiosity about the world that identifies 'I wonder' problems, writing a measurable question that provides insight into these problems, determining relevant, valid and accessible data, planning and carrying out data collection, checking, cleaning and organizing data, recognizing the data's limitations, analyzing and interpreting data, articulating findings, looking for explanations, and producing further questions (Makar, 2008).

Similar to Makar (2008), Konold and Higgins (2003) maintained that a statistical question should require developing a measurement instrument and data collection process. Students must learn both to figure out how to make a statistical question specific enough so they can collect relevant data and not to trivialize their question (Konold & Higgins, 2003). Also, deciding what population you want to study is a part of formulating a statistical question (Konold & Higgins, 2003); hence, the consideration of subjects is important (MacGillivray & Pereira-Mendoza, 2011). Moreover, an investigator needs to decide what variables to use and what data to obtain while formulating statistical questions (MacGillivray & Pereira-Mendoza, 2011).

To summarize, students need to answer some questions while formulating a statistical question; for example, *'Can the question be answered with data? Will answering the statistical question provide insight into to the research topic under study?'* (Bargagliotti & Franklin, 2015, p.23). In other words, a statistical investigation question should require data collection process with the clear variable (Konold & Higgins, 2003; Makar, 2008; MacGillivray & Pereira-Mendoza, 2011; Makar & Fielding-Wells, 2011). Indeed, it is important to realize that answer to a statistical question changes based on the data that vary. Therefore, in this study, the questions posed by students are examined by noticing if they require data collection.

2.2.2 The Features of the Collecting Data Component:

In this part, the features of the collecting data component are summarized.

Pfannkuch and Wild (2000) explained that designing the study, anticipating problems, and finding ways to minimize them are the issues of the collecting data component. For this reason, sample size, sample representativeness, questionnaire preparing and pilot study issues are handled in the collecting data component (Pfannkuch & Wild, 2000). On the other hand, knowledge of the problems involved in data collection, record-keeping and storage are critical because data must be criticized and the variables do not fit the measurement unit and implausibilities in the data must be cleaned (Pfannkuch & Wild, 2000). Indeed, data handling and data cleaning are required to prepare data for analysis in this part (MacGillivray & Pereira-Mendoza, 2011).

Similarly, MacGillivray and Pereira-Mendoza (2011) explained the issues in the collecting data component, which are questions about what is wanted to be explored, what can be measured or observed if it is measured. Moreover, an investigator needs to consider how to obtain representative data in order to make inferences about larger groups or more general situations and which type of data are to be collected (primary) or provided (MacGillivray & Pereira-Mendoza, 2011). More specifically, primary

sources mean that data are collected by researchers themselves by conducting an experiment, survey or observation (Graham, 2006; MacGillivray & Pereira-Mendoza, 2011). On the other hand, secondary sources refer to the data that have already been collected by someone else and that can be found in texts and the web via a search engine such as Google (Graham, 2006; MacGillivray & Pereira-Mendoza, 2011).

Moreover, Makar and Fielding-Wells (2011) explained that the collecting data component includes measurement protocols and sampling design in order to reduce unexplained variability and anomalies. Indeed, the quality of a study depends on how the sample has been obtained. Data may be collected from a sample because of impossibility or impracticalness to access to populations (Konold & Higgins, 2003). The key point is the sample should be representative of population (Konold & Higgins, 2003). To provide representativeness, sample should be selected randomly which means every item in the population has equal chance of selection (Graham, 2006).

To summarize, students need to answer some questions while collecting data; for example, *'Will the data collection plan measure a variable or variables that provide appropriate data to address the statistical question? Does the plan provide data that allows for generalization of results to a population or to establish a cause and effect conclusion?'* (Bargagliotti & Franklin, 2015, p.23). Indeed, data sources, study design and sampling issues are important issues of the collecting data component. Therefore, in this study, both data sources decided by students for the given situations and the questionnaires designed by students for the survey design are examined.

2.2.3 The Features of the Analyzing Data Component:

In this part, the features of the analyzing data component are summarized.

Pfannkuch and Wild (2000) explained that in the analysis phase, the first stage is data exploration, namely, looking for patterns through intuition and context knowledge. It is important because realizing the unexpected features of the data initiates new ideas and helps to generate new hypothesis (Pfannkuch & Wild, 2000). Moreover, a proper model such as graphs, centers, spreads, etc. should be used for data in order to find the patterns in data while analyzing it (Pfannkuch & Wild, 2004). Indeed, analyzing data includes not only representing data but also changing data representations to show alternative insights (Makar & Fielding-Wells, 2011).

Similarly, MacGillivray and Pereira-Mendoza (2011) stated that analyzing data component includes choosing data representations and summary statistics for data exploration. Also, investigating variations, reasoning with statistical models, and incorporating statistics and context are the issues of this component (MacGillivray & Pereira-Mendoza, 2011). Indeed, a gradual development of variation is needed, which is variation within dataset to variation between groups of data to variation across datasets from the same or similar situations or contexts (MacGillivray & Pereira-Mendoza, 2011).

According to Graham (2006), statistical elements such as data summaries and graphs are chosen in the analyzing data component. He argued that determining a statistical element depends on the nature of data such as single/paired or discrete/continuous, and the purpose of the enquiry such as describing, comparing or interrelating. Indeed, the actual matter is students have an idea about what insights graphs and summaries could provide about the data although it is important for students to draw graphs and calculate summary values in analyzing data component (Graham, 2006).

Similar to Graham, Konold and Higgins (2003) maintained that determining how to organize data depends on what one wants to know; hence, there is no any fixed criterion other than its intended aim for judging one data display as superior to another. On the other hand, they explained that scaling plots and numerating the plots are important. Indeed, frequencies of zero are also an important scaling issue when working with numerical data in order to see clumping in the data or to judge the

magnitude of difference between various data points (Konold & Higgins, 2003). Selecting scales and the issues such as minimum or maximum values on the axes, interval sizes between numbers and relative sizes of the x and y axes affect how the data appear. These issues are critical to make the data appear as they 'really' are (Konold & Higgins, 2003).

In conclusion, analyzing the data component requires answering some questions like *'Do the analyses provide useful information for addressing the statistical question? Are they appropriate for the data that has been collected?'* (Bargagliotti & Franklin, 2015, p.23). In other words, analyzing the data component includes both choosing an appropriate data representation with the aim of investigation and the type of data. On the other hand, the graphs need to be carefully constructed in order to interpret data correctly. Therefore, in this study, the graphs constructed by students are examined by considering not only their appropriateness for the aim of the items but also the construction of them.

2.2.4 The Features of the Interpreting Results Component:

In this part, the features of the interpreting results component are summarized.

The interpreting results component of the statistical investigation process requires relating the results of analysis to the investigation questions, indeed to the context of the problem (Bargagliotti & Franklin, 2015; Graham, 2006; Pfannkuch & Wild, 2000). Indeed, competing explanations should be carefully considered while interpreting data (Pfannkuch & Wild, 2000). On the other hand, another issue is generalizability of conclusions which depends on methods of sampling population (Pfannkuch & Wild, 2000).

MacGillivray and Pereira-Mendoza (2011) stated that interpreting results component requires communicating, interpreting and discussing. They emphasized that making appropriate comments and interpretations is more important than making correct

ones. Moreover, there should be emphasis on distinguishing between what data is telling and what might be the reasons behind (MacGillivray & Pereira-Mendoza, 2011).

Similarly, Konold and Higgins (2003) stressed that to figure out how to quantify variability and perceive and characterize the group as a whole when individuals in that group differ from one another are the issues in the interpreting results component. Also, data needs to be seen as an aggregate, a group with emergent properties that often are not evident in any individual member, rather than as amalgam of individuals each with their own characteristics (Konold & Higgins, 2003). Moreover, they stated that a distinction should be made between all the known things and the collected data.

In conclusion, interpreting the results component requires answering some questions like *'Is the interpretation sound given how the data were collected? Does the interpretation provide an adequate answer to the statistical question?'* (Bargagliotti & Franklin, 2015, p.23). In other words, it is important to connect the results back to the original statistical question and give an answer that allows for variability in the data while interpreting analyses. Moreover, interpreting the results component includes interpreting the analysis, reflecting on the process, and drawing critical inferences (Makar & Fielding-Wells, 2011). Therefore, in this study, students' interpretations are examined by considering if they are reflecting the analysis.

2.3 Studies on Participants' Understanding of the Statistical Investigation Process

The aim of the current study is to analyze students' level of understanding regarding the statistical investigation process. Therefore, studies on participants' understanding of the whole statistical investigation process or its components are the focus of this section. This section is divided into three parts. In the first part, studies conducted with pre-service teachers are summarized. In the second part, studies conducted with

students are summarized. In the last part, studies conducted in Turkey are summarized.

2.3.1 Studies on Pre-Service Teachers' Understanding of the Statistical Investigation Process

Burgess (2001) analyzed statistics skills of thirty pre-service teachers during the analyzing the data and interpreting the results components of the investigation process. The participants were given 'data cards protocol', which comprises data about sixteen children such as name, age, weight, weekly fast food consumption, favorite activity and eye color, and they were asked to examine the data and produce a report which highlights all the aspects of the data that are interesting to them. The study revealed that the overall level of competency in terms of tabulating and graphing the data was very low at analyzing the data level. The tables constructed by students lacked headings and frequencies, while the graphs constructed by them lacked titles and adequate labeling of axes in spite of school exercises and activities highlighting the necessity when graphing (Burgess, 2001). Moreover, the researcher stated that the participants could not choose the graph types in line with their interests, that is, with the features they wanted to investigate. To illustrate, they chose histogram while the appropriate graph type was bar graph (Burgess, 2001). Furthermore, half of the students calculated statistical summaries, mainly means (Burgess, 2001). On the other hand, the study showed that some of the summaries and conclusions written by students were unrelated to their graphs. Many of the students interpreted the results at simplest level by giving a written description of frequencies in the data, a written form of the mode, or something that was shown directly in a graph (Burgess, 2001). A small part of students grouped data into categories and reported frequencies or tendencies as evidenced by measures such as means or totals (Burgess, 2001). The study also showed that some students only considered one variable at a time, while others considered as many as three different variables in their interpretations.

Burgess conducted another study in 2002 with another thirty pre-service mathematics teachers again to examine their interpretations by giving them the same data sets in the 'data cards protocol'. In the study, the interpretations of students were categorized in two parts: summary statements and generalizations. While some participants made generalizations by integrating their interpretations of data with some contextual and statistical knowledge, others made summary statements that cannot connect their interpretations of the data with other statistical knowledge (Burgess, 2002). The study showed that the generalization group dealt with more than two variables and grouped data into subgroups, while the statement group focused only on one variable. On the other hand, only two students stressed the importance of sample size, and in this study small sample size created a difficulty for drawing a conclusion (Burgess, 2002).

On the other hand, Heaton and Mickelson (2002) focused on the whole statistical investigation process instead of some components of it in their study. Forty four pre-service teachers took part in the study. The participants were asked to formulate three investigation questions about teaching and learning issues that are interesting to them. The study revealed that the investigation questions were problematic and they were not useful for investigation purpose other than how many and how much. Also, it was seen that pre-service teachers did not evaluate the data they had collected critically. Moreover, they made recommendations about teaching practice based on data regardless of their analysis or interpretation (Heaton & Mickelson, 2002).

Some studies in the literature focused on elementary or middle school students' understanding in the statistical investigation process instead of adults such as pre-service teachers. In the next section, the studies related to students' understanding are summarized.

2.3.2 Studies on Students' Understanding of the Statistical Investigation Process

Watson and English (2016) focused on the capacities of students to pose an initial meaningful statistical question for a given context by using the SOLO model of Biggs

and Collis. Also, students' capacities of sketching a representation and reaching a conclusion on their representations were examined in the study. Eighty nine 6th grade students participated in the study. Teachers summarized the statistical summaries and data investigation process again at the beginning. The study showed that 45% of the students posed statistical questions that were at relational level; 36% of them posed questions at multi-structural level; and 16% of them posed questions at uni-structural level. At higher levels, students included more specificity and relevant elements to set the scene for a realistic investigation (Watson & English, 2016).

In another study, Chick and Watson (2001) focused on students' capacities in terms of two components of the statistical investigation process, which are analyzing data and interpreting results by using the SOLO model and by giving students the 'data cards protocol'. Twenty-seven students from a suburban primary school in which 5th and 6th grades are together participated in the study. Students were asked to find interesting things in the data cards and to prepare a poster to display their findings. Graphical representations were shown to the students before they prepared their posters. Although most of the students used graphical approaches to show data, it was not clear if they realized the value of such representations for summarizing data (Chick & Watson, 2001). The study showed that most of the students constructed representations at multi-structural level by showing serial classification of one variable and at relational level by showing the association of two variables. Similarly, most of the students made interpretations at multi-structural level summarizing single variable and at the relational level showing the relationship between two variables (Chick & Watson, 2001). Indeed, three students made interpretations at the extended abstract level realizing to use representations to prove or doubt a hypothesis, rather than merely showing what had already been observed (Chick & Watson, 2001).

In another study, Chick (2000) focused on young adults' interpretations by giving them the same data sets in the 'data cards protocol'. Thirty two students who took first year university mathematics service course were asked to prepare a report about which aspects of the data were interesting to them by supporting their claims. The study showed that the students made 219 claims concerning one or more variable

from data, but some of the claims are the features of only a few students in the data set. In other words, the students did not use all the data in the data set, or they focused only on the features of a few people without selecting a sample (Chick, 2000). All the students made at least one interpretation regarding two variables, while some of them made three or four variable combinations (Chick, 2000). On the other hand, the study showed that the students chose to use basic statistical techniques such as graphs, tables, summary statistics, percentages, fractions, and ratios instead of formal statistical arguments in order to support their claims. Indeed, some claims in the reports were not supported, while %29 of the claims involved verbal descriptions only, without any statistical supporting (Chick, 2000). On the other hand, the students' tables and graphs were problematic in terms of their structural features (Chick, 2000). The study showed that the students could not choose an appropriate graph to their interest similar to the result of Burgess' study in 2001.

In some studies, students were made to collect data by themselves instead of giving them the real data. For instance, Watson and English (2016) conducted a study to examine the levels of understanding of the students on the analyzing data component by enabling students to collect data themselves. Ninety six 5th grade students participated in the study. The students were asked to answer the questions about the typical reaction time of Grade 5 students. The students collected their data very carefully using two methods: measuring themselves with Ruler Drop and using Reaction Timer Test from the ABS CensusAtSchool website. The study revealed that about two-thirds of the students could produce a meaningful and appropriate hand-drawn representation of their data. However, 14% of the students unordered or ignored the repeated values while drawing representations and 84% of them usually did not indicate the typical value in their representations (Watson & English, 2016). Most of the students could suggest a reasonable typical value when asked indeed; and about two-thirds of the students could explain their method of deciding the typical value meaningfully (Watson & English, 2016).

In another study, Watson and English (2015) examined the capacities of ninety-five 5th grade students to engage in the practice of statistics by focusing on sample-

population distinction and how this affected the certainty with which a decision was made by making them collect the data themselves. The students were introduced with a newspaper story claiming that a survey of a class of 5th grade students was done in another state, Tasmania. It also claimed that Australian school students were not as environmentally friendly as thought. After the discussion of the article, the students decided to make an investigation by using their class as the sample. Although the students used a ready-made questionnaire from the ABS CensusAtSchool website, they were asked to individually determine the criteria for the questions in order to understand whether students are environmentally friendly or not (Watson & English, 2015). The results showed that all the students apparently understood the task of setting criteria and half of the students could make an interpretation based on their criteria to decide if their class is environmentally friendly. However, minority of students recognized degrees of certainty of their conclusions and gave reasons associated with the criteria they used (Watson & English, 2015). The study also revealed that the students were able to distinguish between a sample and a population. Indeed, the students were aware that valid interpretations of data were dependent on issues such as sampling and sample size (Watson & English, 2015).

In order to increase students' capacities regarding the effect of sampling issues on interpretations, Watson and English (2017) conducted another study with eighty-five 6th grade students. In the study, the students were expected to make interpretations about their class data and four random samples selected from the CensusAtSchool website and then make generalizations for all the sixth graders in Australia. The study showed that %98 of the students made a reasonable interpretation based on the data from their class by using a tool or a strategy. Moreover, %95 of the students knew that they could not generalize their interpretations based on their class data to all Grade 6 students and half of them stated that sampling was not suitable for this generalization (Watson & English, 2017). More specifically, most of the students suggested that more data was necessary, whereas fewer students suggested random samples in order to make more certain decisions (Watson & English, 2017). On the other hand, the students were asked to choose four random samples from the

population and to make interpretations about them. The results showed that 10% of the students made interpretations that did not match their plots, 78% of them made interpretations based on the brief report on the observations from plots, and only 12% of them gave extended detailed descriptions implicitly noting variation. Moreover, most of them generalized their decisions to population since they chose random samples from all over Australia (Watson & English, 2017). In spite of using random samples, some students still thought that they could not generalize their decisions to all grade 6 students because of small sample size and differences between people (Watson & English, 2017). Similarly, the results of the study of Henriques and Oliveira (2016) revealed that the majority of the students realized the importance of sample representativeness, random sampling and sample size to draw meaningful conclusions on the population.

On the other hand, some studies in the literature focused on more components or the whole process. For example, Bush, Karp, Albanese, and Dillon (2015) conducted a study to examine 6th and 7th grade students' understanding by collecting, displaying, analyzing and interpreting data in meaningful ways. The students were given a research question asking about the age of the known oldest person and students were asked to collect data from their own, parents and grandparents in order to make comparative inferences among three samples. In the study, the students made a wall-sized graph to organize their data and then calculated the measures of central tendency especially mean and median during the analysis process. Although some students had problems calculating mean because of more than one data point about the same age, it was noticed that they understood the median conceptually (Bush et al., 2015). However, the students realized the outliers and their effect on mean and range (Bush et al., 2015). In spite of their unawareness about shape of data, they could make a description about the shape of the data (Bush et al., 2015). Also, the study showed that the students understood both the concept of mean absolute deviation and its algorithm, and realized that their data set could not be representative of other schools or other countries because of factors such as small size of sample and randomness (Bush et al., 2015) similar to other studies.

Another study to determine the understanding of children of statistical investigation was conducted by English (2014) with 3rd grade students. In the study, the students collected the data themselves by conducting a survey. The study showed that the students had some challenge in designing survey questions that were clear to the respondent and that enabled the collection of manageable data to answer their research questions. However, they realized that options for survey questions would have to be provided and the questions and options be kept to a reasonable number (English, 2014). Without a specific direction, the students were encouraged to represent their data in more than one way in the analysis stage. Although the students had not been taught, unexpectedly, the majority of them created a circle graph by using estimation, ruler, their finger widths and percentages to determine sector sizes in order to analyze their data (English, 2014). Moreover, they made scaling in creating a bar graph although they were not taught about it (English, 2014). The study showed that each group could report what they discovered and conveyed their analysis of the data to others. However, the students made some generalization about a larger population by focusing only on their own group members' views or their playground observations in real life (English, 2014).

Although there have been many studies examining students' understanding of the statistical investigation process by engaging students to process, Pfannkuch (2005) examined students' understanding by asking them to evaluate a prepared statistical investigation process. Thirty 15 year-old students took part in study. As the study revealed, few students realized that a statistical investigation question should be measurable or appropriate for the given data set. Moreover, minority of students realized the importance of size of data and reasonable sampling methods in order to make a decision or draw a conclusion at the planning stage (Pfannkuch, 2005). The study revealed that a majority of students realized the importance of choosing an appropriate graph for the task at the analyzing data component (Pfannkuch, 2005). Indeed, some students realized that categorizing the data in a different way might produce a different conclusion (Pfannkuch, 2005). On the other hand, most students

could not realize that their conclusions were valid from perspective of inference space judgment.

There also exist studies in the Turkish literature related to students' understanding of the statistical investigation process. The, next section summarizes the studies in Turkey.

2.3.3 Studies on Students' Understanding of the Statistical Investigation Process in Turkey

The Turkish middle school curriculum includes a learning domain called 'Data Analysis'. The learning domain includes some objectives related to the statistical investigation process. Some of the objectives are formulating research questions, gathering suitable data for statistical questions, drawing bar graphs, pie charts or line graphs according to appropriateness of data, and interpreting the data in graphs (MoNE, 2018). Although the importance of the statistical investigation process has been emphasized in the national curriculum of Turkey (MoNE, 2018), the studies that focus on students' experiences in the statistical investigation process are at their infancy (Güven et al., 2015).

In the Turkish literature, there are some studies focusing on some components of the tatistical investigation process especially analyzing data and interpreting results (Enisoğlu, 2014; Hotmanoğlu, 2014; Memnun, 2013). For example, Enisoğlu (2014) focused on the analyzing the data component, especially on the three measures of tendency. The study analyzed seventh grade students' solution strategies, errors and misinterpretations while solving questions regarding the concepts of mean, median and mode given in bar graph representations. The study showed that using the average formula was the most common strategy in finding a mean or constructing a data set when the mean was given. Moreover, the students used numerical procedures commonly in finding the mode and median of a data set (Enisoğlu, 2014). On the other hand, the study showed that many errors were related to all the concepts. For

example, some students only found the sum of the values and stated this sum as the mean of the data set. Besides, seventh grade students generally considered the average to be equal to the mean of a data set (Enisoğlu, 2014). Moreover, students had errors related to reading the data values correctly which were given on the bar graphs (Enisoğlu, 2014). On the other hand, the study also revealed that students had inadequate knowledge regarding when to compute and use the average of a data set. Indeed, students did not have a conceptual understanding of the concept of average (Enisoğlu, 2014).

On the other hand, Hotmanoğlu (2014) examined the understanding of students' in drawing graphs and interpreting graphs. The data was collected from 111 eight grade students. The research revealed that most of the students had difficulty in determining the initial point of coordinate system and marking the paired orders coordinate system while constructing graphs. Moreover, most of the students were unsuccessful in scaling the coordinates properly; indeed, some students represent just the data values without any scaling (Hotmanoğlu, 2014). On the other hand, the study revealed that few students connected the dots to each other by the nearness of them to each other instead of order. Although the students did not have any difficulty in interpreting the biggest and the smallest data values given on the bar graphs, they had difficulty in interpreting the values between the biggest and smallest values (Hotmanoğlu, 2014). Moreover, the students made interpretations only focusing on one variable when they were given a paired bar or line graphs (Hotmanoğlu, 2014). The researcher concluded that the students were more successful in making interpretations about reading the data and reading between data than reading beyond the data.

Similar to Hotmanoğlu (2014), Memnun (2013) examined students' ability to read and construct graphs, but specifically focusing on line graphs. The data was collected from 143 seventh grade students. The study showed that most of the students were unsuccessful in constructing line graphs. It was seen that the students made some mistakes such as representing paired orders on the coordinate system, not connecting the dots to each other or connecting the dots to each other by the nearness of them to each other instead of ordering similar to findings of Hotmanoğlu (2014).

Furthermore, the study revealed that some of the students constructed a bar graph instead of a line graph, and while most of the students could read the data given in the line graph correctly, they could not use that data in solving questions.

On the other hand, some studies focused the entire statistical investigation process in the Turkish literature (Güven et al., 2015; Hacısalihoğlu-Karadeniz, 2016). Hacısalihoğlu-Karadeniz (2016) conducted a study to examine fifty-three 5th grade students' achievement in the statistical investigation process. The study showed that most of the students could choose the statistical investigation question from the given choices but most of them could not explain the reasons why it was a statistical investigation question. However, students were more successful in pose survey questions based on the situations given to them (Hacısalihoğlu-Karadeniz, 2016). Also, the study showed that most of the students had difficulties in constructing frequency tables or bar graphs when they were asked to construct a graph or table. Indeed, the students constructed bar graphs when they were asked to construct a frequency table or vice-versa (Hacısalihoğlu-Karadeniz, 2016). Another result of the study was that many students made wrong interpretations about the bar graphs or tables to given to them.

On the other hand, Güven, Öztürk and Özmen (2015) examined students' understanding in the whole statistical investigation process by giving a real context problem requiring real data collection. Twenty two 8th grade students participated in the study and students were given a two-week period for data collection. The study showed that the students were unsuccessful in posing statistical questions related to the context and defining the variables in the context. Indeed, their questions mostly were like question types that did not require any statistical investigation to answer, or their answers changed according to people (Güven et al., 2015). However, it was shown that while the students gathered data and got more information about the context, their questions began to differentiate in a statistical way. Similarly, the study revealed that there was a relation between students' hypotheses and context knowledge; namely, students made hypotheses more easily if the problem context was from their daily lives. The students collected their data by using the Internet

(Güven et al., 2015). However, the study showed that a few students made up their data by guessing or defining untrue numbers rather than collecting real data. On the other hand, the students whose problem contexts were more related to daily life decided more easily how to collect data according to which variables (Güven et al., 2015). The students constructed tables or graphs were not adequate in terms of including all the gathered data because of focusing on only one variable in spite of their multivariate data sets (Güven et al., 2015). The study also showed that the students were unsuccessful in choosing an appropriate graph for the data and numerating the coordinates properly. Also, students did not make any categorization in data while constructing tables and graphs (Güven et al., 2015). On the other hand, a small portion of the students made interpretations by giving general information about their problems, while most of the students did not make any interpretations (Güven et al., 2015).

As seen, many studies showed that students have problems while constructing and interpreting graphs (Güven et al., 2015; Hacısalihoğlu-Karadeniz, 2016; Hotmanoğlu, 2014; Memnun, 2013). Therefore, some studies in the literature focused on students' views about the difficulties they experience with graphic drawing and reading (Kranda & Akpınar, 2019). In the study of Kranda and Akpınar (2019), most of the students stated that they do not have any difficulty while both constructing and interpreting bar graphs. However, students stated that they have difficulties while constructing line graphs such as confusing the lines with each other and not connecting dots to each other (Kranda & Akpınar, 2019). Moreover, they stated that they have difficulties in interpreting line graphs because of some reasons such as finding it complex or not being able to interpret the lines (Kranda & Akpınar, 2019). On the other hand, students explained that they have problems while constructing pie charts such as dividing the chart into equal slices and not being able to construct a circle (Kranda & Akpınar, 2019). However, most of the students stated that they do not have difficulty while interpreting pie charts (Kranda & Akpınar, 2019). The researchers concluded that students generally think that they do not have difficulty

while reading graphs and they have more difficulty while constructing graphs than reading them.

2.4. Summary of the Literature Review

In this chapter, the literature review related to the aims of the study was presented. In accordance with aims of the present study, first of all, the frameworks of statistical investigation process were stated. Then, the features of each component of the investigation process were included. Lastly, the studies on participants' understanding of the statistical investigation process were presented.

The statistical investigation process consists of four components which are formulating a statistical investigation question, collecting data, analyzing data and interpreting results. The results of the related studies showed that students had some problems while posing a statistical investigation question (Güven et al., 2015; Heaton & Mickelson, 2002). For example, the questions did not require any statistical investigation because of lack of variability (Güven et al., 2015) or were not useful for the investigation purpose other than how many and how much (Heaton & Mickelson, 2002). On the other hand, in another study conducted by Watson and English (2016), most of the students posed statistical investigation questions including specificity of variables. Another study showed that students had some problems in designing survey questions that were clear to the respondent and that enabled the collection of manageable data to answer their research questions (English, 2014). On the other hand, in another study conducted by Hacısalihoğlu-Karadeniz (2016) most of the students were successful in pose survey questions based on the situations given to them. Therefore, it was seen important to examine students' level of understanding of posing both statistical research questions and survey questions in order to collect appropriate data for the research and because of the some conflicts in the literature. For this reason, in the present study, students' level of understanding of posing statistical investigation questions and survey questions was investigated.

There are studies examining participants' level of understanding of analyzing data and interpreting results component of statistical process in the related literature (Burgess, 2001; Burgess, 2002; Bush et al., 2015; Chick, 2000; Chick and Watson, 2001; English, 2014; Güven et al., 2015; Watson & English, 2015; Watson & English, 2016; Watson & English, 2017). The results of some studies showed that students have problems in choosing the appropriate graph for their data or the investigation question (Burgess, 2001; Güven et al., 2015), while others showed that students could choose appropriate graphs for their data or the investigation question (Bush et al., 2015; Chick & Watson, 2001; English, 2014). On the other hand, students have problems while constructing their graphs such as labeling, scaling, numerating the axes and ignoring repeated values or some values in the data sets (Burgess, 2001; Chick, 2000; Güven et al., 2015; Hotmanoğlu, 2014; Watson & English, 2016). However, some studies revealed that students made scaling by constructing a bar graph or determined sector sizes of a circle graph by using estimation, ruler, their finger widths and percentages although they were taught not to do so (English, 2014). In conclusion, the studies in the related literature revealed different results about choosing an appropriate graph for the data or aim and structural features of the graphs. For this reason, in the present study, students' level of understanding of analyzing data in terms of both choosing an appropriate graph for the data type and structural features of the graphs was investigated.

Finally, as far as the interpreting the results component is concerned, some studies showed that students made unrelated interpretations about their graphs or their analysis (Burgess, 2001; Heaton & Mickelson, 2002), while others stated that students made interpretations based on their observations of the plots (Watson & English, 2017). On the other hand, some studies stated that students interpreted the results at simplest level by talking about frequencies in the data (Burgess, 2001) and by focusing only on one variable at the same time (Burgess, 2002). However, some studies revealed that students made interpretations at the relational level showing the relationship between two or more variables (Chick, 2000; Chick & Watson, 2001). To sum up, the studies in the related literature revealed different results about

students' interpretations in terms of the appropriateness of the results to the data set and in terms of focusing on how many variables at the same time. For this reason, in the present study, students' level of understanding of interpreting results in terms of both appropriateness to the data set and how many variables have been focused on at the same time.

CHAPTER 3

METHODOLOGY

In this chapter, methodology used to conduct this study is described. The chapter provides information about the research design, population and sample, reliability and validity of instruments, data collection procedures, analysis of data, assumptions and limitations. Lastly, internal and external validity of the study is presented.

3.1. Design of the Study

The main purpose of study is to examine 7th grade students' levels of understanding of the statistical investigation process when they are given real data sets. In order to reach the purpose, the survey research design was preferred in this study because surveys are conducted to describe some aspects and characteristics of a population (Fraenkel, Wallen, & Hyun, 2012). Particularly, this study was designed as a cross-sectional survey with the aim of collecting data at one point of time from a sample selected to describe a population (Fraenkel, Wallen, & Hyun, 2012). Furthermore, there exist two types of surveys which are quantitative and qualitative survey (Jansen, 2010). If the aim is to determine diversity of any topic in a population, then the survey type is qualitative (Jansen, 2010). Since the current study aimed to investigate the diversity of the students' levels of understanding and critical evaluations regarding the statistical investigation process, the design of this study was qualitative survey study. The collected data were analyzed through item based in-depth analysis to identify students' levels of understanding and descriptive statistics were computed.

3.2. Participants

There are two basic methods of sampling which are probability and non-probability sampling (Merriam, 2009). Probabilistic sampling is not necessary in qualitative research because generalization is not a goal of qualitative research (Merriam, 2009). Therefore, the most appropriate sampling strategy is nonprobability sampling – purposeful sampling in the qualitatitve studies (Merriam, 2009). The goal of purposeful sampling is to have a sample that will yield the most relevant and plentiful data that the researchers need (Yin, 2011). Merriam (2009) stated that some common types of purposeful sampling are typical, unique, maximum variation, convenience, and snowball or chain sampling. Convenience sampling is used when the researcher selects a sample based on time, money, location, and availability of participants (Merriam, 2009). Therefore, the convenience sampling method was used in this study. Indeed, due to the convenience of location and availability, the participants were selected from the public middle school in which the researcher worked as a teacher. According to Merriam (2009), it is necessary to determine the criteria of selection in choosing sample before starting purposeful sampling. The criteria of the present study were having been taugted to pose investigation questions and survey questions, to construct bar, line and circle graphs and to interpret these graphs. Therefore, the participants were selected among the seventh grade students. Accordingly, the Statistical Investigation Process Questionnaire was applied to 121 students in the school. All the seventh grade students of the school completed the Statistical Investigation Process Test. The school had five classes, three of which consisted of girls and two of which consisted of boys. The demographic information of the participants, such as their class, age and gender were asked for while collecting data. The details of the demographics are presented in Table 3.1 below:

Table 3.1 Participants' Demographic Information

Classes	Sample size (n)	Gender		Age (Average)
		Female	Male	
7/A	22	22	0	12 years 5 months
7/B	21	21	0	12 years 4 months
7/C	25	25	0	12 years 4 months
7/D	28	0	28	12 years 4 months
7/E	25	0	25	12 years 5 months
TOTAL (N)	121	68	53	12 years 4 months

3.3. Data Sources

This study investigated the understanding level of seventh grade students during the statistical investigation process. The data for this study were collected the Statistical Investigation Process Questionnaire (SIPQ).

3.3.1. Statistical Investigation Process Questionnaire

In the present study, data were collected through an instrument that was developed by the researcher. The test was prepared in three phases. Firstly, the objectives of fifth, sixth and seventh grades Turkish National Middle School Mathematics Education Curriculum related to the 'Data Analysis' learning domain were identified. The 'Data Analysis' learning domain of the Turkish National Middle School Mathematics Education Curriculum includes objectives like students are expected to pose statistical investigation questions required gathering data, organize data by making tables and bar graphs and interpret the data at 5^{th} grade (MoNE, 2018). Moreover, students are expected to pose questions which require comparing two data sets, collecting, organizing, analyzing and interpreting data at 6^{th} grade (MoNE, 2018). Furthermore, students should use mean and range to compare two different data sets at this level. On the other hand, pie charts and line graphs are taught and students interpret these graphs at 7^{th} grade (MoNE, 2018). Also, students are expected

to represent their data with appropriate graph types or tables. Moreover, summary statistics such as mean, median and mode are handled. When all of these objectives were determined as a whole, it was seen that they are parts of a statistical investigation process whose components are formulating a question, collecting data, analyzing the data, and interpreting results (Franklin et al., 2005). Therefore, the objectives of the curriculum related to the statistical investigation process were focused on this study. Secondly, the related literature was reviewed. Some questions were adapted from the literature based on the literature review. Lastly, additional items were prepared by the researcher to ensure that students experience all the phases of the statistical investigation process. When the items of the questionnaire were being prepared, each question was matched with the objectives to ensure that there was at least one item measuring each objective from the selected objectives of the fifth, sixth and seventh grade mathematics curriculum.

The Statistical Investigation Process Questionnaire consisted of four open-ended questions. In the questionnaire, the scenario of the question 'Summer Holiday' was adapted from the literature. Also, the information given about some students was adapted from the literature in the question 'Individual Characteristics'. The information cards were developed as 'Data Cards Protocol' in the literature. Moreover, the framework of all the questions was adapted from the literature. On the other hand, the scenarios of the remaining questions were developed by the researcher. Below, detailed information about each question is given.

Question 1: Summer Holiday

Question 'Summer Holiday' adapted from Pfannkuch (2005) consists of four parts. In the question, students were given a table of data showing the maximum temperatures of two cities Marmaris and Alanya and a story involving a decision about where to go for a summer holiday. The aim of the question is to investigate students' understanding in the statistical investigation process which requires making comparison between two independent data sets that include continuous variables.

Therefore, the question ‘Summer Holiday’ consists of four sub-questions which are related to one component of the investigation process. In the sub-question ‘a’, students were asked to pose a question which requires comparing two independent samples with the purpose of examining students’ level of understanding in formulating question component. In the sub-question ‘b’, students were asked about which data sources could be used to obtain the given data set with the purpose of examine students’ levels of understanding in collecting data component. In the sub-question ‘c’, students were asked to draw the most appropriate graph that allows them to compare the temperatures of cities with the purpose of examining students’ level of understanding in analyzing data component. Lastly, in the sub-question ‘d’, the students were asked to write their conclusions from the graph with the purpose of examining students’ level of understanding in interpreting results component. The first question is presented below.

1) Summer Holiday

Miss Ayşe and her family want to have a summer holiday in June. Miss Ayşe decided to examine the temperatures of Marmaris and Alanya which are among the most popular places in the country. To choose a more suitable place, she has found the last June's temperatures and recorded the maximum temperatures in both places. These are shown in the tables below.

Days	Maximum Temperature in Marmaris (°C)		Days	Maximum Temperature in Alanya (°C)
1	42		1	42
2	42		2	40
3	41		3	36
4	35		4	34
5	35		5	34
6	36		6	32
7	35		7	35
8	36		8	35
9	26		9	35
10	38		10	34
11	39		11	34
12	39		12	34
13	39		13	35
14	39		14	35
15	38		15	34
16	36		16	33
17	33		17	34
18	32		18	35
19	34		19	32
20	35		20	32
21	37		21	33
22	37		22	33
23	38		23	33
24	38		24	34
25	39		25	35
26	37		26	34
27	31		27	34
28	30		28	32
29	33		29	33
30	37		30	36
31	39		31	36

Answer the questions below:

a) Pose a statistical investigation question which requires comparing the temperatures according to cities.
b) Which data sources could be used to obtain the data?
c) Draw the most appropriate graph that allows you to compare the temperatures of the cities. Explain the reason for choosing your graph.
d) Write your conclusions from your graph.

Figure 3.1 Question 1

Question 2: Individual Characteristics

In question 2 'Individual Characteristics', the 'Data Cards Protocol' was adapted from Watson et al. (1995). The *data cards protocol* has as its central focus a set of data about 16 individual children. For each child, the data comprise information about name, weight, eye color, favorite activity, amount of fast food meals consumed per week, and age. In this study, the amount of chocolate consumed per week was used instead of the amount of fast food. Gender is specifically identified as well. In the question, the students were asked to identify and justify any interesting features of the data. The aim of the question is to investigate students' understanding in the statistical investigation process when they were given a multivariate data set. The question 'Individual Characteristics' consists of five sub-questions. In the sub-question 'a', the students were asked to pose a statistical investigation question that highlights any aspects of the data which they think interesting with the purpose of examining students' level of understanding in formulating question component. In the sub-question 'b', the students were asked about which data sources could be used to obtain the given data set with the purpose of examining students' level of understanding in collecting data component. In the sub-question 'c', the students were asked to pose questions that must ask participants to obtain the data with the purpose of examining students' level of understanding in collecting data component. In the sub-question 'd', the students were asked to draw the most appropriate graph for their statistical question with purpose of examining students' level of understanding in analyzing data component. Lastly, in the sub-question 'e', the students were asked to write their conclusions from the graph with the purpose of examining students' level of understanding in interpreting results component. The second question is presented below.

2) Individual Characteristics

Below, some characteristics of sixteen different people are given. Examine these caharacteristics.

Ahmet Yıldız Gender: Male Age: 12 Favorite activity: Football Eye color: Blue Weight (kg): 45 Amount of chocolate consumed per week: 5	Ali Çalışkan Gender: Male Age: 14 Favorite activity: TV Eye color: Blue Weight (kg): 60 Amount of chocolate consumed per week: 10	Ayşe Özateş Gender: Female Age: 11 Favorite activity: Table tennis Eye color: Brown Weight (kg): 32 Amount of chocolate consumed per week: 1	Berat Demir Gender: Male Age: 9 Favorite activity: Football Eye color: Green Weight (kg): 26 Amount of chocolate consumed per week: 1
Davut Öztürk Gender: Male Age: 8 Favorite activity: TV Eye color: Blue Weight (kg): 30 Amount of chocolate consumed per week: 7	Dilek Akıncı Gender: Female Age: 15 Favorite activity: Swimming Eye color: Blue Weight (kg): 50 Amount of chocolate consumed per week: 2	İrem Zengin Gender: Female Age: 18 Favorite activity: Reading Eye color: Blue Weight (kg): 66 Amount of chocolate consumed per week: 4	İlknur Üstün Gender: Female Age: 9 Favorite activity: Table tennis Eye color: Green Weight (kg): 33 Amount of chocolate consumed per week: 4
İbrahim Şimşek Gender: Male Age: 10 Favorite activity: Football Eye color: Green Weight (kg): 29 Amount of chocolate consumed per week: 0	Aysun Tokgöz Gender: Female Age: 12 Favorite activity: Volleyball Eye color: Brown Weight (kg): 32 Amount of chocolate consumed per week: 0	Meryem Özer Gender: Female Age: 13 Favorite activity: Reading Eye color: Green Weight (kg): 55 Amount of chocolate consumed per week: 3	Ramazan Aylak Gender: Male Age: 16 Favorite activity: Table tennis Eye color: Green Weight (kg): 54 Amount of chocolate consumed per week: 2
Pınar Kılıç Gender: Female Age: 8 Favorite activity: Volleyball Eye color: Brown Weight (kg): 24 Amount of chocolate consumed per week: 0	Selin Karaca Gender: Female Age: 17 Favorite activity: Reading Eye color: Brown Weight (kg): 56 Amount of chocolate consumed per week: 1	Serkan Çallı Gender: Male Age: 17 Favorite activity: TV Eye color: Blue Weight (kg): 66 Amount of chocolate consumed per week: 8	Yalçın Bakar Gender: Male Age: 18 Favorite activity: TV Eye color: Brown Weight (kg): 74 Amount of chocolate consumed per week: 12

Answer the questions below:

a) Pose a statistical investigation question that highlights any aspects of data which you think are interesting.
b) Which data sources could be used to obtain the data?
c) Pose questions that must be asked to participants to obtain the data.
d) Draw the most appropriate graph that allows you to interpret your statistical question. Explain the reason for choosing the graph.
e) Write your conclusions from your graph.

Figure 3.2 Question 2

Question 3: Battery Lives

Question 3 'Battery Lives', which was created by the researcher, consists of four parts. In the question, the students were given a table of data showing the battery lives of two companies Alfa and Beta and a story involving a decision about which batteries to buy for a toy. The aim of the question is to investigate students' understanding in the statistical investigation process requiring making comparison between two independent data sets that include non-continuous variable. Therefore, the question 'Battery Lives' consists of four sub-questions which are related to one component of the investigation process. In the sub-question 'a', the students were asked to pose a question which requires comparing two independent samples with the purpose of examining students' level of understanding in formulating questions component. In the sub-question 'b', the students were asked about which data sources could be used to obtain the given data set with the purpose of examining students' level of understanding in collecting data component. In the sub-question 'c', the students were asked to draw the most appropriate graph that allows them compare battery lives of companies with the purpose of examining students' level of understanding in analyzing data component. Lastly, in the sub-question 'd', the students were asked to write their conclusions from the graph with the purpose of examining students' level of understanding in interpreting results component. The third question is presented below.

3) Battery Lives

A toy company is looking for a battery company for its toys. The company that wants **longer lived** batteries for the toys decides to examine battery lives of companies Alfa and Beta whose batteries are suitable for toys. For this purpose, the toy company gets nine batteries from two battery companies and records the lives of the batteries in a table.

Number of Batteries / Company	1	2	3	4	5	6	7	8	9
Alfa	25 saat	20 saat	24 saat	15 saat	16 saat	31 saat	11 saat	24 saat	23 saat
Beta	20 saat	22 saat	17 saat	20 saat	25 saat	25 saat	20 saat	24 saat	25 saat

Answer the questions below:

a) Pose a statistical investigation question which requires comparing battery lives of companies.
b) Which data sources could be used to obtain the data?
c) Draw the most appropriate graph that allows you to compare battery lives of companies. Explain the reason for choosing the graph.
d) Write your conclusions from your graph.

Figure 3.3 Question 3

Question 4: Job Groups

Question 'Job Groups', which was created by the researcher, consists of five parts. In the question, the students were given a table of data showing job names of a group of students. The aim of the question is to investigate students' understanding in the statistical investigation process which requires making summarization about data set that includes categorical variable. The question 'Job Groups' consists of five sub-questions. In the sub-question 'a', the students were asked to pose a statistical investigation question that requires to obtaining given data set with the purpose of

examining students' level of understanding in formulating questions component. In the sub-question 'b', the students were asked about which data sources could be used to obtain the given data set with the purpose of examining students' level of understanding in collecting data component. In the sub-question 'c', the students were asked to pose questions that must be asked participants to obtain the data with the purpose of examine students' level of understanding in collecting data component. In the sub-question 'd', the students were asked to draw the most appropriate graph that allows them to compare job groups with the purpose of examining level of students' understanding in analyzing data component. Lastly, in the sub-question 'e', the students were asked to write their conclusions from their graph with the purpose of examining students' level of understanding in interpreting results component. The fourth question is presented below.

4) Job Groups

The head of a middle school made an investigation about jobs in students' dreams. For this purpose, 30 students were chosen from the school and their answers were recorded.

Mathematics teacher	Oculist	Computer engineer	Tailor	Mechanic
Turkish teacher	Mechanical engineer	Civil engineer	Elementary teacher	Secretary
Lawyer	Mathematics teacher	Pediatrician	Lawyer	Computer engineer
Family doctor	Mathematics teacher	Tailor	Turkish teacher	Family doctor
Pediatrician	Lawyer	Architect	Secretary	Architect
Civil engineer	Architect	Pediatrician	Pediatrician	Mathematics teacher

Answer the questions below:

a) Pose a statistical investigation question which requires obtaining the data?
b) Which data sources could be used to obtain the data?
c) Pose questions that must be asked students to obtain the data.
d) Draw the most appropriate graph that allows you to compare job groups. Explain the reason for choosing the graph.
e) Write your conclusions from your graph.

Figure 3.4 Question 4

After preparing the questionnaire, content related evidence was provided in order to ensure the validity of the instrument. Before the pilot study was conducted, the statistical investigation process questionnaire was examined by two experts from the Elementary Mathematics Education Department of different universities in order to provide content related evidence for the validity of the instrument. The questions of the instrument were checked by the experts based on the table of specification in terms of appropriateness of each question and their objectives. In other words, the experts checked whether or not a question met the intended objectives. Moreover, the experts evaluated the appropriateness of the questions in terms of comprehensibility for seventh grade students and level of difficulty. The table of specification of questions of the questionnaire is presented in Table 3.2 below:

Table 3.2 Table of Specification for the SIPQ Items

	Objectives
Formulate Questions	Students are able to pose statistical investigation questions. 2a, 4a
	Students are able to pose statistical investigation questions that require compare two independent samples. 1a, 3a
Collect the Data	Students are able to get or choose suitable data for statistical questions. 1b, 2b, 3b, 4b
	Students are able to gather suitable data for statistical questions. 2c, 4c
Analyze the Data	Students are able to draw bar graphs, pie charts or line graphs according to appropriateness of data. 1c, 2d, 3c, 4d
Interpret the Results	Students are able to interpret the data is shown in bar graphs or line graphs. 1d, 2e, 3d, 4e

To sum up, totally four questions with eighteen sub-questions were asked in the Statistical Investigation Process Questionnaire. The details regarding the pilot study of the questionnaire are explained in the following part of the chapter.

3.4. Pilot Study

The pilot study was implemented to determine the appropriate testing time duration for the implementation of the Statistical Investigation Process Questionnaire, to adjust the difficulty level of the questions, to control the comprehensiveness of each question and to check the validity and reliability of it.

The pilot study of the questionnaire was conducted by the researcher in a middle school at the Pendik district, Istanbul during the 2017-2018 fall-semester. Twenty eighth grade middle school students who reached the identified objectives of the study in their previous semester took the questionnaire including four questions with eighteen sub questions.

In the pilot study, the students were given eighty minutes to answer the questions. However, it was noticed that more time was needed than eighty minutes to complete the questionnaire. Therefore, the students were given one hundred twenty minutes in the actual study.

In the ‘Summer Holiday’ question, the students had difficulty in showing all temperature values of thirty one days in their graphs. Many of them showed approximate values of two weeks. Therefore, temperature values of first fifteen days were given in the actual study.

In the ‘Individual Characteristics’ question, some students drew a graph that was unrelated to the statistical investigation question. In the interviews made with them, it was seen that they were interested in more than one characteristic of individuals. While they posed a statistical investigation question dependent on their one interest, they drew a graph on another interest. Therefore, the students were asked to draw the

most suitable graph that allowed them to make an interpretation about the statistical investigation question they posed in the first question.

The last version of the questionnaire is presented in Appendix C.

In the present study, an inter-rater reliability study was conducted with 20 students from the pilot study in order to check reliability since the questions were open-ended. The answers were scored by the researcher and one of her colleagues according to the rubric. The items, for which the coders gave different scores according to the rubric whose details were given below, were detected and discussed by the coders. The reasons for the inconsistency between the scores were examined and both the questions and the rubric were reorganized. Particularly, it was seen that the most significant problem was related to the 1st question of each item, which is related to formulating research questions. Students' wording had a different meaning for each coder. This confusion was solved by getting help from the advisor. Except for this situation, there were no other inconsistenc between the coders.

3.5. Data Collection Procedure

The data were collected during the spring semester of the 2017-2018 academic year. The statistical investigation process questionnaire was developed based on the related literature in the fall semester of the same academic year. Then, expert opinions were received about whether the questions were consistent with the components of the statistical investigation process; they were found appropriate to seventh grade students and curriculum, and clear. After the necessary revisions of the items were done according to the expert comments on the questionnaire, at the beginning of data collection procedure, the official permissions were received from the Middle East Technical University Human Subjects Ethics Committee (see Appendix A) at the beginning of the data collection procedure. Then, the necessary permissions were obtained from the Ministry of National Education (see Appendix B) in order to administer the statistical investigation process questionnaire in the public school.

After getting the necessary permissions, the pilot study was conducted in order to examine the validity and reliability of the questionnaire.

The statistical investigation process questionnaire was administered to 121 middle school seventh grade students during the spring semester of the 2017-2018 academic year. Two mathematics teachers, who were the actual teachers of the participants of this study, were informed about the purpose and the procedures of this study. Then, the data were collected after the teachers had just completed teaching the statistics concepts. The statistical investigation process questionnaire was administered by the researcher during participants' mathematics lessons and their religion and ethics lessons. The students were stated to notice the explanations given at the beginning of each question in the questionnaire. In addition, it was stressed that all their responses would be kept completely confidential and would only be used for the study. During each administration, the students were given approximately 120 minutes. The whole data collection process lasted for one week.

3.6 Analysis of Data

Item based analysis was conducted in order to answer the research questions of the study. More specifically, the rubric was developed by the researcher to identify the students' understanding in each component of the statistical investigation process, which are formulating question, collecting data, analyzing data and interpreting results. The items related to different components were scored using different scoring systems.

The first component of the statistical investigation process is formulating questions. The items related to formulating questions component were scored using 0 to 2 points scoring system. The rubric was prepared by taking into account the participants' responses and the related literature. A statistical investigation question should require developing a measurement instrument and data collection process (Bargagliotti & Franklin, 2015; Konold & Higgins, 2003). On the other hand, the questions are non-

statistical which ask about an individual case (Arnold, 2008) or basic information that can typically be found by referring to books or searching the World Wide Web, or by asking someone (Chin & Kayalvizhi, 2002). As a result of these studies in the literature, two points were given to the questions that require data collection to answer with clear meaning; then, one point was given to the questions asking about an individual case or basic information, namely which do not require data collection, and lastly, no point was given to the questions unrelated with the data set or no response. The details of the rubric are represented in Table 3.3:

Table 3.3 Scoring Rubric for Statistical Investigation Question

Codes	Answer types
0	• No response • Irrelevant questions
1	• A question that asks about an individual case • A question that asks about finding basic information searching the internet
2	• A question that requires data collection with clear meaning • A question that asks for the most popular and most common • A question that asks about the overall distribution of the data or what is typical

The second component of the statistical investigation process is collecting data. The related literature stated that collecting data component includes designing the study (Pfannkuch & Wild, 2000). Indeed, sample size (Pfannkuch & Wild, 2000), sample representativeness (Konold & Higgins, 2003), which type of data are to be collected (primary) or provided (secondary) (MacGillivray & Pereira-Mendoza, 2011) and questionnaire preparing (Graham, 2006) are the issues of collecting data component. However, the Turkish mathematics curriculum includes two objectives: students should be able to get or choose suitable data for statistical questions and students should be able to gather suitable data for statistical questions related to collecting data component (MoNE, 2018). Therefore, the collecting data components are handled in

two parts which are deciding on data sources and preparing a survey by posing a survey question for the appropriate data sets by taking into account the related literature and the curriculum.

In the deciding on data sources part of the collecting data component, the items related to data sources were scored using 0 to 1 point scoring system. The rubric was prepared by taking into account the participants' responses and the related literature. One point was given to the relevant data sources for the given data sets such as meteorology pages, survey, experiment and survey in order; no point was given to irrelevant answers or no response. The details of the rubric are represented in Table 3.4:

Table 3.4 Scoring Rubric for Determining Data Sources

Codes	Answer types
0	• No response • Irrelevant answers
1	• Relevant answers

In the preparing a survey part of collecting data component, the items related to posing survey questions were scored using 0 to 2 points scoring system. The rubric was prepared by taking into account the participants' responses and the related literature. Konold and Higgins (2003) stated that wording is very critical when preparing survey questions. In other words, they should be precise which means everyone has to understand the question in the same way (Konold & Higgins, 2003). In addition to the clearness of the survey questions to the respondents, they should enable the collection of manageable data to answer the research question (English & Watson, 2015). As a result of the studies in the literature two points were given to the questions which enable to collect the given data sets and which the participants could understand. Then, one point was given to questions that have ambiguous variables or unclear meaning for participants. Also, one point was given to research questions. Lastly, no point was given to no response. The details of the rubric are represented in Table 3.5:

Table 3.5 Scoring Rubric for Posing Survey Questions

Codes	Answer type
0	• No response
1	• Research questions • Questions that have ambiguous variables or unclear meaning for participants.
2	• Questions which enable to collect the given data sets and which the participants could understand

The third component of the statistical investigation process is analyzing data. Analyzing data component includes selecting appropriate graphical methods and using them to analyze the data (Graham, 2006; MacGillivray & Pereira-Mendoza, 2011). Indeed, the nature of the data and the purpose of the enquiry are major constraints in order to make these choices (Graham, 2006). By noticing these major constraints, the items related to choosing appropriate graphical methods were scored using 0 to 3 points. Firstly, three points were given to the graphs that are appropriate to both variable type and aim of the statistical question for comparison research questions. Secondly, two points were given to the graphs if variable type or aim is inappropriate for comparison research questions, while two points were given to the graphs that are appropriate to variable type for summary research questions. Then, one point was given to the graphs if variable type and aim were inappropriate for comparison research questions, while one point was given to the graphs that were inappropriate to variable type for summary research questions. Lastly, no point was given to no response. Beside appropriate choices for nature of data or purpose of enquiry, graphs should be constructed as structurally correct because the structural features of graphs affect how the data appear, hence making proper interpretations according to graphs possible (Konold & Higgins, 2003). However, a plot with labeled axes is not better than one without labeled axes if the purpose is to determine where the data were centered (Konold & Higgins, 2003). Therefore, in this study it is very critical to show all data values correctly on the graphs and numerate the coordinates correctly in order to make proper interpretations. As a result, each point except 0

point was divided into two parts based on graphs' structural features and taking the related literature into account. In other words, students' graph construction skills were scored 0 to 1 points. One point was given to graphs in which all data values are shown with correct numeration of the coordinates, proper labels and proper scaling or small mistakes in labels or scaling. No point was given to graphs where few data values are shown or graphs with coordinates are not numerated in increasing order from the origin. The details of the rubric are presented in Table 3.6:

Table 3.6 Scoring Rubric for Constructing Graphs

Codes	Answer type
0	• No response
1.0	• Graphs that are inappropriate to both type of data and aim for comparison research questions while inappropriate to type of data for summary research questions with few data values • Graphs that are inappropriate to both type of data and aim for comparison research questions while inappropriate to type of data for summary research questions with wrong numeration of the coordinates
1.1	• Graphs that are inappropriate to both type of data and aim for comparison research questions while inappropriate to type of data for summary research questions with all data values shown with correct numeration of the coordinates, and small mistakes in labels or scaling • Graphs that are inappropriate to both type of data and aim for comparison research questions while inappropriate to type of data for summary research questions with all data values shown with correct numeration of the coordinates, proper labels and proper scaling
2.0	• Graphs that are not appropriate either to type of data or aim for comparison research questions while appropriate to type of data for summary research questions with few data values • Graphs that are not appropriate either to type of data or aim for comparison research questions while appropriate to type of data for summary research questions with wrong numeration of the coordinates
2.1	• Graphs that are not appropriate either to type of data or aim for comparison research questions while appropriate to type of data for summary research questions with all data values

	shown with correct numeration of the coordinates, and small mistakes in labels or scaling • Graphs that are not appropriate either to type of data or aim for comparison research questions while appropriate to type of data for summary research questions with all data values shown with correct numeration of the coordinates, proper labels and proper scaling
3.0	• Graphs that are appropriate to both type of data and aim for comparison research questions with few data values • Graphs that are appropriate to variable type and aim for comparison research questions with wrong numerating of the coordinates
3.1	• Graphs that are appropriate to both type of data and aim for comparison research questions with all data values shown with correct numeration of the coordinates, and small mistakes in labels or scaling • Graphs that are appropriate to type of data and aim for comparison research questions with all data values shown with correct numeration of the coordinates, proper labels and proper scaling

Table 6 (continued)

The last component of the statistical investigation process is interpreting results. The items related to interpreting the graphs were scored based on three levels. The rubric was prepared by taking into account the related literature, especially based on Friel, Curcio and Bright's study (2001). They determined three levels of graph comprehension that are elementary, intermediate and advanced levels. Therefore, the rubric was scored by using 0 to 3 scoring system. In the rubric, point three, advanced level, were given for reading beyond data, which means extrapolating from data and analyzing the relationships implicit in a graph. Point two, intermediate level, were given for reading between data, which means interploting and finding relationships in the data as shown in a graph. This includes comparisons such as greater than, greatest, etc. and use of other mathematical concepts and skills such as addition, substraction, etc. Point one, elementary level, was given for reading the data, which

means focusing on extracting data from a graph. No point was given to no response. The details of the rubric are presented in Table 3.7:

Table 3.7 Scoring Rubric for Interpreting Results

Codes	Answer types
0	• No response
1 Elementarylevel	• Focusing on extracting data from a graph
2 Intermediate level	• Interploting and finding relationships in the data
3 Advanced level	• Extrapolating from data and analyzing the relationships implicit in a graph

Also, students' interpretations were examined according to their correctness in each understanding level except level 0. In other words, students' interpretations were also presented as wrong or correct at each understanding level in the findings chapter.

3.7. Trustworthiness

Validity and reliability are concerns that requires careful attention regardless of the type of research (Merriam, 2009). For this reason, validity and reliability issues should be considered while assessing how the data are collected, analyzed, interpreted, and how the findings are presented (Merriam, 2009). In qualitative studies, the validity and reliability issues are considered using different terminologies such as credibility, dependability, transferability, and confirmability (Lincoln & Guba, 1985). The trustworthiness of the research design is the quality of the qualitative research and the terms of credibility, dependability, transferability, and confirmability are the criteria for the trustworthiness of the research design (Lincoln & Guba, 1985). In this section, credibility, transferability and dependability of the study are discussed.

3.7.1 Credibility

Credibility in qualitative research and internal validity in quantitative research "deals with the question of how research findings match the reality" (Merriam, 2009, p.213). In order to increase the credibility of a study; some strategies such as triangulation, member check, adequate engagement in data collection, researcher's position (reflexivity), and peer review were suggested (Merriam, 2009). In this study, triangulation and researcher's position were employed and the researcher's bias was taken into consideration in order to ensure credibility.

To increase credibility, the best known strategy is triangulation (Merriam, 2009). There exist four types of triangulation that are data triangulation, investigator triangulation, theory triangulation, and methodological triangulation. In the present study, investigator triangulation was used to ensure credibility. The data was analyzed by more than one researcher. The data was coded by the researcher and a co-coder in order to achieve investigator triangulation.

Another factor which affects credibility of the findings was researcher's position or reflexivity. It refers to how the process is affected by the researcher and affects the researcher (Probst & Berenson, 2014). Therefore, the researcher needs to explain her/his "biases, dispositions and assumptions" in order to increase the credibility of the findings (Merriam, 2009). The role of researcher and bias were explained in detail below.

3.7.2 Dependability (Consistency)

Dependability in qualitative research or reliability in quantitative research was explained as 'whether the results are consistent with the data collected' (Merriam, 2009, p.251). Consistency and dependability of a study can be ensured by using the strategies such as triangulation, researcher's position, peer review and audit trail. In the present study, investigator triangulation was performed in the present study as

discussed above. Also, the researcher's position was explained in detail to obtain the data.

3.7.3 Transferability

Transferability in qualitative research refers to external validity in quantitative research. External validity of a study means to what extent the results of the study can be generalized (Fraenkel, Wallen, & Hyun, 2012). However, in qualitative studies, generalizability or transferability is different from quantitative studies because generalizability from a random sample to the population cannot be made (Merriam, 2009). In qualitative research, the most common understanding of generalizability is to think cosidering the readers of the study (Merriam, 2009). Reader or user generalizability includes to what extent findings of a study could be applied to the people in similar situations (Merriam, 2009). In other words, the person who reads the study decides if the findings can be applied to his or her situation (Merriam, 2009). Nevertheless, it is the responsibility of the researcher to provide enough detailed description of the context of the study in order to enable readers to compare the "fit" with their situations (Merriam, 2009). Hence, in this study, the researcher paid attention to providing sufficient and detailed description of context and participants of the current study to allow the reader to apply the findings of the study to other situations; namely, ensuring the transferability of the findings.

3.8 Researcher Role and Bias

Researchers have an important role for collecting and analyzing data in qualitative studies (Merriam, 1998). Researchers could analyze the data and interpret the results according to their perspectives, views, and wishes (Johnson, 1997). Therefore, researcher bias has a potential threat to validity because qualitative research is less structured than quantitative research (Johnson, 1997). In parallel with this, it is

important to identify these biases or subjectivities and monitor them as to how they may be shaping the collection and interpretation of data rather than trying to eliminate them (Merriam, 2009). In the rest of this part, the attempts to identify and reduce biases and the role of the researcher were explained.

In this study, the participants were not taught by the researcher. Therefore, they did not solve any questions similar to those in the present study. Until the data collection day, the students were not given the instrument. The purpose was to prevent that students from being familiar with the instrument. Moreover, the data was collected by the researcher. While collecting data collection, the students were not made any explanation about the questions. The students were only given about the time limit. On the other hand, a detailed rubric was prepared, and the students' answers were scored by two coders to ensure credibility and consistency.

3.9 Limitations of the Study

In this section, the limitations of the study are discussed. Firstly, in this study, the participants were selected via purposive sampling, indeed convenience sampling. The participants were chosen from a school in which girls and boys are attend separate classes. For this reason, the participants of the study were not representative of the seventh grade students from other schools in which girls and boys attend the same classes. Additionally, the findings regarding the students' understanding in components of statistical investigation process was limited with the questions of statistical investigation process questionnaire, namely when different questions are asked related to the components of statistical investigation process, different findings could be found. Furthermore, the findings of the present study were limited with the participants' ability of self-expression since the items of the questionnaire required answers of their own statistical and survey questions or their reasoning for their graphs or decisions.

CHAPTER 4

FINDINGS

The aim of the current study was to analyze seventh grade students' level of understanding in the statistical investigation process when they are given prepaerd data sets. The findings of the study are presented in four sections based on the aim of the study. Each section presents the findings regarding seventh grade students' level of understanding of the four components of the statistical investigation process, which are formulating question, collecting data, analyzing data, and interpreting results. In each section, the findings are presented by analyzing students' answers in the Statistical Investigation Process Questionnaire (SIPQ), which they completed, in order to identify their level of understanding of each component of the statistical investigation process.

4.1. Students' Level of Understanding of Formulating Question

The first aim of the present study was to analyze seventh grade students' level of understanding of posing a statistical investigation question in the statistical investigation process. The students were asked to pose a statistical investigation question suitable for the given scenarios in each item in the SIPQ.

The questions posed by the students were categorized into three levels for each item. Table 4.1 presents the distribution of the frequencies of students across three levels for each item.

Table 4.1 The distribution of students' questions across three levels for each item

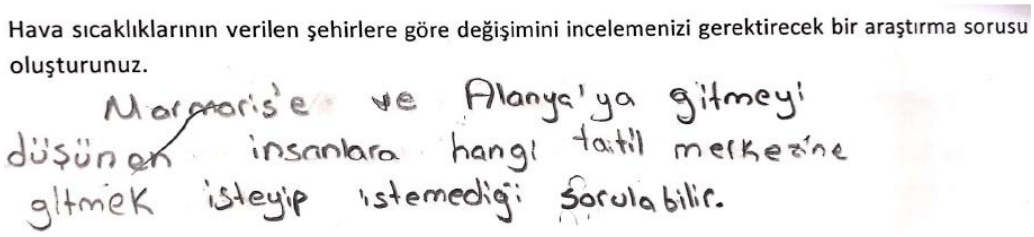
Items Levels	Item 1-a (Summer Holiday)	Item 2-a (Individual Characteristics)	Item 3-a (Battery Live)	Item 4-a (Job Groups)
0	27 22.3%	42 34.7%	47 38.8%	37 30.6%
1	52 43%	27 22.3%	17 14.1%	25 20.7%
2	42 34.7%	52 43%	57 47.1%	59 48.8%
Total	121 100%	121 100%	121 100%	121 100%

Table 4.1 shows that the findings for the items except 'Summer Holiday' are similar to each other. The majority of the students posed questions at Level 2, while few of the them posed questions at Level 1 for the items 'Individual Characteristics' (43% ; 22.3%), 'Battery Lives' (47.1% ; 14.1%) and 'Job Groups' (48.8% ; 20.7%). On the other hand, most of the students (43%) posed questions at Level 1, while few of them (22.3%) posed questions at Level 0 for the item 'Summer Holiday'.

In the following sections, in order to answer the first research question of the present study, the answers of students at different understanding levels are explained in detail by providing examples from students' answers for each item. In other words, how seventh grade students posed a statistical investigation question at different understanding levels is explained for each understanding level.

Level 0: Nearly a third of the students posed questions at level 0 for each item. As seen in Table 4.1, 22.3% of the students performed at Level 0 in item 1-a. Also, 34.7% of the students performed at Level 0 in item 2-a. Similarly, 38.8% of the students performed at Level 0 in item 3-a, while 30.6% of them performed at Level 0 in item 4-a.

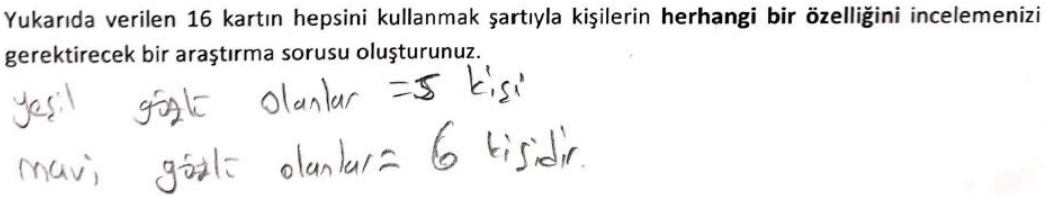
At Level 0, generally students did not give any answer or they wrote sentences that were not questions. Indeed, they wrote some advice about asking people about their city preference for holiday, which brings to mind survey questions. Figure 4.1 shows the answer of such a student.


Hava sıcaklıklarının verilen şehirlere göre değişimini incelemenizi gerektirecek bir araştırma sorusu oluşturunuz.

Marmaris'e ve Alanya'ya gitmeyi düşünen insanlara hangi tatil merkezine gitmek isteyip istemediği sorulabilir.

Figure 4.1 The answer of student 21 to item 1-a

Also, some students wrote sentences that were not questions, but interpretations about the data set. For example, some students wrote the number of people whose eye color was green or blue. Figure 4.2 shows the answer of such a student.


Yukarıda verilen 16 kartın hepsini kullanmak şartıyla kişilerin **herhangi bir özelliğini** incelemenizi gerektirecek bir araştırma sorusu oluşturunuz.

yeşil gözlü olanlar = 5 kişi
mavi gözlü olanlar = 6 kişidir.

Figure 4.2 The answer of student 39 to item 2-a

Moreover, students wrote questions that could not be answered using the given data set. In fact, they were not suitable for the purpose of the given scenario. For instance,

some of the students wrote questions such as ‘How can we find whether or not the live of battery is increasing or decreasing?’ as presented in Figure 4.3.

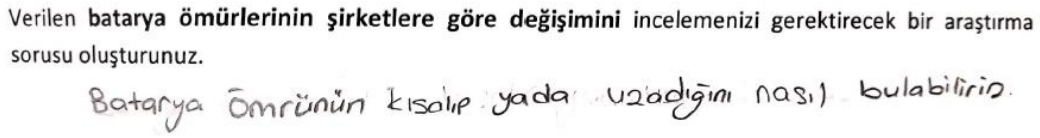


Figure 4.3 The answer of student 31 to item 3-a

On the other hand, they wrote some words instead of an investigation question. For example, they wrote words such as ‘survey’ that is related to the data collection procedure. Figure 4.4 shows the answer of such a student.

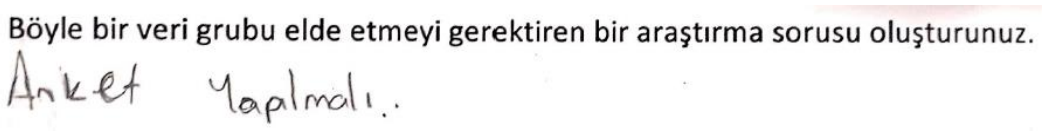


Figure 4.4 The answer of student 55 to item 4-a

To sum up, while most of the students did not give any answers at Level 0, a small part of them wrote non sense sentences or gave advice that were not suitable for the given scenarios in items and the given data sets. It was seen that some students could not write any questions for the given situations and purposes.

Level 1: A small part of students posed questions at Level 1 for each items except for the item ‘Summer Holiday’. As seen in Table 4.1, while a big portion of the students

(43%) performed at Level 1 in item 1-a, 22.3% of the students performed at Level 1 in item 2-a. Also, 14.1% of the students performed at Level 1 in item 3-a, while 20.7 % of them performed at Level 1 in item 4-a.

At Level 1, the students wrote some questions, but they were non-investigable questions including basic information. Figure 4.5 shows a basic information question asking about the last year temperatures of Marmaris and Alanya.

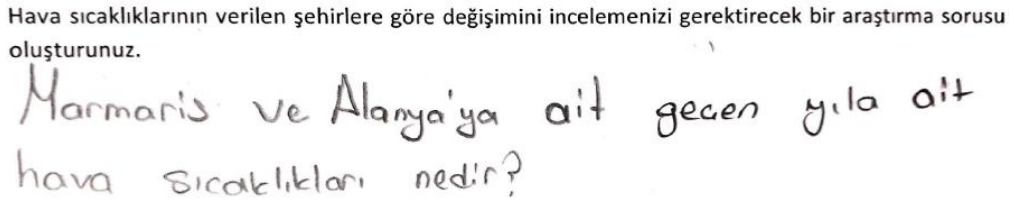


Figure 4.5 The answer of student 6 to item 1-a

Moreover, the students wrote some questions, but they were non-investigable questions. The questions asked about only an individual case instead of all the data set. A question asking about the person who eats most chocolate in a week seen in Figure 4.6 can be given as an example.

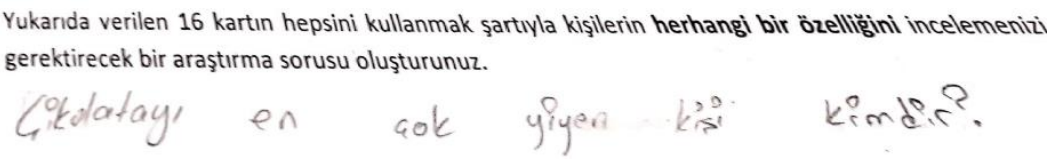


Figure 4.6 The answer of student 52 to item 2-a

Similarly, some questions asked about just one battery which has longest life span as presented in Figure 4.7.

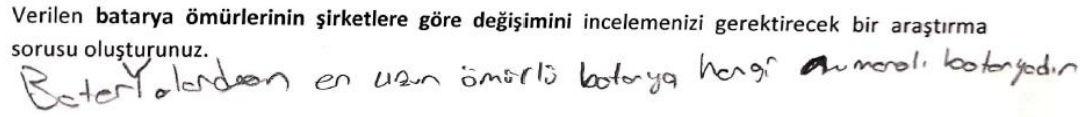


Figure 4.7 The answer of student 86 to item 3-a

Furthermore, some students usually wrote survey questions instead of investigation questions. A survey question asking about the jobs in the dreams of participants is presented as an example in Figure 4.8.

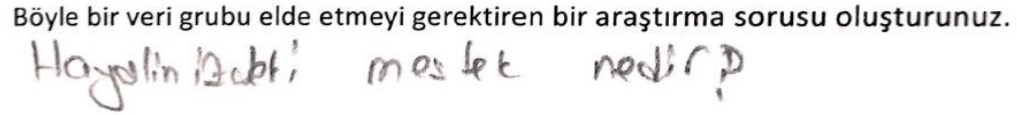


Figure 4.8 The answer of student 6 to item 4-a

To sum up, some students posed questions which asked about basic information or individual cases at Level 1. Although students could write questions different from Level 0, the questions they wrote were non-investigable.

Level 2: Nearly half of the students posed questions at Level 2 for each item. As seen Table 4.1, while fewer part of students (34.7%) performed at Level 2 in item 1-a, more students (43%) performed at Level 2 in item 2-a. Similarly, 47.1% of the

students performed at Level 2 in item 3-a while 48.8% of them performed at Level 2 in item 4-a.

At Level 2, the students wrote statistical investigation questions, requiring data collection in order to be answered. It was seen that the students pose three different types of statistical investigation questions, which are comparison, summary and relationship questions at Level 2. First of all, many students wrote comparison questions because of the scenarios given in the items 'Summer Holiday' and 'Battery Lives'. In item 1-a, the students posed a statistical investigation question which required comparing two different data sets consisting of continuous variables. For example, many students posed comparison questions such as 'In which city, Marmaris or Alanya, is temperature higher in month July?'. Figure 4.9 shows the answer of such a student.

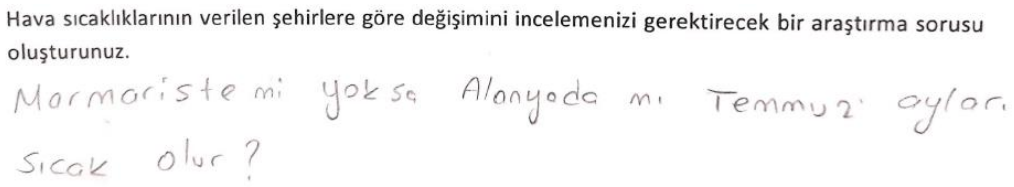


Figure 4.9 The answer of student 11 to item 1-a

Similarly, in item 3-a, the students posed a statistical investigation question which required comparing two different data sets consisting of non-continuous variables different from 'Summer Holiday' item. For instance, most of the students wrote comparison questions like 'Which companies' batteries do have longer life span?'. Figure 4.10 shows the answer of such a student.

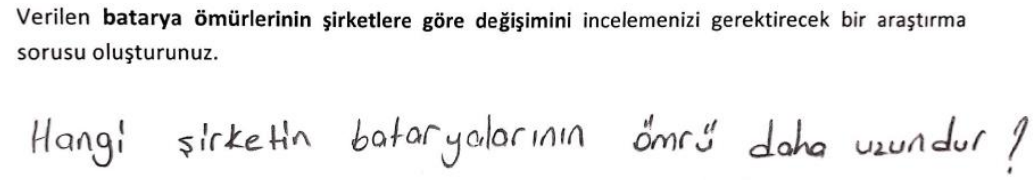


Figure 4.10 The answer of student 7 to item 3-a

On the other hand, a few students (10 students) pose comparison questions in the item 'Individual characteristics'. In this kind of questions, it was seen that the students divided the given data set into sub groups especially based on gender. As presented in Figure 11, some of them wrote questions like 'Are boys fatter than girls?'

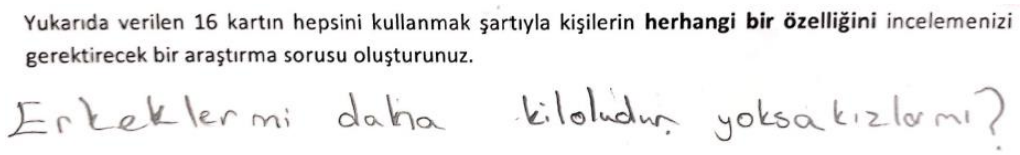


Figure 4.11 The answer of student 121 to item 2-a

Secondly, the students posed summary questions asking about most popular or most common in the data set especially in the items 'Job Groups' and 'Individual Characteristics'. Indeed, nearly half of the students wrote questions such as 'Which jobs do the students dream for their future?' in the item 'Job Groups'. Figure 4.12 shows the answer of such a student.

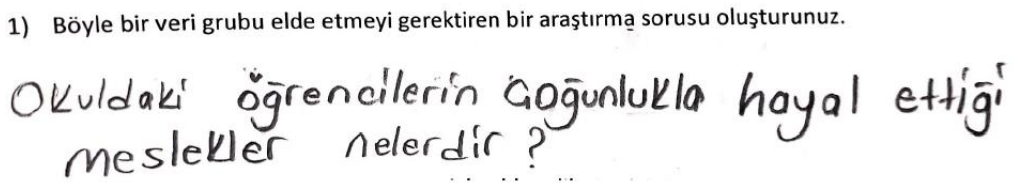


Figure 4.12 The answer of student 20 to item 4-a

Similarly, some students posed summary questions asking about the overall distribution or typical value of the data set. As presented below, some students posed questions like 'What is the average of chocolate consumption in week?'.

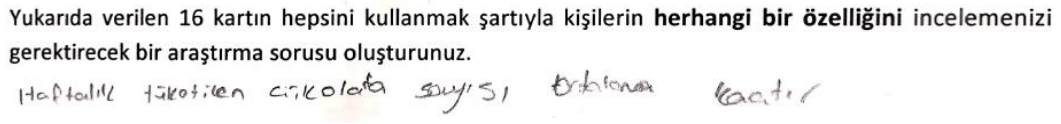


Figure 4.13 The answer of student 41 to item 2-a

Lastly, few students (5 students) posed relationship questions. These students posed questions searching whether or not there is a relationship between the amount of chocolate consumption in a week and weight or the hobbies. Figure 4.14 shows the answer of such a student.

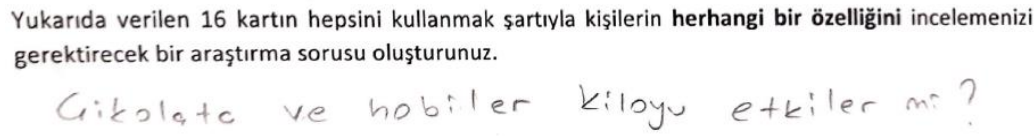


Figure 4.14 The answer of student 11 to item 2-a

In general, nearly half of the students performed at Level 2 while posing a statistical investigation question. In other words, they could write appropriate investigative questions for the given data sets. Most of the questions written by the students were comparison research questions and summary research questions. Few students wrote relationship research questions.

Another aim of this study was to define the understanding level of seventh grade students in the data collection component of the statistical investigation process. Therefore, in the next section, the findings related to the data collection component are presented.

4.2. Students' Level of Understanding of Collecting Data

The second aim of the present study was to analyze seventh grade students' level of understanding of collecting data component in the statistical investigation process. Collecting data component of the statistical investigation process is divided into two parts: deciding data sources and posing survey questions. The students were asked to decide how the given data sets could be gathered in the second part of each item in the SIPQ. Moreover, the students were asked to pose a survey question in the third part of items 'Individual Characteristics' and 'Job Groups' because they were given real data sets gathered by surveying in these items. The students' answers were categorized into two for the sub-items related to deciding on data sources and into three for the sub-items related to posing a survey question. Table 4.2 presents the distribution of frequencies of students across levels for the two parts of the collecting data component.

Table 4.2 The distribution of students' level of understanding in the data collection component

	Deciding on Data Sources				Posing Survey Questions	
Items Levels	Item 1-b Summer Holiday	Item 2-b Individual Characteristics	Item 3-b Battery Live	Item 4-b Job Groups	Item 2-c Individual Characteristics	Item 4-b Job Groups
0	86 71.1%	81 66.9%	99 81.8%	77 63.6%	28 23.1%	27 22.3%
1	35 28.9%	40 33.1%	22 18.2%	44 36.4%	15 12.4%	15 12.4%
2	-	-	-	-	78 64.5%	79 65.3%
Total	121 100%	121 100%	121 100%	121 100%	121 100%	121 100%

Table 4.2 revealed that most of the students performed at Level 0, while a small part of them performed at Level 1 as far as deciding on data sources in all items was concerned. In spite of this general similarity, the ratios of levels of the item 'Battery Lives' are dissimilar to other items. Indeed, nearly a fifth of the students (18.2%) performed at Level 1 for the item 'Battery Lives', while nearly a third of students performed at Level 1 for the other items. As a result, the majority of the students (81.8%) were unsuccessful in the item 'Battery Lives' than the other items while deciding on data sources. On the other hand, the students performed at nearly the same understanding level while posing survey questions in both items 'Individual Characteristics' and 'Job Groups'. Most of the students (approximately 65%) posed survey questions at Level 2 while fewer students (12.4%) posed survey questions at Level 1. The frequencies presented in Table 4.2 are explained in the following two parts of the data collection component of the statistical investigation process.

4.2.1. Students' Level of Understanding in Deciding on Data Sources

In this part of study, the understanding level of students to decide on data sources is presented. The students were given data sets that were collected by using different data sources in each item in the SIPQ. In the item 'Summer Holiday', the students were given a data set that was gathered by using secondary sources such as meteorology pages on the internet or newspapers. In this item, students were expected to decide secondary data sources such as internet pages or newspapers that were suitable to collect given data set.

In items 'Individual Characteristics' and 'Job Groups', the students were given a data set that was gathered by conducting a survey, which is the primary data source. In this item, the students were expected to decide that 'conducting a survey' was suitable to gather the given data set.

In the item 'Battery Lives', the students were given a data set that was gathered by conducting an experiment which, is the primary data source. In this item, the students were expected to decide that 'conducting an experiment' was suitable to gather the given data set.

In order to determine whether or not the students correctly decided on the data sources as explained above, the answers of the students at different understanding levels were explained in detail for each item providing examples. In other words, how seventh grade students decided on the data sources at different understanding levels is explained for each understanding level.

Level 0: Most of the students performed at Level 0 for each item. As seen in Table 4.2, 71.1% of the students performed at Level 0 in item 1-b, while 66.9% of the students performed at Level 0 in item 2-b. Moreover, a very big portion of the students (81.8%) performed at Level 0 in item 3-b, while 63.6% of them performed at Level 0 in item 4-b.

At Level 0, while some students did not give any answer, some of them wrote some non sense words such as ‘mean, median or mode’ as the data source in all items. Also, some students decided on wrong ‘data sources’ for the given items. For example, some students stated that ‘observation’ was used to collect the given data sets in each item.

Level 1: A small part of the students performed at Level 1 for each item. As seen in Table 4.2, 28.9% of the students performed at Level 1 in item 1-b, while 33.1% of the students performed at Level 1 in item 2-b. Moreover, a few students (18.2%) performed at Level 1 in item 3-b, while 36.4% of them performed at Level 1 in item 4-b.

At Level 1, the students determined the suitable data sources for the given data sets in each item. For example, the students stated that ‘internet or meteorology pages’ could be used to gather the given data set in the item ‘Summer Holiday’. Also, they stated that ‘survey’ should be conducted to gather the given data sets in the items ‘Individual Characteristics’ and ‘Job Groups’. Lastly, they stated that ‘experiment’ should be conducted to gather the given data set in item ‘Battery Lives’.

The results showed that students were more successful in determining ‘conducting survey’ as the data source than the other data sources. They were more unsuccessful in determining ‘conducting an experiment’ as the data source.

In summary, it seemed that the students had the poorest performance in determining the data sources than the other parts of the statistical investigation process. It was seen that students had problems about the Central Tendency Measurements as they did not know why they are used. Moreover, it was noticed that even though many students could pose a survey question for the related items, they could not determine ‘conducting a survey’ as a data source. The other purpose of the collecting data component was to examine the level of understanding of seventh grade students in

posing survey questions. Therefore, in the next section the findings related to posing survey questions are presented.

4.2.2. Students' Level of Understanding in Posing Survey Questions

In this part of the present study, seventh grade students' level of understanding of posing a survey question is presented. The students were asked to pose a survey question suitable for the scenarios of items 'Individual Characteristics' and 'Job Groups' whose given data set was collected by conducting a 'survey' in the SIPQ. The students' answers were categorized into three levels for each item. In order to determine students' level of understanding of posing survey questions, the answers of the students at different understanding levels are explained in detail for each item providing examples from students' answers.

Level 0: Nearly a quarter of the students performed at Level 0 for each item. As seen in Table 4.2, 23.1% of the students performed at Level 0 in item 'Individual Characteristics', while 22.3% of the students performed at Level 0 in item 'Job Groups'. At this level, the students did not pose any question.

Level 1: A few students performed at Level 1 for each item. As seen in Table 4.2, 12.4% of the students performed at Level 1 in both items 'Individual Characteristics' and 'Job Groups'. At this level, some of the students posed statistical investigation questions instead of survey questions. In other words, these questions could not be answered only by asking one person as they include variability, i.e. a data collection procedure. Therefore, to answer them, a study must be conducted. For example, some students posed questions asking how many people have the same hobbies, weight or eye color. Figure 4.15 shows the answer of such a student.

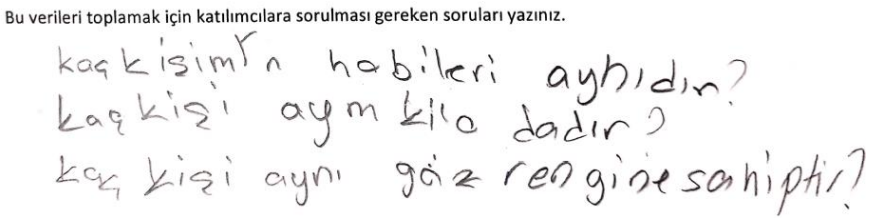


Figure 4.15 The answer of student 8 to item 2-c

Similarly, some students posed statistical investigation questions asking for the most common in the data sets. For example, some students posed questions asking which job groups were chosen most or least. Figure 4.16 shows the answer of such a student.

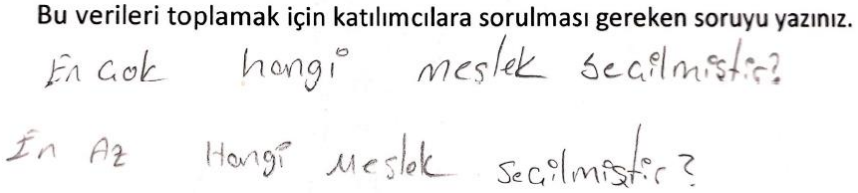


Figure 4.16 Answer of student 59 for item 4-c

On the other hand, at Level 1, some students wrote survey questions but the variables of them were unclear. In other words, everybody understood different things because of unclearness and answered the question talking about different variables. Figure 4.17 shows such an example by asking to participant to mention about them.

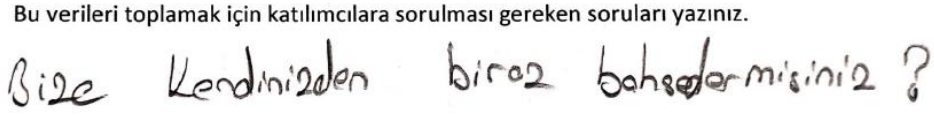


Figure 4.17 The answer of student 113 to item 2-c

Lastly, some students posed questions which could be answered by the participants but they could not be answered by the given data set. For example, some students posed questions asking the reason for choosing that job. Figure 4.18 shows the answer of such a student.

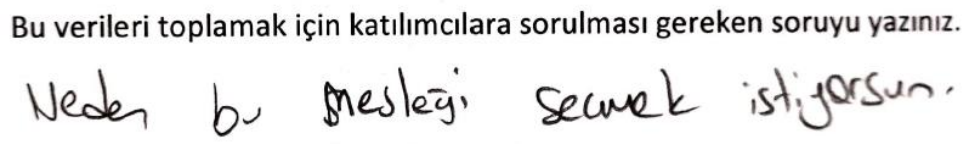


Figure 4.18 Answer of student 59 for item 4-c

Level 2: Most of the students performed at Level 2 for each item. As seen in Table 4.2, 64.5% of the students performed at Level 2 in item 'Individual Characteristics'. Similarly, 65.3% of them performed at Level 2 in item 'Job Groups'. At this level, the students posed survey questions with clear variables, which enabled to gather the given data sets.

In the item 'Individual Characteristics', the students asked about name, gender, age, hobby, eye color, weight and the amount of chocolate consumption during a week in their questions. Figure 4.19 shows the answer of such a student.

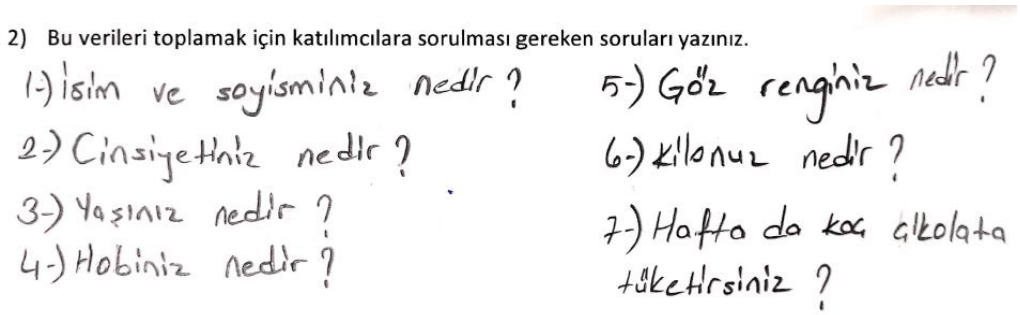


Figure 4.19 The answer of student 7 to item 2-c

In the item ‘Job Groups’, the students posed questions asking about dream jobs for future. Figure 4.20 shows the answer of such a student.

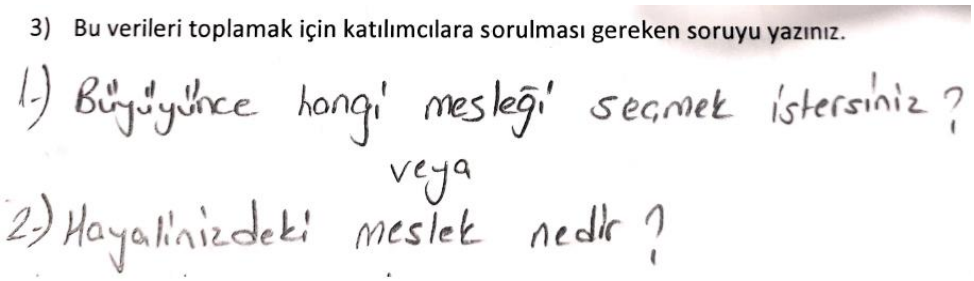


Figure 4.20 The answer of student 7 for item 4-c

To sum up, most of the students had high level of understanding of posing survey questions. They knew how to pose a survey question with clear variables correctly for the given data sets. Another purpose of this study was to define the level of understanding of seventh grade students of the analyze data component of the statistical investigation process. Therefore, in the next section, the findings of this study related to analyzing the data component are presented.

4.3. Students’ Level of Understanding of Analyzing Data

The third aim of the present study was to analyze seventh grade students’ level of understanding of analyze data in the statistical investigation process. The students were asked to draw a graph appropriate for both data type and purpose of the items in the SIPQ.

In ‘Summer Holiday’ item of the SIPQ, the students were given a scenario that required choosing a city for holiday with two data sets involving temperatures of two different cities in month July. In the analyzing the data part of this item, the students

were expected to draw a paired-line plot that gives the opportunity to compare two different data sets consisting of continuous variables.

In ‘Individual Characteristics’ item, the students were given a multivariate data set consisting of six different features of sixteen different people. In this item, the students were expected to draw graphs appropriate for the type of data.

In ‘Battery Lives’ item, the students were given a scenario that required deciding to buy batteries for toys of a toy company. In the analyze part, the students were expected to draw a paired-bar graph that gives the opportunity to compare two different data sets consisting of non-continuous variables.

In ‘Job Groups’ item, the students were given a data set collected by the manager of a middle school to determine the jobs which were dreamed by students for future. In this item, the students were expected to draw a bar graph or pie charts which are suitable for non-continuous variables.

Students’ graphs were categorized into four levels in terms of their appropriateness for the data type or the purpose of the items by using four levels. Then, except Level 0, each level was divided into two sub-levels according to the structural components of the graphs such as scale, labels of coordinates, especially numerating coordinates. Moreover, the graphs are examined in terms of completeness, which is, containing all the data values in the data sets. Furthermore, representativeness of graphs for data sets was determined, which means marking the data values correctly on the graphs. In other words, in the sub levels, it was presented whether or not graphs were constructed correctly, completely and as representative of the data. Table 4.3 presents the distribution of frequencies of students across levels for each item. At all levels, the graphs were also examined in terms of structural components such as scale, labels of coordinates, especially numeration of coordinates.

Table 4.3 The distribution of students' graphs across the levels for each item

Items Levels		Item 1-c (Summer Holiday)	Item 2-d (Individual Characteristics)	Item 3-c (Battery Live)	Item 4-d (Job Groups)
0		25 20.7%	41 33.9%	37 30.6%	48 39.7%
1	0	18 14.9%	22 18.2%	15 12.4%	8 6.6%
	1	7 5.8%	17 14%	14 11.6%	13 10.7%
2	0	25 20.7%	20 16.5%	11 9.1%	25 20.7%
	1	33 22.3%	16 13.2%	10 8.3%	15 12.4%
3	0	2 1.7%	1 0.8%	6 4.9%	-
	1	10 8.3%	1 0.8%	24 19.8%	-
Total		120 99.2%	118 97.5%	117 96.7%	109 90.1%

Table 4.3 revealed that except for the item 'Summer Holiday', most of the students performed at Level 0 for the items 'Individual Characteristics' (33.9%), 'Battery Live' (30.6%) and 'Job Groups' (39.7 %). However, most of the students (22.3%) performed at Level 2.1 in the item 'Summer Holiday'. On the other hand, all of the students did not construct a graph to analyze the given data. The table showed that few students (12 students) constructed a table instead of graph in the item 'Job Groups' than the other items.

In the following sections, in order to answer the third research question of the present study, the answers of the students with different understanding levels are explained in detail by providing examples from students' answers from each item.

Level 0: Nearly a third of students performed at Level 0. As seen in Table 4.3, 20.7% of the students performed at Level 0 in item 1-c, while 33.9% of them performed at Level 0 in item 2-d. Moreover, 30.6% of the students performed at Level 0 in item 3-c, while 39.7% of them performed at Level 0 in item 4-d. At this level, students did not construct any graph.

Level 1.0: As seen in Table 4.3, 14.9% of the students performed at Level 1.0 in item 1-c, while 18.2% of them performed at Level 1.0 in item 2-d. Moreover, 12.4% of the students performed at Level 1.0 in item 3-c, while 6.6% of them performed at Level 1.0 in item 4-d.

At this level, the students did not construct a graph that was appropriate to both type of data and aim of comparison research questions, while they were appropriate to type of data for summary research questions. In other words, they drew bar graphs for continuous variables or line plots for non-continuous variables for summary research questions. In addition to unsuitable graph choice for type of data, they drew separate graphs for two different data sets for comparison questions. For example, they drew a bar graph of weather of Marmaris instead of paired-line plots to compare the temperature of Marmaris and Alanya. Besides, students numerated the coordinates in a wrong way. Also, some students made mistakes while labeling the coordinates. Moreover, all data values in the sample were not presented on the graphs. Figure 4.21 shows the answer of such a student.

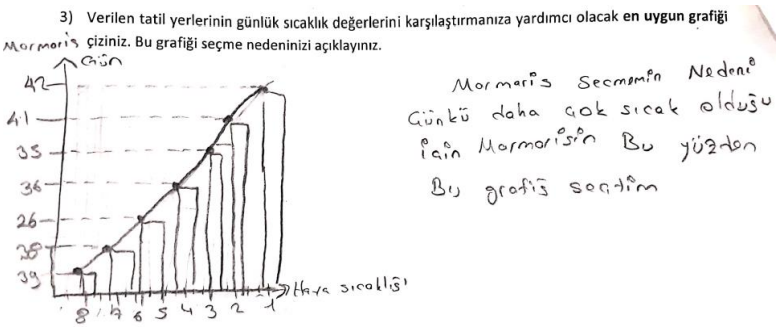


Figure 4.21 The answer of student 44 for item 1-c

Besides wrong numeration of coordinates and missing values in the data sets, some students constructed unrepresentative graphs for the data sets. In other words, the students made mistakes in presenting the frequencies and values in the data sets. For example, some students had problems about counting the frequencies for each weight point. On the other hand, some graphs were problematic in terms of connecting paired orders with lines. It was seen that some students connected the dots to each other by the nearness of them to each other instead of order as presented below.

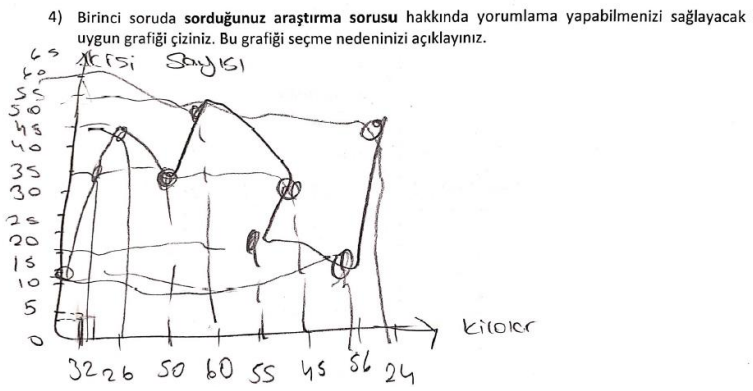


Figure 4.22 The graph of student 38 for item 2-d

As seen in the graph, the students constructed a line plot instead of a bar graph to present frequencies of weight points. Although the students failed to choose the appropriate graph for the type of data, some of them drew well-constructed graphs as explained at Level 1.1.

Level 1.1: As seen in Table 4.3, few the students (5.8%) performed at Level 1.1 in item 1-c, while 14% of them performed at Level 1.1 in item 2-d. Moreover, 11.6% of the students performed at Level 1.1 in item 3-c and 10.7% of them performed at Level 1.1 in item 4-d.

At this level, students did not construct a graph that was appropriate to both type of data and aim of comparison research questions, while they were appropriate to type of data for summary research questions. For example, they drew line plots instead of bar graphs to present the amount of chocolate consumption in a week. However, they constructed graphs with correct numeration of axes. Besides, they presented all the values or frequencies in the data sets correctly in their graphs. Figure 4.23 shows the answer of such a student.

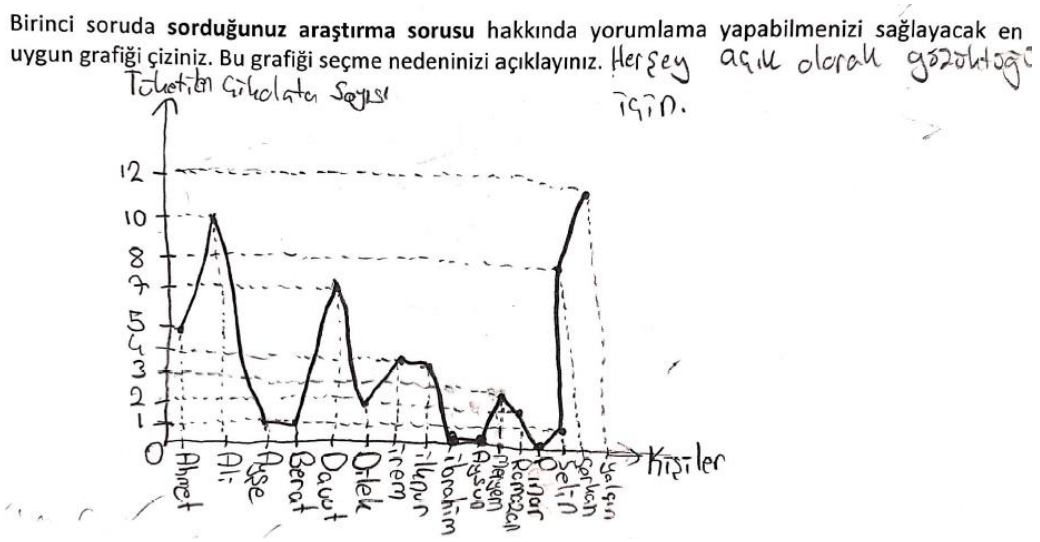


Figure 4.23 The graph of student 28 for item 2-d

As seen in the graph, the students constructed line plot instead of bar graph to present the frequencies of weight points. Although the students failed to choose the graph that was appropriate to both type of data and aim for comparison research questions or appropriate to type of data for summary research questions at Level 1.0 and 1.1, many students chose appropriate graphs for the data sets as explained at Level 2.0 and 2.1.

Level 2.0: As presented in Table 4.3, 20.7% of the students performed at Level 2.0 in item 1-c, while 16.5% of them performed at Level 1.1 in item 2-d. A small part of the students (9.1%) performed at Level 2.0 in item 3-c, while 20.7% of the students performed at Level 2.0 in item 4-d.

At Level 2.0, the students chose type of graphs that were not appropriate either to type of data or aim for comparison research questions while appropriate to type of data for summary research questions. In other words, they drew paired bar graphs for continuous variables or two separate line graphs for non-continuous variables for comparison research questions. The students drew bar graphs or pie charts for non-continuous variables and line plots for continuous variables for summary questions. In spite of correct graph choice for type of data for summary questions, some students made mistakes about the place of zero '0' on the coordinate system as presented below:

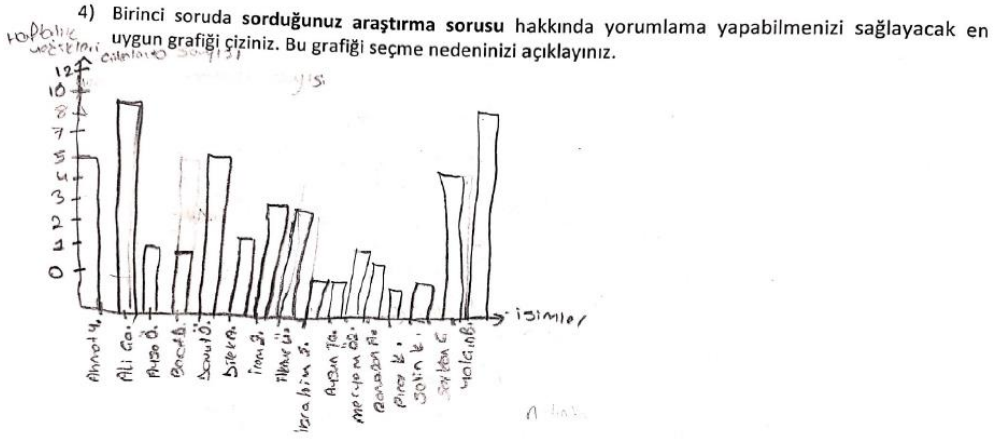


Figure 4.24 The graph of student 41 for item 2-d

In addition to the fault regarding of the place '0' on the coordinate system, many students failed while numerating the coordinates of their graphs as seen below.

Figure 4.25 The graph of student 50 for item 4-d

Unfortunately, the students could not realize that there was a problem with this kind numerating. They did not criticize why teaching mathematics and being a pediatrician were perceived as the least preferred jobs although they were the most preferred jobs in the data set.

Similarly, the students could not realize that the most preferred jobs should have bigger slices than the less preferred ones while constructing pie charts. At this level, the students just wrote the name of jobs on the slices of pie chart without considering the ratio between them. Figure 4.26 shows the answer of such a student.

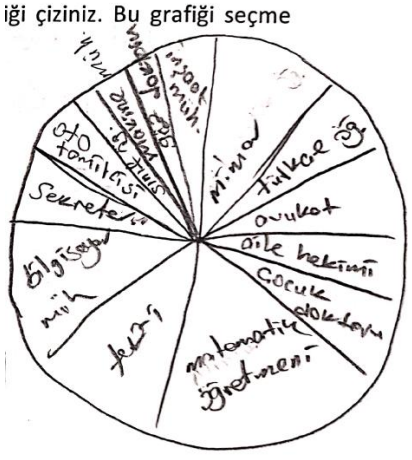


Figure 4.26 The graph of student 117 for item 4-d

Level 2.1: As presented in Table 4.3, a big part of the students (22.3%) performed at Level 2.1 in item 1-c. On the other hand, 13.2% of the students performed at Level 2.1 in item 2-d, while 8.3% of them performed at level 2.1 in item 3-c. Lastly, 12.4% of the students performed at Level 2.1 in item 4-d.

At this level, the students chose type of graphs that were not appropriate either to type of data or aim for comparison research questions while appropriate to type of data for summary research questions. In other words, they constructed paired bar graphs for non-continuous variables or two separate line graphs for continuous variables for comparison research questions as seen below.

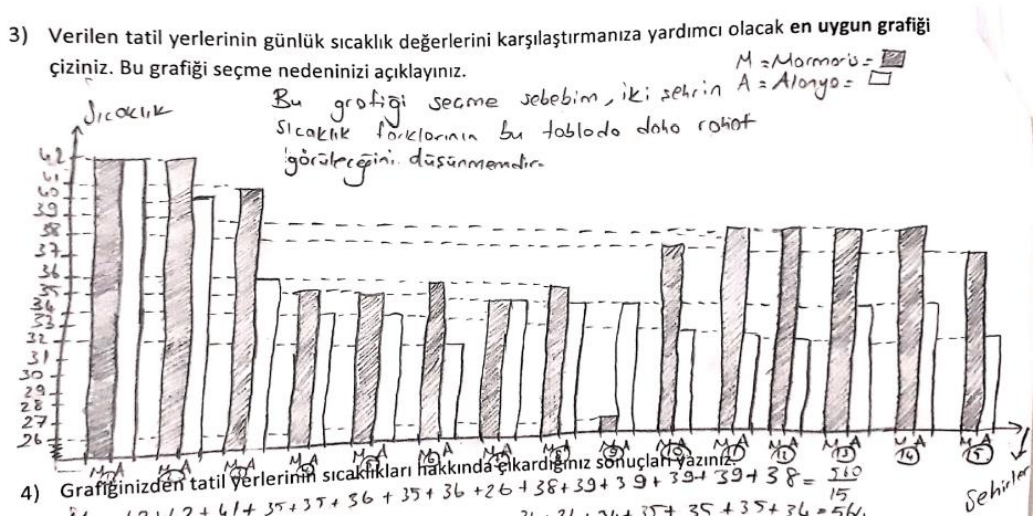


Figure 4.27 The graph of student 18 for item 1-c

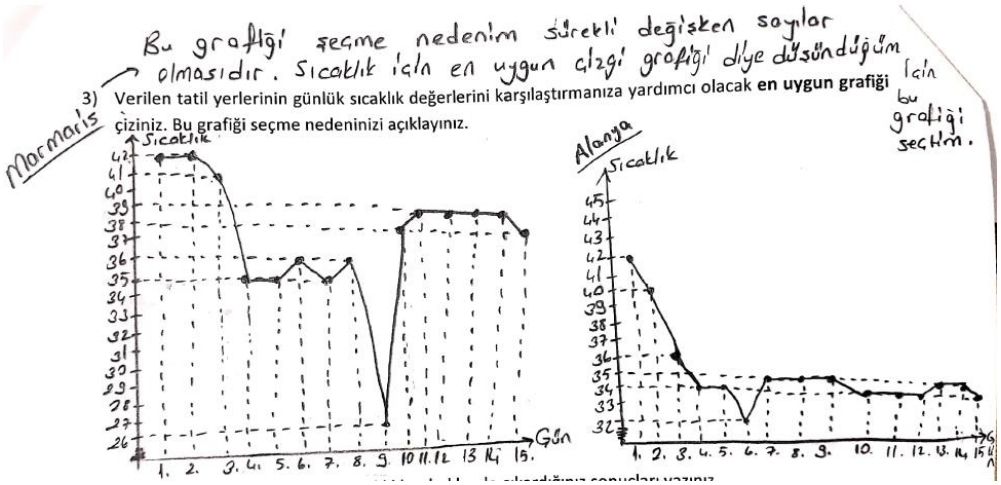


Figure 4.28 The graph of student 7 for item 1-c

As seen above, some students constructed paired bar graphs with the purpose of comparing temperatures of the cities Marmaris and Alanya in spite of inappropriateness of bar graphs for the continuous variable. On the other hand, some students constructed separated line graphs without noticing the purpose of comparing the temperatures of the cities.

Moreover, the students constructed line plots to present continuous variables while they constructed bar graphs and pie charts to present non-continuous variables for summary research questions. Besides correct choice of graph type, the students constructed the graphs with correct numeration of coordinates. Also, they presented all the frequencies and values correctly in the data sets on the graphs. For example, the students constructed bar graphs to show the frequencies of each hobby in the item 'Individual Characteristics'. Figure 4.29 shows the answer of such a student whose graph is complete and representative of data sets.

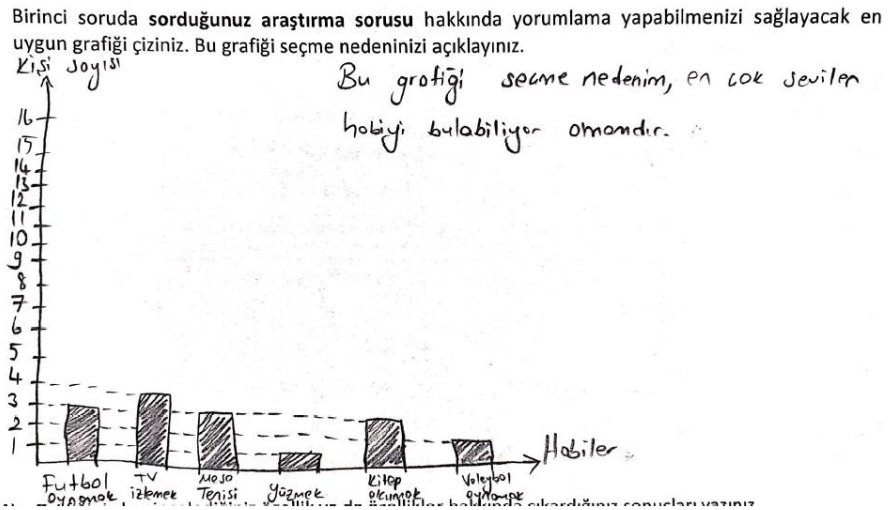


Figure 4.29 The graph of student 117 for item 2-d

As seen, the students constructed their graphs with correct numeration and labeling of the coordinates. The students presented all the frequencies in the data sets correctly in their graphs.

Similar to the correctness of frequencies, the students computed the size of slices correctly if they decided to construct pie charts. Then, they constructed their pie charts by noticing the ratio between categories as presented below:

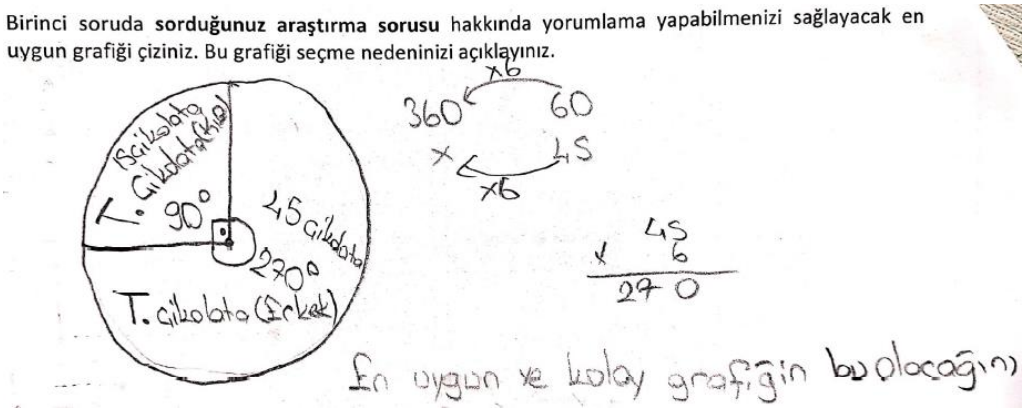


Figure 4.30 The graph of student 117 for item 2-d

Also, some students made classification of jobs in the item ‘Job Groups’ while constructing bar graphs. For example, they made a class as ‘teacher’ instead of using the mathematics teacher, Turkish teacher and elementary teacher separately. Figure 4.31 shows the graph of such a student.

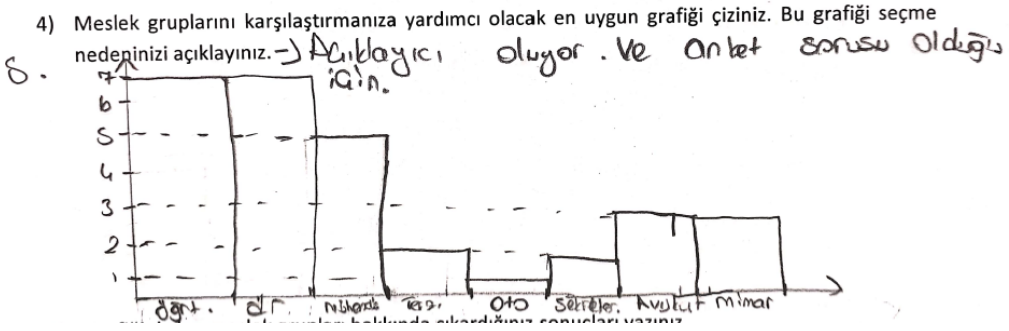


Figure 4.31 The graph of student 117 for item 4-d

Level 3.0: A very small part of students performed at Level 3.0. As presented in Table 4.3, 1.7% of the students performed at Level 3.0 in item 1-d, while 0.8% of them performed at Level 3.0 in item 1-e. Moreover, 4.9% of the students performed at level 3.0 in item 3-d.

At this level, the students constructed graphs which were appropriate not only for the data type but also purpose of comparing two different data sets on the same graph. Therefore, this level is related to comparison investigation questions. As a result, no graph was categorized at Level 3.0 in the item ‘Job Groups’ whose purpose was to summarize the data set.

Although the students chose the appropriate graph for the type of data and purpose of item, they made some mistakes in numerating on the axes. Indeed, one of the students did not numerate x- axes as presented below:

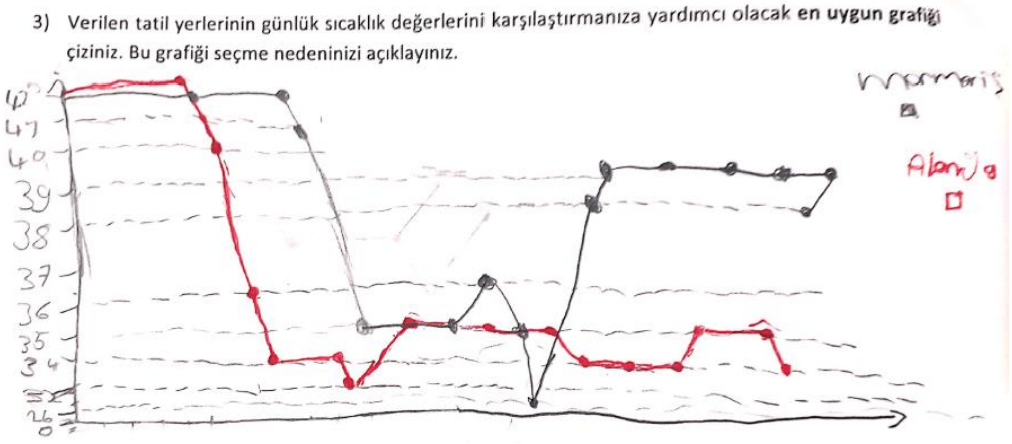


Figure 4.32 The graph of student 101 for item 1-c

Also, some students constructed graphs that were not representative of all data sets. They presented just some data values instead of all the data sets on the graphs. Figure 4.33 shows the graph of such a student.

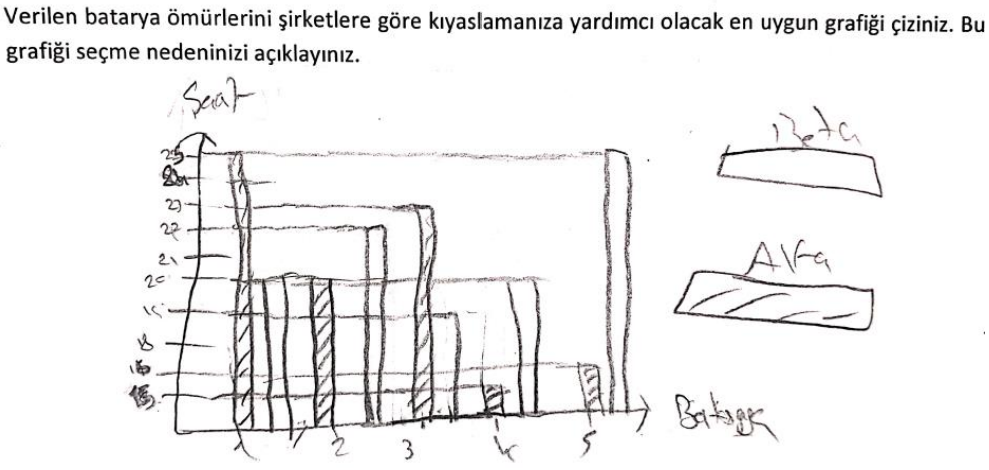


Figure 4.33 The graph of student 87 for item 3-c

As presented, the students generally did not make improper numerating on the coordinates at Level 3.0, but some students forget to numerate the x axis. At this level, the graphs were usually not complete, did not include all the values in the data sets.

Level 3.1: As presented in Table 4.3, 8.3% of the students performed at Level 3.1 in the item 1-d, while 0.8% of them performed at Level 3.1 in item 1-e. However, 19.8% of the students performed at Level 3.1 in item 3-d.

At this level, the students constructed graphs which were appropriate not only for the data type but also for the purpose of comparing two different data sets on the same graph. Moreover, they constructed graphs whose coordinates were numerated and labeled in a proper way. Also, all the data values in the data sets were presented on the graphs correctly. Figure 4.34 shows the graph of such a student.

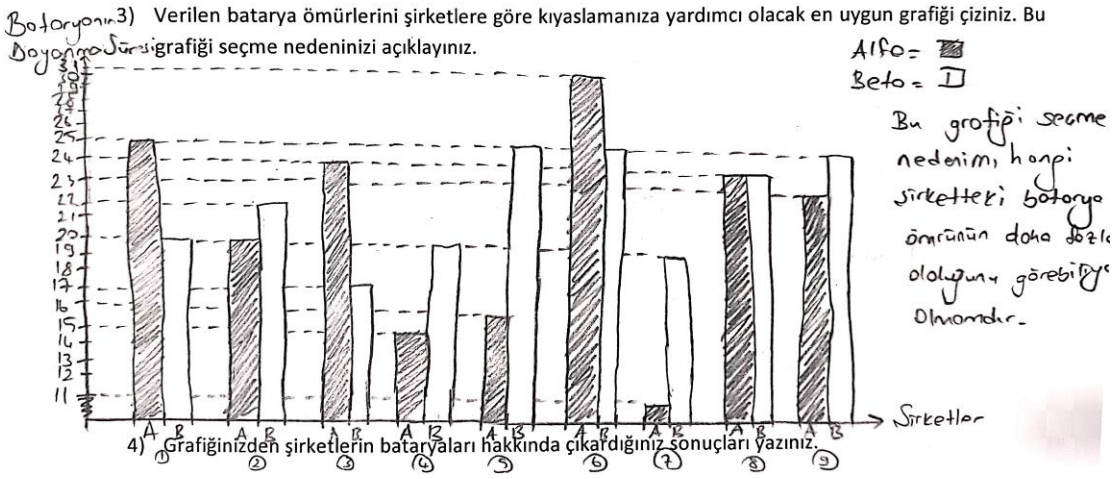


Figure 4.34 The graph of student 18 for item 3-c

In each item, the students were asked to construct graphs according to the aim of each item. However, it seemed that a small part of the students constructed tables instead

of graphs. The tables were not categorized because of less preference of students. For example, just one student constructed a table in the item ‘Summer Holiday’. Moreover, three students constructed a table in the item ‘Individual Characteristics’, while four students constructed a table in the item ‘Battery Lives’. Furthermore, twelve students constructed a table in the item ‘Job Groups’. It was seen that the students did not prefer to construct a table to compare two data sets consisting of continuous variables as much as other situations. Indeed, the students constructed a table mostly to summarize the data set consisting of many categories as in the item ‘Job Groups’. Most of the students labeled the columns and rows of the tables. Besides, they usually showed the frequencies and data values correctly in the items ‘Summer Holiday’, ‘Individual Characteristics’ and ‘Battery Lives’. However, they made some mistakes about the frequencies of job groups in the item ‘Job Groups’ as presented below:

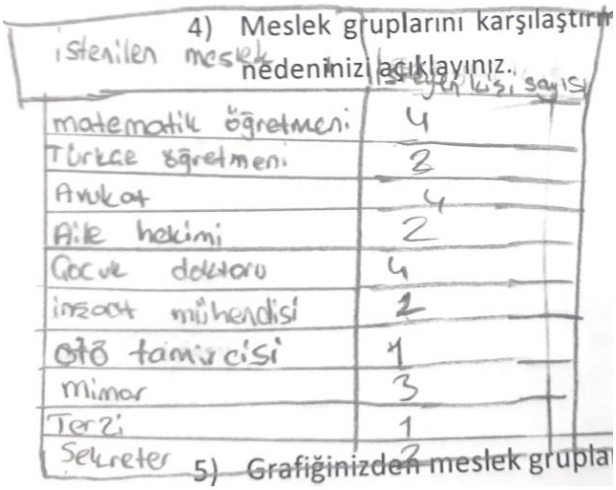


Figure 4.35 The table of student 9 to item 4-d

In this table, the frequencies of lawyer, civil engineering and tailor were written wrongly. Also, some job groups such as ophthalmologist, mechanical engineer, computer engineer, elementary teacher and mechanic were not shown in the table.

To sum up, in the analyze data component of the statistical investigation process, the students usually had problems about determining a graph that is both appropriate for the type of data and purpose of the items. Also, most of the students had problems while drawing a well-constructed graph. They had problems especially in numerating the axes in an increasing manner. Similarly, most of the students preferred to write just the numbers in the data sets to the coordinates instead of scaling.

Another purpose of this study was to define the understanding level of seventh grade students in the interpreting results component of the statistical investigation process. Therefore, in the next section, the findings of this study related to interpreting results component are presented.

4.4. Students' Level of Understanding of Interpret Results

The fourth aim of the present study was to analyze seventh grade students' level of understanding of interpreting results in the statistical investigation process. The students were asked to interpret results on the graphs they constructed in each item in the SIPQ. Students' interpretations were categorized into four levels for each item. Table 4.4 presents the distribution of frequencies of students across three levels for each item.

Table 4.4 The distribution of students' interpretations across the four levels for each item

Items Levels	Item 1-d (Summer Holiday)	Item 2-e (Individual Characteristics)	Item 3-d (Battery Live)	Item 4-e (Job Groups)
0	22 18.2%	32 26.4%	35 28.9%	50 41.3%
1 (Elementary)	6 5%	22 18.2%	5 4.1%	16 13.2%

2(Intermediate)	39 32.2%	44 36.4%	36 29.8%	47 38.8%
3 (Advanced)	54 44.6%	23 19%	45 37.2%	8 6.6%
Total	121 100%	121 100%	121 100%	121 100%

Table 4.4 (contunied)

Table 4.4 revealed that most of the students interpreted the results at Level 3 (advanced) while the least part of them interpreted the results at Level 1 (elementary) for the items 'Summer Holiday' (44.6% ; 5%) and 'Battery Live' (37.2% ; 4.1%). However, very few students (6.6%) interpreted the results at Level 3 (advanced), while most of them (41.3%) performed at Level 0 for the item 'Job Groups'. On the other hand, most of the students (36.4%) interpreted the results at Level 2 (intermediate) for the item 'Individual Characteristics'.

In the following sections, in order to answer the fourth research question of the present study, the answers of the students at different understanding levels are explained in detail by providing examples from students' answers for each item. In other words, how seventh grade students made interpretations at different understanding levels is explained for each understanding level.

Level 0: Nearly a quarter of the students performed at Level 0 for each item. As seen in Table 4.1, fewer students (18.2%) performed at Level 0 in item 1-d. Also, 26.4% of the students performed at Level 0 in item 2-e while 28.9% of the students performed at Level 0 in item 3-d. However, more students (41.3%) performed at Level 0 in item 4-e. At this level, students did not make any interpretation.

Level 1 (Elementary): As seen in Table 4.4, a small part of the students (5%) performed at elementary level in item 1-d. Similarly, 4.1% of the students performed at elementary level in item 3-d. On the other hand, more students (18.2%) performed at elementary level in the item 2-e, while 13.2% of them performed at elementary level in item 4-e.

At this level, the students lifted or extracted the information from the data. They told the temperatures of cities from their graphs just by looking. For example, they said that 'The temperature is 42 ^{o}C on the first day in Marmaris, while it is 42 ^{o}C in Alanya.' and 'The temperature is 38 ^{o}C in Marmaris, while it is 34 ^{o}C in Alanya.' as seen below:

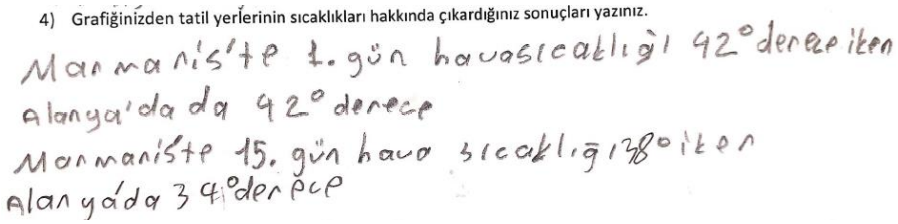


Figure 4.36 The answer of student 102 for item 1-d

Similarly, they just told about the frequencies of a category. For example, some students stated that 'There are 6 people with blue eyes. There are 5 people with brown eyes. There are 5 people with green eyes' as seen below.

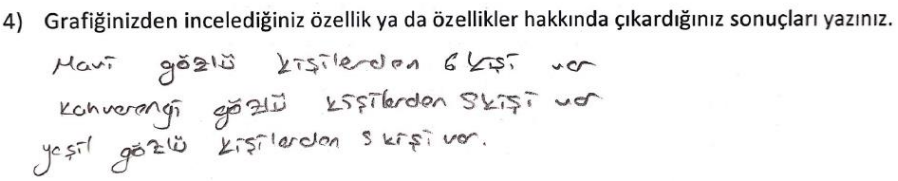


Figure 4.37 The answer of student 14 for item 2-e

In another example, the students wrote the frequencies of people for each job group as presented below:

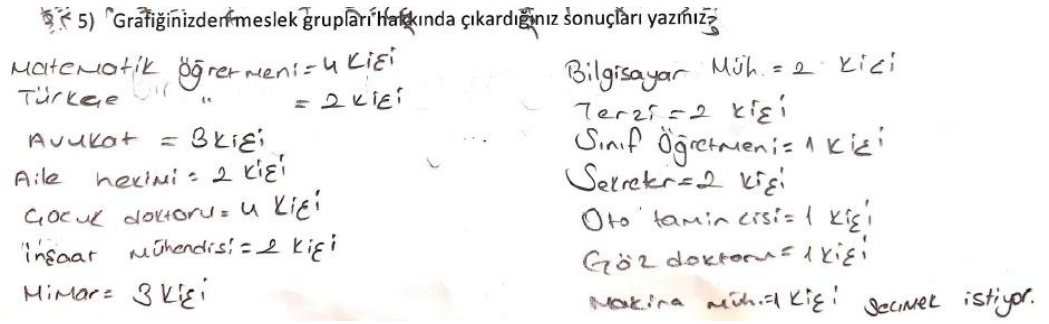


Figure 4.38 The answer of student 14 for item 4-e

On the other hand, some students made interpretations about what their graph told about at elementary level. For example, some students said that they learned about the life span of batteries as seen below:

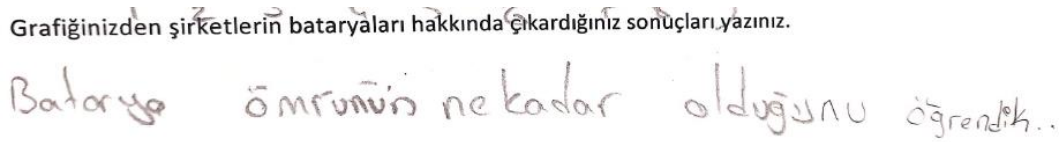


Figure 4.39 The answer of student 14 for item 3-d

Besides, the interpretations of the students were examined in terms of their correctness. The results are presented in Table 4.4.1.

Table 4.4.1 The distribution of students' interpretations in terms of correctness for elementary level

Item	Item1-d (Summer Holiday)	Item 2-e (Individual Characteristics)	Item 3-d (Battery Live)	Item 4-e (Job Groups)	Sum
Wrong	2	1	-	1	4
Correct	4	21	5	15	45

As seen in Table 4.4.1, four of the interpretations were wrong while 45 of them were correct at elementary level. According to the results, students usually read the data on the graph correctly.

Level 2 (Intermediate): A big part of the students made interpretations at intermediate level. As seen in Table 4.4, 32.2% of the students performed at intermediate level in item 1-d, while 36.4% of them performed at elementary level in item 2-e. Similarly, 29.8% of the students performed at elementary level in item 3-d while 38.8% of them performed at elementary level in item 4-e.

At intermediate level, the students integrated the presented information. They made comparisons such as greater than, less than, the greatest and the least. For example, the students made interpretations like 'The warmest day is on the first day and the coldest day is on the ninth day in Marmaris.' as presented in below:

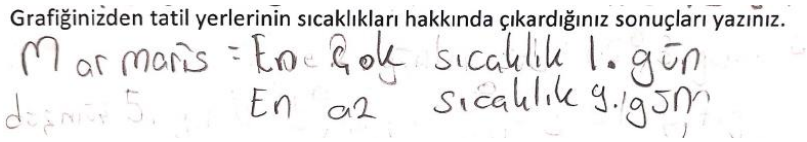


Figure 4.40 The answer of student 28 for item 1-d

Similarly, the students stated ‘The lives of batteries are 31 hours at most and 11 hours at least.’ as presented below:

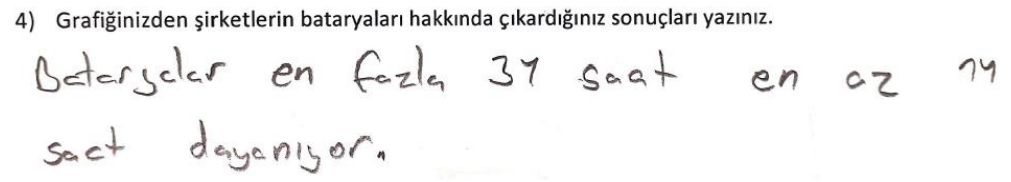


Figure 4.41 The answer of student 114 for item 3-d

In the same way, many students wrote that ‘The most chosen jobs are mathematics teacher and pediatrician. The least chosen jobs are ophthalmologist, mechanical engineer, elementary teacher, and mechanic.’ Figure 4.39 shows the graph of such a student.

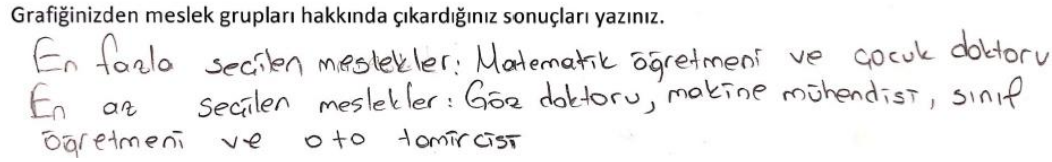


Figure 4.42 The answer of student 68 for item 4-e

Moreover, some students emphasized the equal frequencies in the data set. For example, they said that the number of people with green eyes and brown eyes are equal to each other as seen below:

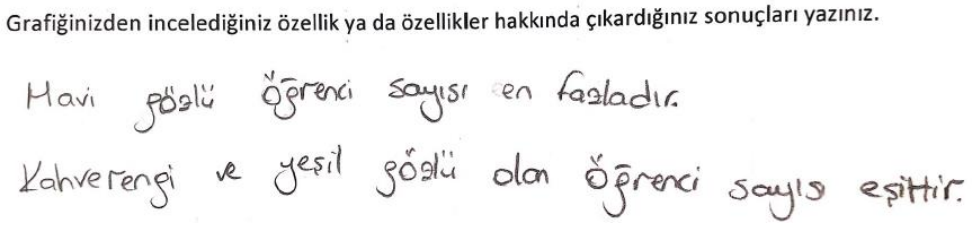


Figure 4.43 The answer of student 23 for item 2-e

Besides, the interpretations of students were examined in terms of their correctness. The results are presented in Table 4.4.2.

Table 4.4.2 The distribution of students' interpretations in terms of correctness for intermediate level

Item	Item1-d (Summer Holiday)	Item 2-e (Individual Characteristics)	Item 3-d (Battery Live)	Item 4-e (Job Groups)	Sum
Wrong	9	10	9	19	47
Correct	30	34	27	28	119

As seen in Table 4.4.2, 47 of the interpretations were wrong, while 119 of them were correct at intermediate level. According to the results, students made some mistakes while comparing the frequencies of different categories.

Level 3 (Advanced): As seen in Table 4.4, a big part of the students (44.6%) of the students performed at advanced level in item 1-d, while 19% of them performed at advanced level in item 2-e. Moreover, 37.2% of the students performed at advanced level in item 3-d, but a very small part of students (6.6%) performed at advanced level in item 4-e.

At advanced level, the students had a deep understanding of the structure of data. They extended, predicted or inferred from the presented information. In other words, students moved beyond the data. For example, some students made interpretation about the variability of data sets such as 'The weather of Alanya is usually constant. The temperature of Marmaris is usually unstable.' Figure 4.41 shows the graph of such a student.

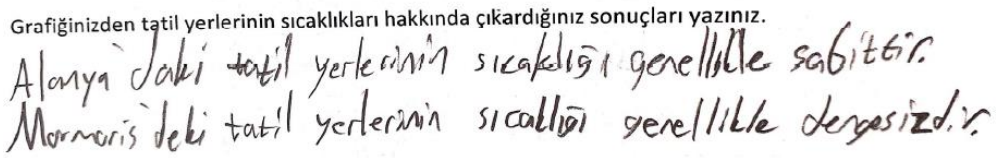


Figure 4.44 The answer of student 23 for item 1-d

Also, some students noticed the relations between different variables such as weight and chocolate consumption. For example, some of students explained that the people who consume chocolate were fatter by noticing the outliers in the data set as presented below:

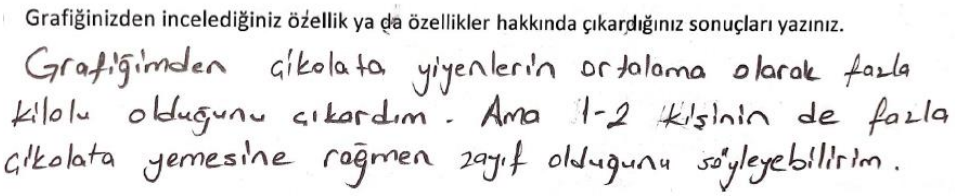


Figure 4.45 The answer of student 7 for item 2-e

Moreover, some students made interpretations about the trends in the data set. For example, some students computed the mean of batteries in the data sets to decide

which battery brand is more long-lasting. Figure 4.46 shows the graph of such a student.

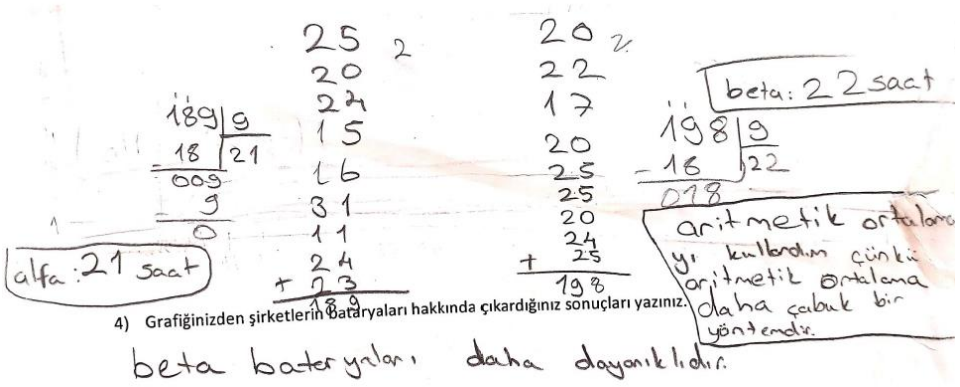


Figure 4.46 The answer of student 121 for item 3-d

Similarly, the students made interpretations about the trends without computing the mean by grouping the data set according to a variable. For example, some students noticed that 'students usually dreamed of jobs related to science or technical areas' as seen below:

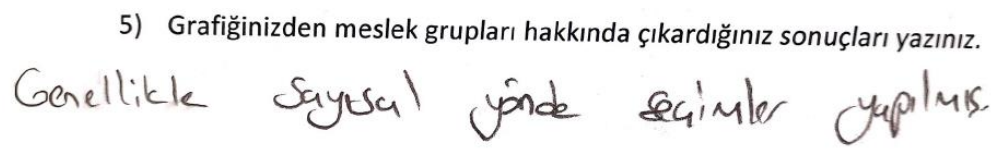


Figure 4.47 The answer of student 39 for item 3-d

Besides, the interpretations of the students were examined in terms of their correctness. The results are presented in Table 4.4.3.

Table 4.4.3 The distribution of students' interpretations in terms of correctness for advanced level

Item	Item1-d (Summer Holiday)	Item 2-e (Individual Characteristics)	Item 3-d (Battery Live)	Item 4-e (Job Groups)	Sum
Wrong	5	9	13	4	31
Correct	49	14	32	4	99

As seen in Table 4.4.3, 31 of interpretations were wrong, while 99 of them were correct at advanced level. According to the results, students made some mistakes while moving beyond the data.

To sum up, most students performed at advanced level in the items 'Summer Holiday' and 'Battery Lives'. In these items, the students were expected to compare two different data sets. On the other hand, the students performed at intermediate level in the items 'Individual Characteristics' and 'Job Groups'. It was expected because in the item 'Job Groups', the students were expected to summarize the data set. However, it was unexpected for the item 'Individual Characteristics' because there were many variables to relate to each other at advanced level. Although there were many variables that could be related to each other, the students just realized the relationship between weight and amount of chocolate consumption in a week.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

The aim of the present study was to investigate the level of understanding of seventh grade students in the statistical investigation process when they are given real data sets.

This chapter includes the summary of the findings in accordance with the purposes of the study and a discussion of the findings with regard to previous studies. Furthermore, implications and recommendations for further studies are presented.

5.1. Students' Level of Understanding in terms of Formulating Question

The Statistical Investigation Process Questionnaire (SIPQ) includes questions regarding the posing statistical investigation question component of the statistical investigation process. Firstly, the understanding levels of the students were determined by an overall analysis of each question. The findings of the present study showed that in general, the understanding levels of the students in posing a statistical investigation question were at level 2.

More specifically, in the present study, nearly half of the students posed a statistical investigation question except the item 'Summer Holiday'. This result was surprising if we considered the objectives in the the curriculum. More specifically, there exist objectives related to posing summary investigation questions in the 5^{th} grade and comparison investigation questions in the 6^{th} grade (MoNE, 2018). However, there were not any objectives related to posing questions in the 7^{th} grade in the Turkish curriculum (MoNE, 2018). Although students were not taught about posing statistical

investigation questions at seventh grade again, their knowledge about the statistical information might be permanent.

When the questions posed by students were examined, it was seen that they posed mostly comparison and summary question. In other words, the students posed statistical investigation questions that asked to compare two different data sets or asked about most popular or most common of a data set. It might be related to the items of SIPQ. In the items 'Summer Holiday' and 'Battery Lives', the students were asked to pose a statistical investigation question that requires comparing the two given data sets. Therefore, the students might have posed comparisons questions because they were asked to do it. Moreover, stundents were given a scenario in which jobs in students' dreams were investigated in the item 'Job Groups'. The students might have posed summary questions by asking the most dreamed job because the data set was obtained with the purpose of learning the most dreamed job.

On the other hand, the students' summary and comparison question choice might be related to curriculum objectives. They were asked to pose a statistical investigation question which highlights any aspects of data which are interesting to them in the item 'Individual Characteristics'. Although the students were not asked to pose any kind of statistical question, most of them posed questions asking about most popular and most common variables in the data sets or comparing variables of two different data sets. Indeed, a few students posed relationship questions asking about whether or not there is a relationship between two variables. As stated above, the curriculum includes objectives to pose summary questions and comparison questions while there are not any objectives about posing relation question (MoNE, 2018). In other words, the students might have preferred to pose summary or comparison investigation questions instead of relation investigation question because of their deficiency about relation questions.

On the other hand, some students posed questions which asked about basic information or individual cases. It might be related to the fact that the students could not realize the difference between a question and a statistical question. In other words,

the students lacked knowledge about statistical questions including variability as Hacısalihoğlu-Karadeniz (2016) stated in her study. Another reason might be that students forgot how to pose a statistical question because they were taught about it in the 5th and 6th grades.

On the other hand, third of the students did not pose any questions. It might be related to lack information of the students in posing a statistical investigation question. Moreover, a few students wrote non-sense responses such as 'survey' or 'There are 5 people whose eyes are green' although they were asked to pose a statistical investigation question. These might be related to that the students careless about reading the direction in the items.

5.2. Students' Level of Understanding in terms of Collecting Data

The Statistical Investigation Process Questionnaire includes questions regarding collecting data component of the statistical investigation process. This component consists of two parts which are deciding data sources and posing survey questions. Firstly, the understanding levels of the students were determined by an overall analysis of each question.

The findings of the present study related to deciding on the data sources showed that most of the students could not decide on the data sources of the items correctly. Indeed, according to the students, the most strange and difficult part in all the statistical investigation process was to realize how the given data sets could be gathered. It is not unexpected because data sources are less emphasized than the other components of the investigation process in the Turkish mathematics curriculum (MoNE, 2018). Moreover, the objectives related to data sources are just included in 5th and 6th grade levels in the middle school mathematics curriculum (MoNE, 2018). The failure of the students might be related to oblivion. In other words, the seventh grade students could have forgotten the data sources which were taught in the 5th and 6th grade levels.

Despite the failure of the students on deciding data sources, students were more aware of 'survey' than other sources while deciding on appropriate data sources in the given data sets. On the other hand, a very small portion of the students were aware of 'experiment' as a data source. It is not surprising because the 'survey' is the most stressed data source while 'experiment' is not included as a data source in the Turkish mathematics curriculum (MoNE, 2018).

When the students' wrong answers were examined as far as deciding on data sources is concerned, it was seen that most of the students gave answers such as 'mean, median, mode or average'. The students were taught about these concepts three weeks before they took the SIPQ. Although most of the students know the names of the central tendency measurements, it is uncertain whether or not students know in which situations the averages are used. This finding is inconsistent with the result of the studies of Bush et al. (2015). Their studies showed that students understand median conceptually. On the other hand, the findins is agreed with the results of the study of Enisoğulu (2014). Her study showed that students did not have a conceptual understanding of the concept of average. This finding might be related to that the central tendency measurements were not stressed as much as possible because of time constraints in the lessons.

The second part of the collecting data component is to posing survey question. The findings of the present study showed that in general, the understanding levels of the students in posing a survey question were at level 2. More specifically, the students showed most success in posing a survey question part of all statistical investigation process. This result was inconsistent with the study of English (2014). In the study of English (2014), students had some challenge in designing on survey questions that were clear to the respondent and enabled the collection of manageable data to answer their research questions. This contradiction might be related to students' grade levels. In the present study, the participants were 7^{th} grade, while the participants were 3^{th} grade students in the study of English (2014). In fact, the students are taught to pose survey questions at fifth grade in the Turkish curriculum (MoNE, 2018); however,

the students may not have been taught to pose survey questions at third grade in the curriculum of another country.

On the other hand, approximately 65% of the students posed survey questions, while only 35% of them could realize 'survey' as a data source. It was surprising because many students could pose survey questions without knowing the 'survey' concept. It might be because students were asked to pose questions that must be asked to participants to obtain the given data sets instead of posing survey questions. In other words, students could realize which questions should be asked to elicit the given data sets by thinking logically in spite of their lack of information in concept of 'survey'.

5.3. Students' Level of Understanding in terms of Analyzing Data

The Statistical Investigation Process Questionnaire includes questions regarding analyzing data component of statistical investigation process. Firstly, the understanding levels of the students were determined by an overall analysis of each question. The findings of the present study showed that in general, except one question, a third of students did not construct any graph. Indeed, the ratio of the students who didn't construct any graphs was the smallest in the first item of the SIPQ, while the ratios of the students who didn't construct any graphs was the biggest in the last item of the SIPQ. It might be related to tiredness of students or time constraints. The students may be tired towards the end of the questionnaire and they might not want to construct any graph. Another possibility is that students might not manage their time correctly and they might not have enough time to construct a graph for the last item.

In addition to unanswered questions, the students had difficulty choosing a graph that is suitable for both data type and the aim of the given scenarios like comparing two different data sets. This result supports the studies which presented that participants could not choose appropriate graph types (Burgess, 2001; Güven et al., 2015). On the other hand, it was inconsistent with the seventh grade mathematics curriculum

(MoNE, 2018). According to the curriculum, students should be able to construct bar graphs, line graphs and pie charts to arrange data sets (MoNE, 2018). However, teachers might give more focus on how to construct these graphs than on which situation which graph type is appropriate. State differently, they might not be conducting a discussion about which graph type is suitable for which aim and data type because of time constraints. As a result, they might be preparing examples asking students simply to construct a bar graph or line graph instead of choosing an appropriate graph type for given data sets. Another reason for students' difficulty might be related to the questions they solved in their textbooks as shown below:

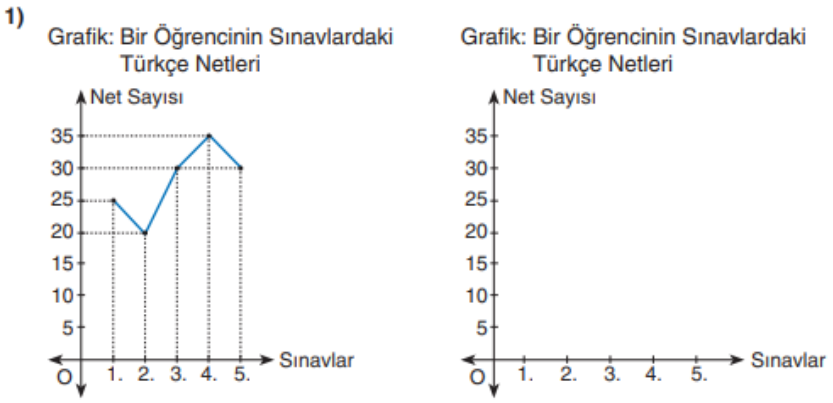


Figure 5.1 Question From Middle School Mathematics 7 Textbook by O. Bilen, pg. 241.

In this example, the students were given a line graph representing a student's scores in five different Turkish exams. The students were asked to construct a bar graph using the data in the line graph. Line graphs are used to reflect a functional relationships or time-series data (Friel et al., 2001). However, there is not a time-series data in the example; hence students were given an inappropriate situation for the use of line graphs. Therefore, students might have difficulty choosing a suitable

graph type for the data type and the aim of situation because of these kinds of unsuitable examples. Moreover, the example asked students to construct a bar graph using the data in the line graph. It might lead to a thought like that there is no problem to use a bar graph instead of a line graph or vice-versa. Hence, students might construct any graph according to their desire without thinking about data type and the aim of the situations.

On the other hand, the present study showed that, students have a tendency to choose bar graph instead of line graphs and circle graph (pie charts). As a result of this tendency, students showed more understanding level in choosing paired-bar graphs than paired-line graphs. This result is consistent with the curriculum objectives. The mathematics curriculum includes objectives related to constructing bar graphs at the fifth, sixth and seventh grades (MoNE, 2018). However, students were taught to construct line graphs or circle graphs in the seventh grade for the first time (MoNE, 2018). Students might choose to construct bar graphs instead of line graphs or circle graphs even in inappropriate situation because of their higher levels of familiarity with bar graphs. Moreover, in the study of Kranda and Akpınar (2019), the students stated that they didn't have a problem while constructing bar graph because of their familiarity with the bar graphs. Therefore, the students might choose to construct bar graph because they know it better than others because of their familiarity. On the other hand, this result was in disagreement with the study of English (2014). The study of English (2014) showed that the majority of students created a circle graph. This contradiction might be because the students were given circle sheets in that study. However, in the current study, the students were not given any sheets that could prompt any type of graph.

In addition to choosing the appropriate graph type, the students' graphs were problematic in terms of some structural features. Many of the graphs lacked titles and adequate labeling of axes as similar to the findings in the study of Burgess (2001). It might be related to carelessness of the students. Indeed, they might have forgotten to label axes and title while focusing on representing the data values. Another reason

might be that less attention might be given during regular math lesson to labeling the axes and giving a title.

Another problem regarding the structural features was wrong numeration of the axes. Some students did not write the frequencies of the data values to axes from the smallest to the biggest. Indeed, they numerated their coordinates in the order the data values given to them; hence, some graphs seemed always increasing and decreasing. Similarly, the students made mistakes about the place of zero '0'. These results were consistent with the study of Güven et al. (2015). It might be related to students' deficiency regarding the coordinate system. The students might have not learned well how to numerate the axes of the coordinate system. On the other hand, it might be related to their deficiency in interpreting graphs. If they were better in interpreting the graphs, they could have realized that there was a problem with this kind of numeration. For example, they could have noticed why the mathematics teachers and pediatrician were perceived as the least preferred jobs although they were the most preferred jobs in the data set.

Besides wrong numeration, some graphs were problematic in terms of connecting paired orders with lines. It was seen that some students connected the dots to each other considering the nearness of them to each other instead of order. This result is in agreement with the study of Hotmanoğlu (2014). It might be related to the fact that students could have problems about how or when they should connect the paired orders. Indeed, students might have forgotten how to connect the paired orders to each other as they stated in the study of Kranda and Akpınar (2019).

Another problem was that some students did not show all the values in the data sets or they showed wrong frequencies in their graphs. The students especially represented wrong frequencies on their graphs in the item 'Job Groups'. It might be related to carelessness of the students. They might have counted the frequencies of the jobs wrongly because there were fourteen different job groups that were chosen by 30 people in the item.

On the other hand, the students had problems about determining the size of slices while constructing pie charts. Indeed, they just wrote the name of variables on the slices of pie chart without caring about the ratio between them. It might be because the students might not have calculated the ratios of the slices by using proportion. Indeed, the students could have problems with the proportion topic. However, the study of English (2014) showed that students could determine sector sizes by using estimation, ruler, their finger widths and percentages although they had not been taught. Although the finding of the current study seems to be in contradiction with the study English (2014), there is a detail. The students mostly preferred the pie charts in the item 'Job Groups' and there are the names of fourteen job groups in the data set. In this situation, it is very difficult to determine the size of slices just by estimation. On the other hand, it might be very difficult to compute percentages of each slice because of time constraints.

Besides graphs a few students chose to make a table instead of a graph especially in the item 'Job Groups'. There were the names of fourteen different job groups that were chosen by 30 people in the item. The students might have constructed a table instead of a graph because it was difficult to show so many groups in a graph.

5.4. Students' Level of Understanding in terms of Interpreting Results

The Statistical Investigation Process Questionnaire includes questions regarding interpreting the results component of the statistical investigation process. Firstly, the understanding levels of the students were determined by an overall analysis of each question. The findings of the present study showed that in general, the understanding levels of the students were at intermediate level and advanced level while interpreting results.

More specifically, the students made more complex interpretations than just description of frequencies in the data. This result was in disagreement with the study of Burgess (2001). The study of Burgess (2001) showed that many of the students

interpreted the results at elementary level by giving a written description of frequencies in the data or something that was shown directly in a graph. It might be related to activities performed in the lessons. Teachers might be preparing activities which require comparing two data sets or focusing on more than one variable in their lessons. Therefore, the students might have learned to make more complex interpretations than just stating the frequency of data.

Another finding of the present the study is that the students made more advanced level interpretations about situations which required making comparisons between two different data sets like in the items 'Summer Holiday' and 'Battery Lives'. This result is in disagreement with the study of Hotmanoğlu (2014). The study of Hotmanoğlu (2014) showed that many of the students had difficulty while interpreting the data in the paired-bar graphs. It might be related to revisions in the mathematics curriculum. The data of the study of Hotmanoğlu (2014) was collected in the 2011-2012 academic year. The Ministry of National Education (MoNE) made some updates in the middle school mathematics curriculum after this academic year. The 'data analysis' learning domain has been given more importance after these revisions.

On the other hand, most of the students made interpretations at level 2 (intermediate) in the item 'Individual Characteristics'. The students were given the 'data cards protocol' which include information about six different variables in the item. The students wrote interpretations about the most common eye colour, most popular activity while few students made interpretations related two or more variables such as weight, amount of chocolate consumption or favorite activity. This result was in disagreement with the study of Chick and Watson (2001). The study of them (2001) showed that more than half of the students made interpretations which related two or more variables. It might be related to statistical investigation question posed by students at the beginning of the item. As stated above, few students posed relationship questions asking about whether or not there is a relationship between two variables while most of them posed questions asking about most popular and most common variables in the data sets or comparing variables of two different data sets. In other

words, the students might not focus on the relations between the variables because of their initial questions.

Moreover, few students computed the mean of the temparetures of the given cities or the life span of batteries to make comparison between them although most of them wrote the mean, median and mode as data source. It might be because the students do not know when or in which situation the central tendency measurements are used. It might also be related to the given examples in the lessons. Students might be asked just to compute mean, median or mode without having been made to consider the situations in which they should be applied. Another reason might be the examples in the textbooks of the students. The examples in the textbooks might also be asked just to compute them. Therefore, students might not apply their knowledge to appropriate situations.

Another finding of the present study is that most of the interpretations at all levels were correct. In other words, the students could interpret the results correctly. When the interpretations of students were examined, it was seen that the ratio of the students who made wrong interpretations was the smallest at Level 1 (elementary). To state differently, students could read the frequencies in the graphs correctly. This finding was in agreement with the stıdy of Hotmanoğlu (2014).

On the other hand, the ratio of the students who made wrong interpretations was the biggest at Level 2 (intermediate). When the interpretations of the students examined in detail, it was realized that the students made wrong interpretations mostly in the item 'Job Groups'. For example, they stated the most preferred or the least preferred jobs wrongly. These wrong interpretations might be related to graphs which the students constructed. In the graphs, most of them determined the frequencies of the job groups in the data set wrongly. Therefore, wrong constructed graphs led to wrong interpretations.

Another finding of the present study is that the level of understanding of the students while interpreting results was higher than while analyzing the data. This finding was in agreement with the study of Chick and Watson (2001). The study of them (2001)

showed that the students were able to interpret data at a higher SOLO level than they were able to present data. This might be because the students thought that interpreting graphs is easier than constructing them (Kranda & Akpınar, 2019).

On the other hand, the ratio of students who did not make an interpretation was the smallest for the first question (18.2%), while it was the biggest for the last question (41.3%). It might be related to tiredness and time constraints. The students may be tired towards the end of the questionnaire and they might not want to interpret results. Another possibility is that students might not manage their time correctly and they might not have enough time to interpret the results for the last item.

5.5 Implications

This study offers valuable information to teachers, teacher educators, textbook writers and curriculum developers about the understanding levels of middle school students while undergoing a statistical investigation process. The findings of this study revealed that the seventh grade students had different level of understanding during the each component of the statistical investigation process. Teachers, teacher educators, textbook writers and curriculum developers should take the understanding of the students into consideration in order to prepare an effective teaching environment and learning materials while teaching the statistical investigation process.

More specifically, the results of the study can help teachers to gain insight into middle school students' possible understanding while posing a statistical investigation question or survey question, constructing graphs and interpreting results. Firstly, teachers could benefit from seventh grade students' possible understanding while posing statistical investigation questions and survey questions in order to provide information about the students' understanding regarding the difference between these two types of questions. When they are informed about the possible understanding or difficulties used by middle school students to solve questions regarding the concepts

statistical investigation question and survey question, they might prepare appropriate examples to reveal the difference between them for their mathematics lessons. In this way, students' knowledge regarding these concepts might be developed. Secondly, teachers could benefit from seventh grade students' possible understanding and constructing a graph to gain information about the students' levels of understanding. If teachers know about students' possible understanding or difficulties in choosing appropriate graph for the given data sets, they might change the focus of their lessons from how a graph is constructed to which graph is used for which data sets. In this way, students' knowledge regarding choosing an appropriate a graph for the data sets might be developed. Thirdly, teachers could benefit from seventh grade students' possible understanding and approaches while interpreting results in order to gain information about the students' level of understanding. If teachers know about the students' possible approaches about interpreting results for the given data sets, they might prepare lessons that encourage students to make more advanced interpretations.

In addition, teacher educators can benefit from the findings of the study. More specifically, pre-service middle school mathematics teachers can be informed about middle school students' possible difficulties and errors regarding while investigating students' understanding in the statistical investigation process. In this way, since pre-service teachers will be aware of the defined difficulties and errors, they can prepare appropriate teaching plans to prevent the difficulties and to eliminate the errors when they become in-service teachers.

In addition to teachers and teacher educators, textbook writers and curriculum developers can also benefit from the findings of the study. The teacher guides of mathematics textbooks may benefit from the findings of the present study. More specifically, different type of questions regarding the components of statistical investigation process could be added to textbooks to raise awareness about these components. Textbooks could include problems enabling students to understand that graph types can change according to data type and purpose. Also, they might include problems that provide the opportunity for advanced level interpretation. In this way,

students' level of understanding regarding these components could be developed. Furthermore, questions similar to the ones used in the present study that support the level of understanding of students during the statistical investigation process could be added to mathematics textbooks. To illustrate, a data set and questions related to the components of the statistical investigation process could be given. With these questions, students' understanding might be improved since the questions may be non-routine for middle school students.

5.6 Recommendations for Further Studies

The findings of the present study are limited with the questions asked in the SIPQ since when different questions related to the components of the statistical investigation process are asked, different findings could be reached. Furthermore, a similar study might be conducted in private schools to investigate private middle school students' level of understandings regarding the components of the statistical investigation process. Besides, a further study might be conducted to investigate the reasons behind the errors and the difficulties of middle school seventh grade students regarding the components of the statistical investigation process. In this way, since teachers could be aware of the reasons behind students' difficulties and errors, they could have a high level of readiness regarding the components of the statistical investigation process.

On the other hand, a further study might be conducted to investigate whether there is a relationship between the components of the statistical investigation process and students' level of understanding. Also, another study might examine if there exists a difference between the variables of statistical investigation questions posed by the students in the item 'Individual Characteristics' according to the gender.

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APPENDICIES

A. METU HUMAN SUBJECTS ETHICS COMMITTEE APPROVAL

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
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11 MAYIS 2018

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr. Mine IŞIKSAL BOSTAN

Danışmanlığını yaptığınız Özge ÖZ'ün **"Yedinci Sınıf Öğrencilerinin İstatiksel Araştırma Sürecini Anlamlandırmalarının İncelenmesi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2018-EGT-070** protokol numarası ile **11.05.2018 - 30.11.2018** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

Doç. Dr. Emre SELÇUK
Üye

Dr. Öğr. Üyesi Pınar KAYGAN
Üye

B. PERMISSION OBTAINED FROM MINISTRY OF EDUCATION

T.C.
İSTANBUL VALİLİĞİ
İl Milli Eğitim Müdürlüğü

Sayı : 59090411-20-E.13654078 23/07/2018
Konu: Anket ve Araştırma İzin Talebi

VALİLİK MAKAMINA

İlgi: a) Orta Doğu Teknik Üniversitesinin 13.06.2018 tarih ve 044-14 sayılı yazısı.
b) MEB. Yen. ve Eğ. Tk. Gn. Md. 22.08.2017 tarih ve 12607291/ 2017/25 No'lu Gen.
c) Milli Eğitim Araştırma ve Anket Komisyonunun 19.07.2018 tarihli tutanağı.

Orta Doğu Teknik Üniversitesi Eğitim Bilimleri Enstitüsü yüksek lisans öğrencisi Özge ÖZ'ün **"7. Sınıf Öğrencilerinin İstatistiksel Araştırma Sürecini Anlamlandırmalarının İncelenmesi"** konulu tezi kapsamında, İlimiz Pendik ilçesinde bulunan Züheyde Hanım İmam Hatip Lisesinde; istatistiksel araştırma süreci testi, kişi özellikleri testi ve mülakat soru formunu uygulama istemi hakkındaki ilgi (a) yazı ve ekleri Müdürlüğümüzce incelenmiştir.

Araştırmacının söz konusu talebi; bilimsel amaç dışında kullanılmaması, **uygulama sırasında bir örneği müdürlüğümüzde muhafaza edilen mühürlü ve imzalı veri toplama araçlarının kurumlarımıza araştırmacı tarafından ulaştırılarak uygulanılması, katılımcıların gönüllülük esasına göre seçilmesi, araştırma sonuç raporunun müdürlüğümüzden izin alınmadan kamuoyuyla paylaşılmaması koşuluyla, okul idarelerinin denetim, gözetim ve sorumluluğunda, eğitim-öğretimi aksatmayacak şekilde ilgi (b) Bakanlık emri esasları dâhilinde uygulanması, sonuçtan Müdürlüğümüze rapor halinde (CD formatında) bilgi verilmesi kaydıyla** Müdürlüğümüzce uygun görülmektedir.

Makamlarınızca da uygun görülmesi halinde olurlarınıza arz ederim.

Ömer Faruk YELKENCİ
Milli Eğitim Müdürü

OLUR
23/07/2018

Nihat NALBANT
Vali a.
Vali Yardımcısı

Ek:1- Genelge
2- Komisyon Tutanağı

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C. STATISTICAL INVESTIGATION PROCESS QUESTIONNAIRE

1) Yaz tatili

Ayşe Hanım ailesiyle birlikte temmuz ayında tatile gitmeyi planlıyor. Ayşe Hanım ülkemizin en popüler tatil merkezlerinden olan Marmaris ve Alanya'nın sıcaklık değerlerini incelemeye karar veriyor. En uygun yeri seçebilmek için Ayşe Hanım geçen yılın temmuz ayının günlük sıcaklık değerlerini buluyor. Her iki tatil yerinin en yüksek hava sıcaklık değerlerini not ediyor. Bu sıcaklık değerleri aşağıda tablo halinde verilmiştir.

Günler	Marmaris'in En Yüksek Hava Sıcaklık Değerleri (ºC)
1	42
2	42
3	41
4	35
5	35
6	36
7	35
8	36
9	26
10	38
11	39
12	39
13	39
14	39

Günler	Alanya'nın En Yüksek Hava Sıcaklık Değerleri (ºC)
1	42
2	40
3	36
4	34
5	34
6	32
7	35
8	35
9	35
10	34
11	34
12	34
13	35
14	35

Verilen durumla ilgili aşağıdaki soruları cevaplayınız.

a) Hava sıcaklıklarının verilen şehirlere göre değişimini incelemenizi gerektirecek bir araştırma sorusu oluşturunuz.

b) Bu veriler hangi veri toplama yöntemiyle elde edilmiş olabilir?

c) Verilen tatil yerlerinin günlük sıcaklık değerlerini karşılaştırmanıza yardımcı olacak **en uygun grafiği** çiziniz. Bu grafiği seçme nedeninizi açıklayınız.

d) Grafiğinizden tatil yerlerinin sıcaklıkları hakkında çıkardığınız sonuçları yazınız.

2) Kişi Özellikleri

Aşağıda 16 farklı kişinin bazı özellikleri verilmiştir. Bu özellikleri inceleyiniz.

Ahmet Yıldız Cinsiyet: Erkek Yaş: 12 Hobi: Futbol oynamak Göz rengi: Mavi Kilo (kg): 45 Haftalık tüketilen çikolata sayısı: 5	Ali Çalışkan Cinsiyet: Erkek Yaş: 14 Hobi: TV izlemek Göz rengi: Mavi Kilo (kg): 60 Haftalık tüketilen çikolata sayısı: 10	Ayşe Özateş Cinsiyet: Kız Yaş: 11 Hobi: Masa tenisi Göz rengi: Kahverengi Kilo (kg): 32 Haftalık tüketilen çikolata sayısı: 1	Berat Demir Cinsiyet: Erkek Yaş: 9 Hobi: Futbol oynamak Göz rengi: Yeşil Kilo (kg): 26 Haftalık tüketilen çikolata sayısı: 1
Davut Öztürk Cinsiyet: Erkek Yaş: 8 Hobi: TV izlemek Göz rengi: Mavi Kilo (kg): 30 Haftalık tüketilen çikolata sayısı: 7	Dilek Akıncı Cinsiyet: Kız Yaş: 15 Hobi: Yüzmek Göz rengi: Mavi Kilo (kg): 50 Haftalık tüketilen çikolata sayısı: 2	İrem Zengin Cinsiyet: Kız Yaş: 18 Hobi: Kitap okumak Göz rengi: Mavi Kilo (kg): 66 Haftalık tüketilen çikolata sayısı: 4	İlknur Üstün Cinsiyet: Kız Yaş: 9 Hobi: Masa tenisi Göz rengi: Yeşil Kilo (kg): 33 Haftalık tüketilen çikolata sayısı: 4
İbrahim Şimşek Cinsiyet: Erkek Yaş: 10 Hobi: Futbol oynamak Göz rengi: Yeşil Kilo (kg): 29 Haftalık tüketilen çikolata sayısı: 0	Aysun Tokgöz Cinsiyet: Kız Yaş: 12 Hobi: Voleybol oynamak Göz rengi: Kahverengi Kilo (kg): 32 Haftalık tüketilen çikolata sayısı: 0	Meryem Özer Cinsiyet: Kız Yaş: 13 Hobi: Kitap okumak Göz rengi: Yeşil Kilo (kg): 55 Haftalık tüketilen çikolata sayısı: 3	Ramazan Aylak Cinsiyet: Erkek Yaş: 16 Hobi: Masa tenisi Göz rengi: Yeşil Kilo (kg): 54 Haftalık tüketilen çikolata sayısı: 2
Pınar Kılıç Cinsiyet: Kız Yaş: 8 Hobi: Voleybol oynamak Göz rengi: Kahverengi Kilo (kg): 24 Haftalık tüketilen çikolata sayısı: 0	Selin Karaca Cinsiyet: Kız Yaş: 17 Hobi: Kitap okumak Göz rengi: Kahverengi Kilo (kg): 56 Haftalık tüketilen çikolata sayısı: 1	Serkan Çallı Cinsiyet: Erkek Yaş: 17 Hobi: TV izlemek Göz rengi: Mavi Kilo (kg): 66 Haftalık tüketilen çikolata sayısı: 8	Yalçın Bakar Cinsiyet: Erkek Yaş: 18 Hobi: TV izlemek Göz rengi: Kahverengi Kilo (kg): 74 Haftalık tüketilen çikolata sayısı: 12

Verilen durumla ilgili aşağıdaki soruları cevaplayınız.

a) Yukarıda verilen 16 kartın hepsini kullanmak şartıyla kişilerin **herhangi bir özelliğini** incelemenizi gerektirecek bir araştırma sorusu oluşturunuz.

b) Bu veriler hangi veri toplama yöntemiyle elde edilmiş olabilir?

c) Bu verileri toplamak için katılımcılara sorulması gereken soruları yazınız.

d) Birinci soruda **sorduğunuz araştırma sorusu** hakkında yorumlama yapabilmenizi sağlayacak en uygun grafiği çiziniz. Bu grafiği seçme nedeninizi açıklayınız.

e) Grafiğinizden incelediğiniz özellik ya da özellikler hakkında çıkardığınız sonuçları yazınız.

3) Batarya Ömürleri

Bir oyuncak firması ürettiği oyuncaklar için bir batarya şirketiyle anlaşmak istiyor. Oyuncaklar için **en uzun süre** dayanan bataryayı tercih etmek isteyen firma yöneticileri piyasada oyuncaklarına uygun batarya üreten Alfa şirketi ile Beta şirketinin bataryalarının ömürlerini incelemeye karar veriyorlar. Bunun için her iki şirketten de 9 batarya alıyorlar ve aynı anda oyuncakları çalıştırmaya başlıyorlar ve bataryaların ömürlerini tablolaştırıyorlar.

Tablo: Alfa ve Beta Şirketlerine ait Bataryaların Ömürleri

Batarya numarası / Şirket	1	2	3	4	5	6	7	8	9
Alfa	25 saat	20 saat	24 saat	15 saat	16 saat	31 saat	11 saat	24 saat	23 Saat
Beta	20 saat	22 saat	17 saat	20 saat	25 saat	25 saat	20 saat	24 saat	25 saat

Verilen durumla ilgili aşağıdaki soruları cevaplayınız.

a) Verilen **batarya ömürlerinin şirketlere göre değişimini** incelemenizi gerektirecek bir araştırma sorusu oluşturunuz.

b) Bu veriler hangi veri toplama yöntemiyle elde edilmiş olabilir?

c) Verilen batarya ömürlerini şirketlere göre kıyaslamanıza yardımcı olacak en uygun grafiği çiziniz. Bu grafiği seçme nedeninizi açıklayınız.

d) Grafiğinizden şirketlerin bataryaları hakkında çıkardığınız sonuçları yazınız.

4) Meslek Grupları

Bir ortaokul müdürü öğrencilerin hayallerindeki meslek grupları hakkında bir araştırma yaptırmıştır. Okuldan 30 öğrenci seçilmiş ve cevapları kaydedilmiştir:

Matematik öğretmeni	Göz doktoru	Bilgisayar mühendisi	Terzi	Oto tamircisi
Türkçe öğretmeni	Makine mühendisi	İnşaat mühendisi	Sınıf öğretmeni	Sekreter
Avukat	Matematik öğretmeni	Çocuk doktoru	Avukat	Bilgisayar mühendisi
Aile hekimi	Avukat	Terzi	Türkçe öğretmeni	Aile hekimi
Çocuk doktoru	Matematik öğretmeni	Mimar	Sekreter	Mimar
İnşaat mühendisi	Mimar	Çocuk doktoru	Çocuk doktoru	Matematik öğretmeni

Verilen durumla ilgili aşağıdaki soruları cevaplayınız:

a) Böyle bir veri grubu elde etmeyi gerektiren bir araştırma sorusu oluşturunuz.

b) Bu veriler hangi veri toplama yöntemiyle elde edilmiş olabilir?

c) Bu verileri toplamak için katılımcılara sorulması gereken soruyu yazınız.

d) Meslek gruplarını karşılaştırmanıza yardımcı olacak en uygun grafiği çiziniz. Bu grafiği seçme nedeninizi açıklayınız.

e) Grafiğinizden meslek grupları hakkında çıkardığınız sonuçları yazınız.

D. TURKISH SUMMARY / TÜRKÇE ÖZET

YEDİNCİ SINIF ÖĞRENCİLERİNİN İSTATİSTİKSEL ARAŞTIRMA SÜRECİNİ ANLAMLANDIRMALARININ İNCELENMESİ

Sayısal bilgi her yerde olduğundan (Ben-Zvi & Garfield, 2008), bireyler gazete ve diğer medya kanallarıyla ekonomiden eğitime, sinemadan spora, mutfaktan tıpa birçok alanda istatistiksel bilgiyle sarmalanmış durumdadır (Franklin, et al, 2005). Hayatın tüm alanını kuşatan bu sayısal veriler sonuç çıkarma, kritik değerlendirmeler yapma ve karar vermede önemli bir yer tuttuğundan (Güven et al., 2015) bireylerin istatistiksel bilgiyi analiz edebilme ve bu bilgiden çıkarım yapabilme becerisine sahip olmaları gerekmektedir (Towsend, 2006). İstatistik bilimi ise bireylere çevrelerini sarmış durumda bulunan bu bilgileri anlamlandırmaları ve karar vermeleri için gerekli araçları sağlamaktadır. Bu sebepten ötürü, içinde bulunduğumuz yüzyılda tüm eğitim seviyelerinde istatistiksel becerilerin ve istatistiksel düşünmenin geliştirilmesi büyük öneme sahiptir (MacGillivary & Pereira-Mendoza, 2011).

İstatistik veri toplama ve işleme yoluyla verilerin ötesinde çıkarımlarda bulunabilmeyi sağlayan uygulamalı bir alandır (Holmes, 1997). Diğer bir deyişle, istatistik veri toplama ve anlamlandırma yoluyla gerçek dünyayı anlamaya çalışan bir araştırma sürecidir (Wild, 1994). İstatistik biliminin doğası ve günlük hayatta istatistik bilimine artan ihtiyaç (Reading, 2011), istatistiksel araştırma sürecini ve bu sürecin amacını anlamayı istatistik dersinin önemli hedefleri arasına katmıştır (Gal & Garfield, 1997). Öyle ki istatistik eğitiminin araştırma sürecinin tüm bileşenlerini içermesi gerektiği istatistikçiler ve istatistik eğitimcileri tarafından önemle vurgulanmaktadır (MacGillivray & Pereira-Mendoza 2011). Bu neden dolayı, istatistiksel araştırma süreci Türkiye'de dahil olmak üzere birçok ülkenin öğretim programlarına ve NCTM'in (National Council of Teachers of Mathematics, 2000) program standartlarına dahil edilmiştir (Makar & Fielding-Wells, 2011).

İlgili alan yazını incelendiğinde istatistiksel araştırma sürecinin farklı aşamalardan oluştuğu görülmektedir. Wild and Pfannkuch (1999) istatistiksel araştırma sürecini problem, plan, data, analiz ve sonuç olarak beş aşamaya ayırırken, bu modeli ve NCTM'in hedeflerini temel alan GAISE (2005) raporu ise bu süreci, problemi belirleme, veri toplama, veriyi analiz etme ve sonuçları yorumlama şeklinde dört aşamaya ayırmıştır. Öte yandan Marriott, Davies and Gibson'ın (2009) istatistiksel araştırma sürecini planı problem aşamasıyla birleştirerek problemi belirleme ve plan, veri toplama, veri işleme ve modelleme ve son olarak yorum ve tartışma olarak dört aşamaya ayırdığı görülmüştür. Graham (2006) ise bu süreci GAISE (2005) raporuna benzer şekilde problem oluşturma, veri toplama, analiz etme ve sonuçları yorumlama şeklinde dört aşama şeklinde tanımlamıştır. Genel olarak incelendiğinde istatistiksel araştırma sürecinin problemin belirlenmesi, verinin toplanması, analiz edilmesi ve yorumlanması şeklinde ilerlediği görülmektedir.

İlgili alan yazınında ayrıca öğrencilerin araştırma sürecinin farklı aşamalarındaki becerilerine ve deneyimlerine odaklanan araştırmaların yer aldığı görülmektedir. Bazı araştırmalar öğrencilerin verilen durumlara uygun araştırma problemi oluşturma becerilerine odaklanırken (Watson & English, 2016), bazıları verilen bir araştırma durumuna uygun anket soruları oluşturma becerilerine odaklanmıştır (English, 2014). Öte yandan, bazı araştırmaların çocukların veri toplama becerilerine odaklanırken (English & Watson, 2015a, 2015b; Watson & English, 2015) diğerlerinin öğrencilerin verileri analiz etme ve sonuçları yorumlama becerilerine odaklandıkları görülmüştür (Burgess, 2001; Burgess, 2002; Chick, 2000; Chick & Watson, 2001, Hotmanoğlu, 2014; Memnun, 2013). Fakat aynı anda öğrencilerin araştırma sürecinin tüm aşamalarındaki becerilerini inceleyen sınırlı sayıda araştırma olduğu görülmüştür (Güven et al, 2015; Watson & English, 2017). Bundan dolayı bu araştırmada araştırma sürecinin tüm aşamalarına odaklanarak, öğrencilerin araştırma sürecini anlamlandırmaları hakkında daha bütüncül bilgi sahibi olmak amaçlanmıştır.

Çalışmanın Amacı

Bu çalışmanın amacı yedinci sınıf öğrencilerinin istatistiksel süreci anlama seviyelerini incelemektir. Bu bağlamda öğrencilere gerçek veri kümeleri verilecektir çünkü öğrencilerin istatistiksel araştırma sürecine odaklanmaları için kendilerinin veri toplaması ya da kendilerine hazır veri verilmesi gerekmektedir (Friel, O'Connor, Mamer, 2006). Bu nedenle, bu çalışma öğrencilere gerçek veri kümeleri vererek, istatistiksel araştırma sürecini oluşturan problemi belirleme, veri toplama, veriyi analiz etme ve sonuçları yorumlama aşamalarının her birindeki anlama seviyelerini araştırmayı amaçlamaktadır.

Önemli Terimlerin Tanımları

İstatistiksel araştırma süreci: İstatistiksel araştırma süreci dört aşamadan oluşmaktadır. Bu bileşenler problemi belirleme, veri toplama, veriyi analiz etme ve sonuçları yorumlamadır (Franklin et al., 2005).

Problemi belirleme aşaması: Bu aşama problem durumunu belirlemeyi ve veri toplamayı gerektirecek sorular yazmayı gerektirmektedir (Franklin et al., 2005).

Bu çalışmada problemi belirleme aşaması verilen veri kümelerine uygun istatistiksel soru yazmayı anlatmaktadır.

Veri toplama aşaması: Bu aşama uygun veriyi toplamak için bir plan oluşturmayı ve bu planı uygulamayı gerektirmektedir (Franklin et al., 2005).

Bu çalışmada veri toplama aşaması verilen veri kümelerinin hangi toplama yöntemiyle toplanmış olduğuna karar vermek ve anket soruları yazmayı anlatmaktadır.

Veriyi analiz etme aşaması: Bu aşama veriyi analiz etmek için uygun grafiksel ve sayısal yöntemlerin seçilmesini ve kullanılmasını gerektirmektedir (Franklin et al., 2005).

Bu çalışmada veriyi analiz etme aşaması verilen durumlar için uygun grafik türlerini seçeme ve çizmeyi anlatmaktadır.

Sonuçları yorumlama aşaması: Bu aşama analizleri yorumlamayı ve bu yorumları başlangıçtaki soruyla ilişkilendirmeyi gerektirmektedir (Franklin et al., 2005).

Bu çalışmada sonuçları yorumlama aşaması yapılan analizlerden sonuç çıkarmayı anlatmaktadır.

Gerçek veri kümesi: Gerçek veri kümeleri öğrencilere veriyi işleyebilmeleri için oluşturacakları problemlere bir bağlam sağlar. (Neumann, Hood, & Neumann, 2013).

Bu çalışmada gerçek veri kümeleri gerçek hayattan alınmış veri kümelerini anlatmaktadır.

Yöntem

Çalışma Deseni

Fraenken, Wallen ve Hyun (2012) bir popülasyonun beceri veya bilgi gibi belirli yönlerinin veya özelliklerinin betimlenmesinde tarama tipi araştırma çalışmalarının oldukça faydalı olduğunu belirtmiştir. Bu doğrultuda, yedinci sınıf öğrencilerinin istatistiksel araştırma sürecini anlamlandırmalarını incelemek amacıyla tarama tipi araştırma deseni kullanılmıştır. Ayrıntılı olarak bu çalışma seçilen örneklemden gerekli veriyi tek seferde toplamayı gerektirdiğinden araştırmanın deseni kesitsel tarama olarak belirlenmiştir. Öğrencilerin testteki sorulara sundukları cevaplar öğrencilerin problemi belirleme, veri toplama, veriyi analiz etme ve sonuçları yorumlama aşamaları ile ilgili anlama seviyelerini, hatalarını ve zorluklarını belirlemek amacıyla derinlemesine incelenmiştir.

Katılımcılar

Bu çalışmada örneklem uygun örnekleme yöntemi kullanılarak belirlenmiştir. Bu bağlamda çalışmanın örneklemini 2017-2018 öğretim yılında İstanbul'un Pendik ilçesinde bir devlet okulunda öğrenim gören 121 (68 kız ve 53 erkek) 7. sınıf öğrencisi oluşturmaktadır.

Veri Toplama Aracı

Çalışmanın verileri araştırmacı tarafından hazırlanan İstatistiksel Araştırma Süreci Testi (İAST) ile toplanmıştır.

İstatistiksel Araştırma Süreci Testi

Yedinci sınıf öğrencilerinin istatistiksel araştırma sürecini anlamlandırmalarını incelemek için araştırmacı tarafından 4 açık uçlu sorudan oluşan İstatistiksel Araştırma Süreci Testi (İAST) hazırlanmıştır. Soruların iki tanesi ilgili alan yazınından adapte edilmiş iki tanesi ise araştırmacı tarafından hazırlanmıştır. Testin hazırlanma sürecinde ortaokul matematik dersi öğretim programında yer alan araştırma süreci ile ilgili kazanımlar göz önünde bulundurulmuştur. Ayrıca GAISE'nin (2005) dört bileşenden oluşan istatistiksel araştırma sürecinin teorik çerçevesi soruların hazırlanmasında göz önüne alınmıştır. Bu bağlamda, verilen durumlara uygun araştırma sorularının oluşturulması, veri toplama yöntemine karar verilmesi, anket sorusu hazırlanması, verilen durumlara uygun grafik çizilmesi ve grafiklerin yorumlanması ile ilgili sorular hazırlanmıştır. Test hazırlandıktan sonra iki uzman görüşü alınmış ve yirmi 8. sınıf öğrencisiyle pilot çalışma yapılmıştır. Pilot çalışma sonucunda, verilen 80 dakika sürenin yetersiz olduğuna sonucuna varılmış ve testin tamamlanması için gerçek uygulamada 120 dakika sürenin verilmesine karar verilmiştir. Ayrıca 'Yaz Tatili' sorusunda verilen bir aylık sıcaklık değerinin tamamının grafikte gösterilmesinin zor olduğu gözlenmiş ve öğrencilerin çoğunun ilk

15 günü grafikte gösterdikleri fark edilmiştir. Bundan dolayı gerçek çalışmada ilk 15 günün sıcaklık değerleri verilmiştir. Buna ek olarak pilot çalışmadaki 20 öğrencinin cevapları araştırmacı ve matematik eğitimi doktora öğrencisi olan ikinci kişi tarafından hazırlanan dereceli puanlama anhatarına göre değerlendirilerek sonuçların güvenilirliği test edilmiştir. Cronbach alpha güvenilirlik katsayısı .99 olarak bulunmuştur.

Verilerin Analizi

Öğrencilerin istatistiksel araştırma sürecini anlamlandırmalarının belirlenmesi için öğrencilerin hazırlanan teste verdiği cevaplar derinlemesine incelenmiştir. Öğrencilerin testteki sorulara verdiği cevaplara ve ilgili alan yazınına göre belirlenen dereceli puanlama anahtarında, istatistiksel araştırma sürecinin farklı bileşenleri için farklı kodlama sistemleri kullanılmıştır.

İstatistiksel araştırma sürecinin ilk bileşeni araştırma sorularının yazılmasıdır. Bu bileşene ilişkin cevaplar 0 ile 2 arasında kodlanmıştır. Buna göre veri toplamayı gerektiren sorular 2; veri toplamayı gerektirmeyen sorular 1; alakasız ve boş bırakılan cevaplar 0 olarak kodlanmıştır.

Araştırma sürecinin ikinci bileşeni veri toplamadır. Veri toplama bileşeni veri toplama yöntemine karar verilmesi ve anket soruları oluşturma olarak iki kısımda ele alınmıştır. Veri toplama yöntemini belirleme kısmına ilişkin cevaplar 0 ile 1 arasında kodlanmıştır. Verilen veri setlerine uygun veri toplama yöntemlerini belirten cevaplar 1, yanlış yöntemler ve boş bırakılan cevaplar 0 olarak kodlanmıştır. Anket sorusu hazırlama kısmına ilişkin cevaplar 0 ile 2 arasında kodlanmıştır. Buna göre veri grubunu elde etmeyi sağlayacak açık ve anlaşılır sorular 2; açık ve net olamayan sorular 1; boş bırakılan cevaplar 0 olarak kodlanmıştır.

Araştırma sürecinin üçüncü bileşeni verilerin analiz edilmesidir. Verilerin analiz edilmesi verilen durumlara uygun grafiklerin seçilmesini ve çizilmesini içermektedir.

Öğrencilerin veri türüne ve sorularda verilen amaca uygun grafik seçme becerileri 0 ile 3 arasında kodlanmıştır. Buna göre, karşılaştırma gereken durumlarda hem veri türüne hem de karşılaştırma amacına uygun grafikler 3; karşılaştırma gereken durumlarda veri türü veya karşılaştırma amacının birisine uygun grafikler ve karşılaştırma gerekmeyen durumlarda veri türüne uygun grafikler 2; karşılaştırma gereken durumlarda hem veri türü hem de karşılaştırma amacına uygun olmayan grafikler ve karşılaştırma gerekmeyen durumlarda veri türüne uymayan grafikler 1; boş cevaplar ise 0 olarak kodlanmıştır. Ayrıca öğrencilerin seçtikleri grafikleri doğru inşa etme becerilerini 0 hariç tüm seviyelerdeki grafikler yapısal özellikleri dikkate alınarak 2 kısma ayrılmıştır. Örneğin karşılaştırma amacına ve veri türüne uygun seçilen bir grafik doğru çizildiyse 3.1 olarak fakat çiziminde hatalar yapıldıysa 3.0 olarak kodlanmıştır.

Araştırma sürecinin son bileşeni sonuçların yorumlanmasıdır. Öğrencilerin yorumları Friel, Curcio ve Bright' ın (2001) çalışmaları temel alınarak 0 ile 3 arasında kodlanmıştır. Öğrencilerin grafikte açıkça sunulmayan ilişkileri irdeleyen, değişkenler arası ilişkiler hakkında çıkarımlarda bulunan verilerin ötesini okuma seviyesindeki yorumları 3 (ileri seviye); verilerin karşılaştırılması, grafikte sunulan bilgilerin birleştirilmesini veriler arasını okuma seviyesindeki yorumları 2 (orta seviye); grafikte açıkça sunulan bilgileri tespit eden verileri okuma seviyesindeki yorumları 1 (başlangıç seviyesi); boş bırakılan cevaplar 0 olarak kodlanmıştır.

Bulgular ve Tartışma

Bu araştırmanın amacı yedinci sınıf öğrencilerinin istatistiksel araştırma sürecini anlama seviyelerinin incelenmesidir. Bu nedenle bulgular istatistiksel araştırma sürecinin her bir bileşenine karşılık olarak dört başlık altında sunulacaktır.

Problem Oluşturma Aşamasına ait Bulgular

İstatistiksel araştırma sürecinin ilk aşaması araştırma sorularının oluşturulmasıdır. Bu çalışmada öğrencilerin araştırma sorusu yazma seviyelerinin belirlenmesi amaçlanmıştır. Öğrenci cevapları incelendiğinde öğrencilerin araştırma sorusu yazma konusunda seviyelerinin genel olarak 2 olduğu görülmüştür. Diğer bir deyişle, öğrencilerin neredeyse yarsının verilen durumlara uygun araştırma sorusu oluşturabildiği görülmüştür. Bu durum öğrencilerin araştırma sorusu oluşturma konusundaki bilgilerinin kalıcı olduğu şeklinde yorumlanabilir çünkü beşinci ve altıncı sınıf matematik müfredatında araştırma sorusu oluşturulması ile ilgili kazanımlar bulunurken yedinci sınıfta araştırma sorusu oluşturulması ile ilgili herhangi bir kazanım bulunmamaktadır (MoNE, 2018).

Öğrencilerin çoğunlukla iki veri grubunu karşılaştırmayı gerektiren ya da bir veri grubundaki en popular ya da en çok tercih edilen şeyleri soran araştırma soruları yazdıkları görülmüştür. Bu durum öğrencilere verilen senaryolarla ilgili olabilir. 'Yaz Tatili' ve 'Batarya Ömürleri' sorusunda öğrencilerden kendilerine verilen iki veri grubunu karşılaştırmaları gerektiğinden bu sorularda öğrencilerin verilen veri gruplarını karşılaştırmayı gerektiren araştırma soruları yazdıkları görülmüştür. Öte yandan 'Meslek Grupları' sorusunda öğrencilerin hayallerindeki meslek gruplarından oluşan bir veri grubu verildiğinden öğrencilerin en çok tercih edilen meslek gibi veri grubunu özetlemeyi gerektiren araştırma soruları yazdıkları görülmüştür.

'Kişi Özellikleri' sorusunda öğrencilerden herhangi bir yönlendirme yapılmadan kendilerine ilginç gelen herhangi bir özelliği incelemelerini gerektirecek bir araştırma sorusu yazmaları istenmiştir. Öğrencilerin yine en çok tercih edilen ya da en yaygın özellikleri soran ya da iki veri grubunu karşılaştırmayı gerektiren araştırma soruları oluşturmayı tercih ettikleri görülmüştür. Bu soruda öğrencilerin çok azının (5 öğrenci) iki ya da daha fazla değişken arasında ilişki kurmayı gerektiren araştırma soruları oluşturdukları görülmüştür. Bu durum ortaokul matematik müfredatıyla ilgili olabilir. Ortaokul matematik müfredatında bir veri grubunda en çok tercih edilen veya en yaygın özellikleri soran veya iki farklı veri grubunu karşılaştırmayı gerektiren

araştırma soruları oluşturmayla ilgili kazanımlar bulunurken, iki ya da daha fazla değişken arasında bağlantı kurmayı gerektirecek araştırma soruları oluşturmayla ilgili kazanım bulunmamaktadır (MoNE, 2018).

Öte yandan, bazı öğrencilerin veri toplamayı gerektirmeyen örneğin 'Yalçın Bakar'ın kilosu kaçtır?' gibi tek bir kişi hakkında soran sorular yazdıkları görülmüştür. Bu durum daha önce Hacısalihoğlu-Karadeniz'in (2016) belirttiği gibi öğrencilerin bir sorunun neden araştırma sorusunun olduğu konusunda bir fikirlerinin olmamasından kaynaklanıyor olabilir.

Bir grup öğrencinin araştırma sorusu yerine 'Hayalinizdeki meslek hangisidir?' gibi anket sorusu yazdıkları görülmüştür. Bu durum öğrencilerin araştırma sorusu ve anket sorusu ararsındaki farkı bilmemelerinden kaynaklanıyor olabilir.

Öte yandan öğrencilerin yaklaşık üçte birinin soruları boş bıraktıkları ya da 'Anket yapılmalı' gibi araştırma sorusuyla alakasız cevaplar verdikleri görülmüştür. Bu durum öğrencilerin araştırma sorusunun ne olduğunu bilmemelerinden kaynaklanıyor olabilir.

Veri Toplama Aşamasına ait Bulgular

İstatistiksel araştırma sürecinin ikinci aşaması veri toplamadır. Bu aşama veri toplama yöntemlerinin belirlenmesi ve anket sorusu oluşturma şeklinde iki kısımdan oluşmaktadır.

Öncelikle veri toplama yönteminin belirlenmesine ilişkin cevaplar incelendiğinde öğrencilerin çok büyük bir kısmının veri gruplarının hangi veri toplama yöntemiyle elde edildiğini bilmediklerini göstermiştir. Öyle ki öğrencilerin istatistiksel araştırma sürecinde en çok zorlandıkları ve en yabancı oldukları kısım veri toplama yöntemine karar vermektir. Ortaokul matematik müfredatında istatistiksel araştırma sürecinin en az vurgulanan kısmının veri toplama yöntemleri olduğu düşünüldüğünde bu durum şaşırtıcı değildir.

Öğrencilerin veri toplama yönteminin belirlenmesi kısmındaki genel başarısızlıklarının yanı sıra öğrencilerin anket yöntemini belirlemede daha başarılı, deney yöntemini belirlemede ise daha başarısız oldukları görülmüştür. Bu durum anket yönteminin matematik müfredatında en çok vurgulanan veri toplama yöntemi olması ile ilgili olabilir.

Öte yandan öğrencilerin büyük çoğunluğunun veri toplama yöntemi soran sorulara, aritmetik ortalama, medyan, mod gibi cevaplar verdikleri görülmüştür. Bu durum öğrencilerin merkezi eğilim ölçülerinin isimlerini bilip, nerede ve ne amaçla kullanıldıkları hakkında bilgi eksikliklerinin olduğunu göstermektedir. Bu sonuç öğrencilerin ne zaman ortalama hesaplayıp kullanacakları konusunda bilgilerinin yetersiz olduğunu söyleyen Enisoğlu' nun (2014) çalışmasıyla paralellik gösterirken, öğrencilerin medyan kavramını anladıklarını söyleyen Bush ve diğerlerinin (2015) çalışmasıyla zıtlık göstermektedir. Bu sonuç zaman kısıtlılığından dolayı merkezi eğilim ölçülerinin kavramlarının ve kullanım amaçlarının derslerde yeterince vurgulanmamasından kaynaklanıyor olabilir.

Veri toplama bileşeninin ikinci kısmı anket soruları oluşturmaktır. Bu nedenle anket yapmayı gerektiren veri gruplarında öğrencilerden anket soruları yazmaları istenmiştir. Öğrencilerin cevapları incelendiğinde öğrencilerin araştırma sorusu yazma konusunda seviyelerinin genel olarak 2 olduğu görülmüştür. Öyle ki öğrencilerin araştırma sürecinde en başarılı oldukları kısım anket sorusu oluşturma kısmıdır. Bu sonuç öğrencilerin araştırma sorularını cevaplamak için anlaşılır anket soruları yazmakta güçlük çektiğini belirten English'in (2014) çalışmasıyla çelişki oluşturmaktadır. Bu durum katılımcıların sınıf seviyeleriyle alakalı olabilir. Bu çalışmanın katılımcıları 7. sınıf seviyesinde iken English'in (2014) çalışmasının katılımcıları 3. sınıf seviyesindedir. Ülkemizin ortaokul matematik müfredatında 5. sınıf seviyesinde anket sorusu oluşturma ile ilgili kazanımlar yer alırken, diğer araştırmanın yapıldığı ülkenin matematik müfredatında 3. sınıf seviyesinde veya öncesinde anket sorusu oluşturma ile ilgili herhangi bir kazanım yer almıyor olabilir.

Öte yandan, öğrencilerin sadece %35'inin anketi veri toplama yöntemi olarak belirtirken %65'inin veri grubuna uygun anket soruları oluşturabildiği görülmüştür. Bu durum öğrencilerin 'anket' kavramını bilmeseler de anket sorusu oluşturabildiklerini göstermiştir. Diğer bir deyişle, öğrencilerin bir veri grubunu toplamak için katılımcılara soruması gereken soruların farkında iken bu soruların anket sorusu olduğunun farkında olmadıkları gözlenmiştir.

Verilerin Analizi Aşamasına ait Bulgular

İstatistiksel araştırma sürecinin üçüncü aşaması verilerin analiz edilmesidir. Bu çalışmada öğrencilerin grafik çizme seviyelerinin belirlenmesi amaçlanmıştır. Öğrenci cevapları incelendiğinde birinci soru hariç öğrencilerin üçte birinin grafik çizmedikleri gözlemlenmiştir. Öyle ki son soruya ilerledikçe grafik çizmeyen öğrencilerin oranının arttığı görülmüştür. Bu durum öğrencilerin yorulmuş oldukları için son sorularda grafik çizmek istememelerinden ya da verilen süreyi doğru kullanmadıkları için soruları yetiştirememelerinden kaynaklanmış olabilir.

Öte yandan öğrencilerin iki veri grubunu karşılaştırmaları gereken durumlarda öğrencilerin hem karşılaştırma amacına hem de veri türüne uygun grafik türünü seçmekte zorlandıkları görülmüştür. Bu sonuç ilgili alan yazınındaki çalışmalarla paralellik göstermektedir (Burgess, 2001; Güven et al., 2015). Bu durum öğretmenlerin derslerde hangi durumlar için hangi grafik türlerinin uygun olduğu konusuna yeterince vurgu yapmamalarından kaynaklanmış olabilir. Diğer bir yandan öğrencilerden verilen duruma uygun grafiği seçip verileri düzenlemelerini istemek yerine 'Sütun grafiği çiz. Çizgi grafiği çiz.' gibi yönlendirmelerle hangi grafikleri çizecekleri söylenmiş olabilir. Bu durumda öğrenciler düşünmeden sadece yönergeleri takip ettikleri için hangi durumda hangi grafik türünün uygun olduğuna kendi başlarına karar vermekte zorluk yaşıyor olabilirler.

Ayrıca öğrencilerin sütun grafiği çizmeyi çizgi grafiği ve daire grafiği çizmekten daha çok tercih ettikleri gözlemlenmiştir. Bu sonuç ortaokul matematik müfredatıyla

ilgili olabilir. Müfredatta sütun grafiği çizme ile ilgili 5., 6. ve 7. sınıf seviyelerinde kazanımlar bulunurken, çizgi grafiği ve daire grafiği çizme ile ilgili sadece 7. sınıf seviyesinde kazanımlar yer almaktadır. Bu durumda öğrencilerin sütun grafiğine daha alışkın oldukları aşikardır. Bu sütun grafiğine daha alışkın olma durumu öğrencilerin diğer grafiklere göre sütun grafiğini çizmeyi daha kolay bulmalarında etkili olmuştur (Kranda & Akpınar, 2019). Diğer bir deyişle, öğrenciler daha kolay buldukları için sütun grafiği çizmeyi daha çok tercih etmiş olabilirler.

Duruma uygun grafik türünün seçilmesindeki başarısızlığın yanı sıra, grafiklerin yapısal özelliklerinin de hatalar gözlemlenmiştir. Birçok grafikte Burgess'in (2001) çalışma sonuçlarına benzer şekilde eksen isimlerinin ve başlığın yazılmadığı görülmüştür. Bu durum dikkatsizlikten ya da öğrencilerin bunları yazmanın önemini kavrayamamış olmasından kaynaklanıyor olabilir.

Öğrencilerin grafik çiziminde sık yaptıkları diğer bir hata eksenlerin yanlış numaralandırılmasıdır. Öğrenciler verilen değerleri küçükten büyüğe bir sıralama gözetmeksizin eksenlere yerleştirmişlerdir. Bu durumda sürekli artan grafikler veya sürekli azalan grafikler elde etmişlerdir. Ayrıca bir grup öğrencinin '0'ın yerini bilmediği görülmüştür. Bu sonuçlar Güven ve diğerlerinin (2015) sonuçlarıyla benzerlik göstermektedir. Bu durum öğrencilerin koordinat sistemi konusundaki bilgi eksikliklerinden kaynaklanmış olabilir. Öğrenciler koordinat sisteminin nasıl numaralandırılacağını yeterince öğrenememiş olabilirler.

Eksenleri yanlış numaralandırmanın yanı sıra öğrencilerin sıralı ikilileri çizgilerle birleştirirken hata yaptıkları gözlemlenmiştir. Öyle ki öğrenciler sırayı göz ardı ederek noktaları kendilerine en yakın noktalarla birleştirmişlerdir. Hotmanoğlu'nun (2014) araştırmasının sonuçlarıyla benzerlik içinde olan bu sonuç öğrencilerin noktaları birbirine nasıl bağlayacaklarını unutmalarından kaynaklanmış olabilir (Kranda & Akpınar, 2019).

Diğer yandan bazı öğrencilerin grafiklerinde tüm veri grubunu göstermedikleri ya da verilerin sıklıklarının yanlış gösterildiği gözlemlenmiştir. Öğrenciler özellikle 'Meslek Grupları' sorusunda mesleklerin tercih edilme sıklıklarını yanlış

belirtmişlerdir. Bu durum soruda 30 öğrenci tarafından seçilen 14 farklı mesleğin verilmesinden kaynaklanmış olabilir. Öğrenciler dikkatsizlik sonucu bazı mesleklerin seçilme sıklıklarını sayarken yanlışlıklar yapmış olabilirler.

Diğer yandan öğrencilerin daire dilimlerinin büyüklüklerini belirlerken sıkıntı yaşadıkları görülmüştür. Öyle ki öğrencilerin daire dilimlerinin merkez açılarını hesaplamadan dilimler çizip, kategoriler arasındaki orana dikkat etmeksizin daire dilimlerinin üzerine sadece kategorilerin isimlerini yazdıkları görülmüştür. Bu durum öğrencilerin orantı konusundaki eksikliklerinden kaynaklanıyor olabilir. Öte yandan öğrencilerin genel olarak 'Meslek Grupları' sorusunda daire grafiği çizdikleri görülmüştür. Bu soruda toplamda 14 tane meslek grubu verildiğinden her bir mesleğin merkez açılarını hesaplamak zaman kısıtlamasından dolayı hesaplanamamış olabilir. Ayrıca çok fazla meslek grubu olduğundan bunların her birinin arasındaki oranı tahmin etmekte zor olmuş olabilir.

Öte yandan az sayıda öğrencinin özellikle 'Meslek Grupları' sorusunda grafik yerine tablo çizdikleri gözlemlenmiştir. Bu soruda verilen 14 meslek grubunu aynı grafik üzerinde göstermek zor olacağından öğrenciler tablo çizmeyi tercih etmiş olabilirler.

Sonuçların Yorumlanması Bileşenine ait Bulgular

İstatistiksel araştırma sürecinin son bileşeni sonuçların yorumlanmasıdır. Bu çalışmada öğrencilerin cevapları incelendiğinde sonuçları yorumlama konusunda seviyelerinin genel olarak 2 veya 3 olduğu görülmüştür.

Öğrencilerin karşılaştırma gerektiren iki veri setinden oluşan durumlarda genelde 3. seviyede yorumlar yaparlarken, bir veri grubunu özetlemeyi gerektiren durumlarda 2. seviyede yorumlar yapmışlardır. Bu durum katılımcıların genelde grafikte direk verilen bir özellik ya da sıklık hakkında 1. seviyede yorumlar yaptıklarını belirten Burgess'in (2001) çalışmasıyla farklılık göstermektedir. Bu durum derslerde yapılan aktivitelere bağlı olabilir. Dersin öğretmeni verileri karşılaştırmayı gerektiren ve ya

birden fazla değişkeni incelemeyi gerektiren etkinlikler hazırlamış ve buna bağlı olarak öğrencilerde daha yüksek seviyede yorum yapmayı öğrenmiş olabilirler.

Ayrıca testin sonuna gittikçe yorum yapmayan öğrenci sayısında artış olduğu görülmüştür. Bu durum öğrencilerin yorulmuş oldukları için son sorularda yorum yapmak istememelerinden ya da verilen süreyi doğru kullanmadıkları için soruları yetiştirememelerinden kaynaklanmış olabilir.

Öte yandan tüm seviyelerde yapılan yorumlar incelendiğinde öğrencilerin genelde doğru yorumlar yaptıkları görülmüştür. Tüm sorular incelendiğinde en fazla yanlış yorumun 'Meslek Grupları' sorusunda yapıldığı gözlemlenmiştir. Bu durum dikkatsizlik sonucu 14 meslek grubunu sıklıklarının yanlış sayılmasından kaynaklanmış olabilir.

Öneriler

Bu çalışmada uygun örnekleme yöntemi kullanılmış olduğundan bulguların diğer yedinci sınıf öğrencilerine genellenebilmesi için seçkisiz örnekleme yöntemi kullanılarak belirlenen katılımcılarla tekrarlanabilir. Aynı zamanda ortaokul öğrencileri ile yapılacak olan boylamsal çalışmalar öğrencilerin istatistiksel araştırma sürecini anlamlandırmalarının zaman içerisinde gelişip gelişmediğini göstermesi açısından faydalı olabilir. Ayrıca bu çalışma devlet okulu öğrencileri ile yapıldığından dolayı özel okul öğrencileri ile yapılacak çalışmalar okul türünün öğrencilerin istatistiksel süreci anlama seviyeleri üzerindeki etkisini gösterebilir. Öte yandan bu çalışmanın bulguları İAST'deki sorular ile sınırlıdır. Benzer çalışmalar farklı testler geliştirilerek tekrarlanabilir.

Son olarak, öğrencilerin istatistiksel araştırma sürecindeki hatalarının ve zorluklarının sebepleri incelenebilir. Bu çalışmalar öğrenciler ile yapılacak klinik görüşmelerle desteklenebilir. Klinik görüşmeler öğrencilerin düşünme süreçlerinin

derinlemesine incelenmesine olanak sağlayabileceğinden bu görüşmeler sayesinde istatistiksel araştırma sürecinin anlamlandırılması daha detaylı bir şekilde incelenebilir ve bu görüşmeler öğrencilerin bu süreçteki hata ve zorluklarının muhtemel sebeplerini ortaya çıkarabilir.

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