EXAMINING THE STUDENTS' STATISTICAL LITERACY CONCERNING THE REPRESENTATION AND ANALYSIS OF THE DATA AND INTERPRETATION OF THE RESULTS

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ABSTRACT

EXAMINING THE STUDENTS' STATISTICAL LITERACY CONCERNING THE REPRESENTATION AND ANALYSIS OF THE DATA AND INTERPRETATION OF THE RESULTS

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Statistical literacy is inevitable for conscious citizenship and adjusting to the fast-developing world. Students should be able to represent and analyze data and interpret the results before graduating from middle school (Ministry of National Education, 2018). Therefore, the study aims to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. The data were collected from 248 eight grade students in different regions of Turkey, including Ankara, Kars, Kayseri, and Istanbul, with convenience sampling. The open-ended survey consisted of a contextual task and twelve questions related to the Covid-19 pandemic and daily diet. The questions were prepared by considering the national curriculum objectives of the Turkish mathematics curriculum (2018) and the National Council of Teachers of Mathematics standards (2000). Data were analyzed with the four-stage framework of Sharma, Doyle, Shandil, and Talakia'atu (2011). Since relational thinking is first expected in level 3, the levels are categorized such that the first two are in the low statistical literacy category, and the last two are in the high statistical literacy category. The results show that in the COVID-19 task, 98.39% of students were found to have low-level statistical literacy, while 1.61% were found to have high-

level statistical literacy. In the daily diet task, 91.53% of the students were found to have low-level statistical literacy, while 8.47% had high-level statistical literacy.

Keywords: Statistical Literacy, Representation and Analysis of the Data, Interpretation of Results, Contextual Tasks

ÖZ

ÖĞRENCİLERİN İSTATİSTİKSEL OKURYAZARLIK BAĞLAMINDA VERİLEN VERİLERİ TEMSİL VE ANALİZ ETME VE SONUÇLARI YORUMLAMA BECERİLERİNİN İNCELENMESİ

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Bilinçli vatandaşlık ve hızla gelişen dünyaya uyum sağlamak için istatistik okuryazarlığı kaçınılmazdır. Öğrenciler ortaokuldan mezun olmadan önce verileri temsil ve analiz edebilmelidir, ayrıca sonuçları da yorumlayabilmelidir (Milli Eğitim Bakanlığı, 2018). Bu nedenle çalışma, son iki istatistiksel süreç bileşenini, verilerin temsili ve analizi ve sonuçların yorumlanması, kullanarak Türkiye'nin farklı bölgelerindeki okullarda okuyan sekizinci sınıf öğrencilerinin aşina olmadığı COVID-19 gibi ve aşina olduğu günlük beslenme gibi gerçek yaşam bağlamlarına ilişkin istatistiksel okuryazarlık düzeylerini araştırmayı amaçlamaktadır. Veriler Türkiye'nin Ankara, Kars, Kayseri ve İstanbul gibi farklı bölgelerindeki 248 sekizinci sınıf öğrencisinden kolay ulaşılabilir durum örneklemesi ile toplanmıştır. Açık uçlu anket, Covid-19 salgını ve günlük diyetle ilgili on iki sorudan oluşmuş ve sorular Türk matematik müfredatının (2018) ulusal müfredat hedefleri ve Ulusal Matematik Öğretmenleri Konseyi standartları (2000) dikkate alınarak hazırlanmıştır. Veriler, Sharma, Doyle, Shandil ve Talakia'atu'nun (2011) dört aşamalı çerçevesi ile analiz edilmiştir. İlişkisel düşünme ilk olarak 3. seviyede beklendiği için seviyeler ilk ikisi düşük istatistik okuryazarlığı kategorisinde, son ikisi yüksek istatistik

okuryazarlığı kategorisinde olacak şekilde kategorize edilmiştir. Sonuçlar, COVID-19 görevinde öğrencilerin yüzde 98,39'unun düşük düzeyde istatistik okuryazarlığına sahip olduğu, yüzde 1,61'inin ise yüksek düzeyde istatistik okuryazarlığına sahip olduğunu göstermektedir. Günlük diyet etkinliğinde öğrencilerin yüzde 91,53'ünün düşük düzeyde istatistiksel okuryazarlığa sahip olduğu, yüzde 8,47'sinin ise yüksek düzeyde istatistik okuryazarlığına sahip olduğu tespit edilmiştir.

Anahtar Kelimeler: İstatistiksel Okuryazarlık, Verilerin Temsil ve Analizi, Sonuçların Yorumlanması, Bağlamsal Etkinlikler

To My Family and My Relentless Pillar

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LIST OF ABBREVIATIONS

ABBREVIATIONS

GAISE	Guidelines and Assessment for Statistics Education Report
M	Mean
MoNE	Ministry of National Education
N	Number of Participants
NCTM	National Council of Teachers of Mathematics
OECD	Organization for Economic Co-Operation and Development
SD	Standard Deviation
SLT	Statistical Literacy Task
SOLO	Structure of Observed Learning Outcomes

CHAPTER 1

INTRODUCTION

Countless decisions are made about various topics such as politics, economy, health, and education on a daily basis (Halpern, 1997). Wallman (1993) stated that individuals encounter statistical information and rely on it when they make decisions. Moreover, the advancement of technology and the increasing prevalence of the Internet have made it significantly easier for individuals to access the information they require in a more convenient manner (Ceaparu, 2003). The ability to easily obtain the necessary information is undoubtedly an advantage of the modern world. However, with an overflow of information, individuals are susceptive to wrong and misleading information from sources (Ben-Zvi & Garfield, 2004; Gal, 2004). Therefore, the contemporary world is much more complex and deceptive for people who lack statistical literacy. People need to be statistically literate to understand statistical information and make rational decisions (Towsend, 2006; Wallman, 1993). The significance of statistical literacy becomes apparent as a result of this requirement.

Gal (2004) advocates that as it is crucial for individuals to interpret and critically evaluate statistical claims, statistical literacy is prominent in becoming an active citizen and developing healthy communication through statistical messages. According to Towsend (2006) and Wallman (1993), adequate statistical literacy is necessary to make reasonable decisions and analyze the associated risks. Using an illustrative example like the recent COVID-19 pandemic, governments expected citizens to be vaccinated, taking the well-being of themselves and the society into consideration. Conscious citizens should make the vaccination decision by analyzing the data on vaccines such as the associated risks, the sample size, and the protection

percentage. The associated skill of interpreting the analysis results is an essential part of statistical literacy.

Apart from the added benefits to daily life and becoming a conscious citizen, the steps of scientific research are also based on a data set, analysis, and interpretation. Therefore, statistics is a notable tool in scientific research in many fields. Yet again, this use of statistical literacy can be exemplified through COVID-19. From the perspective of scientists and doctors, statistical literacy is used when conducting experiments, collecting data, and representing the results the way ordinary statistically literate people understand. For these results to be understood, a society with high statistical ability is required since the critical evaluation of represented information is gained through achieving statistical literacy (Rumsey, 2002).

On the other hand, statistical literacy means more than just understanding the representation of statistical information. It also includes the ability to separate correct information from misleading information by actively representing, analyzing, and evaluating statistical statements (Gal, 2004; Watson, 2006). According to Baesler (1997), statistical arguments are more persuasive than developing a narrative argument. Thus, companies use statistics, regardless of their accuracy, to convince people through advertisements and media (GAISE, 2007). These companies aim to promote their businesses and convince people to purchase their products or services while using statistical information to deem their suggestions more credible (Ben-Zvi & Garfield, 2004). Thus, a conscious individual needs to be able to critically evaluate the statistical information after understanding and analyzing the suggestion (Gal, 2004; Watson, 2006).

As it is now established, detecting the misleading information one may be subject to is critical. Considering the nature of children, they need more protection than adults regarding misleading information. Yolcu (2014) stated that statistical displays could deceive people; therefore, teachers and parents should be aware of statistical misrepresentation that might exist in the media and cooperate to protect students. However, it is fair to assume that monitoring every piece of information the student

can be exposed to is impossible. In addition to the impossibility of constantly monitoring students, it is crucial for children to be independent and self-confident, to separate correct information from misleading ones, and to make wise decisions autonomously. Statistical literacy is necessary to achieve these tasks and to be an independent, confident, and conscious citizen. Gaining statistical literacy skills as early as possible is vital (GAISE, 2007).

Although being statistically literate at an early age is crucial, it has a short history in mathematics education research (Gal, 2004). After Watson mentioned how important it was for an individual to be statistically literate at an early age in 1997, the number of studies about statistical literacy started to increase. Watson (1997, p.2) constructed a three-tiered framework. These tiers for statistical literacy are: "a basic understanding of probabilistic and statistical terminology", "an understanding of probabilistic and statistical language and concepts when they are embedded in the context of wider social discussion", and "a questioning attitude which can apply more sophisticated concepts to contradict claims made without proper statistical foundation".

Watson and Callingham later reformed this three-tiered hierarchical framework of statistical literacy. They separated these three tiers into six hierarchical steps, which are "idiosyncratic", "informal", "inconsistent", "consistent non-critical", "critical", and "critical mathematical" (Watson & Callingham, 2003, p.14). These levels resolve the pre-existent contradiction in the tiers and make them more understandable.

Gal (2004) also stated that knowledge and dispositions should be considered for statistical literacy, and that having a positive attitude and inclination towards statistics is crucial for incorporating the thinking process of statistics into one's daily life.

This study was followed by the work of Sharma in 2011, who constructed a four-stage framework taking Watson and Callingham's six-hierarchical level statistical literacy framework as a basis to help teachers scaffold their students' thinking

(Sharma, 2017). Sharma thought that reforming the six-hierarchical framework to a four-stage one would be more beneficial for teachers because it contributes to pedagogical teaching and reinforces the learning of statistical concepts. The four-stage framework of statistical literacy was prepared considering Gal's statistical literacy model (Sharma, 2017). Following the aforementioned studies that aimed to identify an appropriate approach for teaching statistical concepts to students, there is an ongoing emphasis on research related to statistical literacy.

Subsequent to the increasing literature in the respective area, the concept of statistics has been included in the curricula of many countries. Cooper (2002) stated that the need for students to possess competence in statistical thinking increases the significance of statistics education in schools. Thus, when the curricula of middle and high schools are prepared, statistical literacy should be considered and prioritized (Gal, 2004). Many curricula and educational programs from countries such as Australia and the United States included statistical literacy and probability concepts to increase the number of conscious and rational decision-makers. These steps increase students' awareness and statistical literacy level. Additionally, their interpretation and critical evaluation skills can be developed by detecting misleading information, assessing it, and developing an attitude toward it (2021 Update on the Indicator for Statistical Literacy, 2021).

Turkey included statistics and probability concepts in the mathematics curricula for the first time in 2005 (Batur et al., 2021). Observing the objectives of the curricula of Turkey, it can be seen that the first graders should be able to collect data, analyze displays and discuss statistical concepts with other students. The students who graduate from middle school should be able to interpret displays belonging to three data sets and transform them among the displays. In other words, eight grade students are expected to be able to formulate a research question, collect data with an appropriate method, represent and analyze the data set, interpret the results, and make rational decisions according to the results (Ministry of National Education, 2018).

Guidelines and Assessment for Statistics Education (2005) reported that students should be trained to have fundamental statistical knowledge for their employment, citizenship, and daily lives until they graduate from high school to have a fulfilling life. A person who completed elementary education is expected to be statistically literate (GAISE, 2005; Ben-Zvi & Garfield, 2004; Gal, 2002). Considering these objectives, the Turkish middle school mathematics curriculum aims to ensure that students who graduate from middle school are statistically literate citizens.

According to Ben-Zvi and Garfield (2004), preparing lesson plans that emphasize conceptual understanding rather than procedural understanding and incorporating real-world contexts into statistics teaching is essential in equipping students with statistical literacy. When the Turkish middle school mathematics curriculum and its objectives considering statistical literacy are examined, it can be said that, as opposed to the curricula of other countries, the objectives include mostly procedural and computational skills rather than developing a conceptual understanding of statistical literacy approaches (Güven, Baki, Uzun, Ozmen & Arslan, 2021; Shaughnessy, 2007; Sharma, 2017). Güven et al. (2021) stated that teachers make use of context only in problem situations. The study further demonstrated that students could not connect with the context while they exhibited their statistical literacy skills, such as interpreting the attained statistical results in contextual problems (Özmen & Baki, 2017; Yolcu, 2012). In addition, there is a limited number of studies which examined statistical literacy with contextual tasks in Turkey. In general, the studies investigating the statistical literacy levels of middle school students in Turkey contain questions related to the daily life without having a contextual task regarding daily life or an up-to-date scientific context. Furthermore, there is a limited number of studies which worked on the nature of students' statistical literacy influenced by the familiarity of the context for the students. In other words, there is no extensive research in the literature that compare student performances in familiar and unfamiliar contexts.

Also, students from different regions of Turkey have different schooling experiences and vastly different school opportunities. Mizala and Romaguera (2002) found that

the differences in schooling create a difference in the opportunities which affects the students' achievement in a lesson. PISA (2006) support the findings that indicate a significant difference in performance between different school types in Turkey. However, the number of studies which examined the statistical literacy levels' of students who enrolled in different regions of Turkey is limited. Observing the gaps in the literature, the present study determines the nature of statistical literacy of students enrolled in different regions of Turkey when they use their statistical abilities and integrate the statistical objectives, such as representing and analyzing the data and interpreting the statistical results, in a context they encounter in their daily lives and in an up-to-date scientific context.

1.1 Purpose of the Study

The study aims to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. The study addresses the following research question:

"What is the nature of statistical literacy of eighth graders enrolled in schools in different regions of Turkey in an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet regarding the two components of the statistical investigation process, which are representation and analysis of the data, and interpretation of the results?"

1.2 Definition and Important Terms

In this section, the definitions of key terms are provided to enhance the reader's understanding of the study.

Statistical Literacy: "Statistical literacy is the ability to understand and critically evaluate statistical results that permeate our daily lives" (Wallman, 1993, p.1).

In this study, students' statistical levels are specified based on the four hierarchical levels framework of Sharma et al. (2011) concerning the last two statistical process components. These levels are determined according to the findings from the Statistical Literacy Tasks (SLTs), prepared in COVID-19 and daily diet contexts. The four hierarchical levels are Informal/Idiosyncratic, Consistent Non-critical, Early Critical, and Advanced Critical (Sharma, 2017).

Statistical Investigation Process: The investigative cycle "describes the procedures a statistician works through and what the statistician thinks about to learn more in the context sphere" (Wild & Pfannkuch, 2004, p. 41).

The statistical investigation process contains four components: formulating questions, collecting data, representing and analyzing data, and interpreting the results (Franklin et al., 2005). In this study, the last two components, which are representing and analyzing the data and interpreting the results, are examined.

Representing and analyzing the data: This statistical investigation component corresponds to selecting a suitable display or statistical analysis method to reach research findings (Franklin et al., 2005).

Interpretation of the results: This component corresponds to interpreting the findings reached after data analysis (Franklin et al., 2005).

Real-life context: To increase students' recognition of mathematics in everyday life and develop a positive attitude and conceptual understanding, questions that include everyday stories are used (Altay et al., 2017). Two distinct tasks are created, addressing real-life inquiries related to the COVID-19 pandemic and daily diet.

1.3 Significance of the Study

Statistical literacy is essential for people to prosper in their lives in contemporary information societies (Gal, 2002). Statistical literacy involves understanding statistical concepts, reading and representing statistical displays, analyzing them, and critically evaluating statistical information. Thus, having statistical literacy is crucial as one observes and uses statistical information frequently in daily life. Wallman (1993) stated that the decision-making process is an excellent example of implementing knowledge into real life and emphasizing the importance of statistical literacy even in daily life. As per Gal's (2002) research, the use of statistical data is frequently required during the decision-making process. In order to effectively interpret and utilize the obtained information, statistical literacy is a required skill, strengthening the significance of the subject matter.

However, statistical literacy is a relatively unexplored area compared to other fields. The field of research in this area spans approximately twenty-five years. While statistical literacy has a relatively brief history in the global academic literature, its history in Turkey is even shorter. Since the importance of the field has been understood relatively recently, the number of studies conducted on the this topic is few compared to other concepts in mathematics education. Yolcu (2014) stated that the middle-school curriculum in Turkey aims to educate students to be conscious citizens who can exhibit statistical knowledge and appreciate statistical literacy's importance in daily life, and increasing the number of studies on the statistical literacy of students in Turkey is crucial. Therefore, there is a significant gap in terms of the number of studies about the statistical literacy of Turkish students. The question of what can be done to increase the level of students in Turkey remains an understudied area as well. Thus, with the findings of this study, updated and valuable information about the statistical literacy of students in different regions of Turkey could be added to the literature.

Eccles (1999) stated that even though a large part of a child's cognitive development is completed at earlier ages, these changes accelerate in the age range of 6 to 14,

which coincides with the middle school period. Thus, it can be stated that education in middle school is pivotal in providing the necessary statistical literacy ability before the student graduates. The Ministry of National Education (MoNE) (2018) begins education on statistics and data processing in the first grade. However, the number of studies that investigated the statistical literacy of middle school students is few compared to those that investigated the statistical literacy of adults and students in secondary education. Also, the curriculum and the researchers support learning statistical information and concepts. However, it is unknown whether every student possesses the adequate skills indicated in the objectives (Makar & Fielding-Wells, 2011). Thus, if the statistical literacy level of middle school students is low, the reasons for the inadequacy should be searched deeply (Öz, 2019; Yolcu, 2014). In this study, students' statistical literacy levels were determined, and these findings gave valuable information to understand the nature of the statistical literacy of middle school students in Turkey.

Altun (2002) stated that mathematics education aims to help students acquire the mathematical knowledge and skills required in their daily lives and to broaden students' thinking processes and provide them with different perspectives to solve problems using mathematical reasoning. The Turkish mathematics curriculum (2013) determined that students should transform real-life problems into mathematical problems and use their mathematical knowledge to solve them using mathematical modeling. However, according to Demir and Akar-Vural (2017), the reliance on rote learning in mathematics textbooks and the education system leads to a lack of understanding among students regarding the connection between mathematical concepts and real-life situations, as perceived by teachers. Moreover, teachers have the impression that students cannot adequately use mathematical models, formulas, and relations to interpret a real-life context (Demir & Akar-Vural, 2017; Gülten, Ilgar & Gülten, 2010). Thus, the study could examine to what extent students can transfer mathematical information from the curriculum to real-life tasks prepared in two different contexts.

In this study, students from different regions of Turkey have different schooling experiences and vastly different school opportunities. Connell et al. (1982) illustrated that gender, socio-economic class, and family affect opportunities in schooling. Also, Mizala and Romaguera (2002) found that the differences in schooling create a difference in the opportunities in a lesson, such as the given tasks to students, individual care provided by the teacher related to the number of students, and educational settings. The functional and structural social capitals of schools can play an important role. According to Bali and Alvarez (2003) and Cohen et al. (2003), class size is negatively related to student success. Also, the results of PISA (2006) support the findings that indicate a significant difference in performance between different school types in Turkey. Thus, in this study, the statistical literacy of the students from different types of schools, such as a village, public or private, in different cities of Turkey could be determined. In this way, a difference in the statistical literacy level of students from different school types could be examined, and valuable implications could be made for the teacher educators.

The contextual task is crucial to improving students' statistical literacy abilities and providing the ability to connect concepts and real-life situations. Watson (2006) stated that context is significant to statistical literacy and elaborated on the idea by stating that contexts make the problem more explicit. Watson added that students' success increases when the context is included in statistical problem situations (2006). Using contexts, students can conceptualize statistical knowledge more quickly and develop their interpretation and evaluation abilities (Çatman-Aksoy & Işıksal-Bostan, 2020). Thus, teachers should include more contexts in statistics teaching since statistical literacy reinforces the link between statistics and daily life (Yolcu, 2014). Therefore, since this study could present real-life contexts, it could give a chance to examine students' statistical literacy and their interpretation skills of statistical concepts in real-life contexts.

Many researchers claimed that students struggle to analyze and interpret graphical displays (Boote & Boote, 2017; Bright & Friel, 1998; Capraro, Kulm, Hammer, 2005; Kirsch & Mosenthal, 1990; Pereira-Mendoza & Mellor, 1991). Also,

interpreting averages or variation through graphical displays is much more difficult for students who have already had difficulties interpreting the data displays (Enisoğlu, 2014). For a student, selecting the suitable method, such as mean, median, or mode for an average question, and bar graph, line graph, or pie chart for data representation, can be a challenging task due to its complexity. However, students perform better on questions including graphical displays and statistical concepts like average and variation (Enisoğlu, 2014; Shaugnessy & Pfannkuch, 2002). Thus, questions to be used in studies are prepared considering these investigations. The last two components of the statistical process, representing and analyzing the data and interpreting the results, are examined in the study using these concepts with displays and real-life contexts. Thus, it is significant to investigate statistical literacy with sequential questions in a task that includes statistical concepts to measure students' representation, analysis, and data interpretation abilities. This study investigates statistical literacy by questioning the aforementioned components and including all concepts together in the tasks. In order to gauge students' levels of statistical literacy across various components, these concepts are thoroughly analyzed. Furthermore, the representation and data analysis component holds the highest percentage of the Turkish mathematics curriculum objectives (%14). In contrast, the component of interpretation of the results has only 3% (Batur et al., 2021). Therefore, it is significant to examine the difference in students' statistical literacy levels and their in-depth thoughts on different statistical process components, primarily representing and analyzing the data and interpreting the results regarding the percentages of the objectives in qualitative research.

Güven et al. (2021) stated that pre-service teachers were more successful in procedural steps and data analysis than they were in the interpretation of the data. Similarly, Peck et al. (2013) reported that while middle school teachers had difficulties interpreting the data, especially in context, many were highly skilled in data analysis and the procedural part of the statistical investigation process. Therefore, investigating students' statistical literacy levels in related components could enlighten educators and stakeholders in Turkey, encouraging them to review

the number and content of the objectives in the Turkish mathematics curriculum and the statistics education of pre-service and in-service teachers.

Another critical point is that statistical literacy studies in Turkey generally investigate the subject matter using multiple-choice questions. These are not always suitable measurement methods to deeply understand students' critical thinking, evaluation, and interpretation skills (Watson, 1997). By circumventing the pitfalls associated with multiple-choice questions, this research employs open-ended questions to gain deeper insights into students' critical thinking, interpretations, and, ultimately, their level of statistical literacy. According to Yolcu (2014), qualitative research is needed in statistical literacy studies to deeply understand students' understanding and evaluation of statistical messages in real-life contexts. Thus, this research was designed as a qualitative study to gain information about students' thought processes on statistical messages.

Moreover, this study can provide teachers with an innovative, formative, and updated perspective when they prepare lesson plans and choose questions, contexts, and appropriate materials for their statistics lessons. For example, teachers can select up-to-date, real-life contextual questions that allow students to reveal their critical evaluation process and reinforce their interpretation skills on statistical concepts. The study's findings can provide ideas to educators and stakeholders about what eighth graders' statistical literacy levels are in Turkey, which statistical concepts eighth-graders cannot develop or have difficulties with, and whether the statistical literacy levels can be related to the curriculum and the number of objectives of the components.

This study presents students' statistical literacy levels regarding the cities in different regions of Turkey. Based on this information, substantial transformations can be implemented in school environments, textbooks, the Turkish mathematics curriculum, the selection of real-life contexts for statistics lessons, the time allocated for mastering statistical concepts, and the promotion of research aimed at enhancing

students' statistical literacy skills. These measures are crucial in fostering equal educational opportunities across diverse regions of Turkey.

CHAPTER 2

LITERATURE REVIEW

The purpose of the study is to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. Firstly, the statistical literacy concept is examined. Secondly, the theoretical frameworks of statistical literacy, the developed models of statistical literacy, and the selected theoretical framework and why it was selected for this study are explained respectively. Lastly, related studies on statistical literacy are presented in this chapter.

2.1 Statistical Literacy

Statistical literacy has been a relatively new topic compared to other topics in the field of mathematics and statistics (Sharma, 2017). Statistics educators, statisticians, and researchers defined statistical literacy many times, yet there is still no consensus about the definition of statistical literacy (English, 2013; Kaplan & Thorpe, 2010; Ridgway et al., 2011; Schield, 2010).

Wallman (1993) defined statistical literacy as the ability to understand and evaluate statistical information critically to use in a decision-making process in professional and personal life. Gal's statistical literacy definition (2004) emphasizes statistical literacy among adults, encompassing the interpretation and critical evaluation of statistical information in various contexts. Additionally, it involves the ability to communicate one's opinions about the statistical implications encountered.

According to Callingham (2007), being statistically literate means having the ability to use mathematical skills to analyze and comprehend statistical information, as well as assess the relevance of the data in a social context. According to Watson (1997), statistical literacy encompasses the interaction between probability and statistics. This means that it involves not only understanding statistical information and concepts such as interpreting graphs, averages, and variation, but also the ability to apply this knowledge to real-life situations.

Garfield's definition of statistical literacy is similar to Watson's, as it emphasizes the understanding of statistical terminology and symbols, the interpretation of graphs and tables, and the practical application of statistics in various contexts. Garfield's (1999) definition highlights the importance of understanding statistical terminology, symbols, and language, interpreting visual aids, and comprehending statistical data in real-world contexts. The distinction between Garfield's and Watson's (1997) definition lies in the inclusion of questioning abilities, which is not explicitly referenced in Garfield's definition. Furthermore, contrary to Watson, Schield (1999) identifies statistical literacy as a competence instead of an ability. According to Schield (1999), statistical literacy is a supported version of critical thinking. Hence, having knowledge about the formulas or meanings of concepts is insufficient to be a literate person (Watson & Callingham, 2003). Analyzing, interpreting, and critically evaluating statistical knowledge and then applying and communicating with them in a real-life context meaningfully are requirements to be statistically literate (Towsend, 2006). Thus, statistical literacy, which includes understanding statistical messages and interpreting and critically evaluating them, is necessary for conscious citizenship and preventing individuals from deceptions encountered in daily life.

Although there are some differences in the definitions of statistical literacy, such as whether it is considered an ability or not, there are also shared commonalities between these definitions. Regarding statistical literacy, two commonly used terms are "interpretation" and "critical evaluation" of statistical information. Additionally, the term "context" is frequently referenced as it pertains to applying the information from the context to real-life situations and everyday experiences. It is important to

remember that statistics is only meaningful within a specific context, as noted by experts such as Scheaffer (2006) and Franklin et al. (2005). Therefore, it is crucial for the term "context" to be included in any definition of statistical literacy.

In order to delve deeper into statistical literacy, experts sought to establish frameworks and models. Thus, the ensuing section of the literature review features a discussion of these frameworks and models.

2.1.1 Theoretical Frameworks of Statistical Literacy

This section presents the theoretical frameworks of statistical literacy, which are popular in the literature. Sequentially, Watson's three-tiered framework, the six-hierarchical levels construct of Watson and Callingham, GAISE frameworks, and lastly, Sharma and colleagues' four-stage framework for statistical literacy are presented in this section.

2.1.1.1 Watson's Theoretical Framework

Watson (1997) developed a framework to assess statistical literacy levels by considering the cognitive dimensions (Yolcu, 2012). This framework consists of three hierarchical tiers: "basic understanding of terminology," "embedding of language and concepts in a wider context," and "questioning of claims" (Watson, 1997, p.2).

In the first tier, students are expected to understand statistical concepts such as mean, median, and graphical displays and calculate the statistical concepts if needed, regardless of any social context. In this tier, students can demonstrate basic statistical abilities, such as understanding concepts without applying them, performing calculations without evaluation, and often without understanding the purpose of the procedure.

In the second tier, understanding and interpreting the concepts in a social or scientific context involves decision-making. In other words, including knowledge in real-life contexts when students encounter statistical information starts at the second step of Watson's three-tiered statistical literacy construct. In this tier, students can demonstrate some abilities, including contextualizing their solutions. They begin to interpret the statistical information and make decisions based on the information provided.

The last tier is about critically thinking and evaluating using knowledge from other tiers. In this tier, students are expected to not believe any claim without evaluating them. Statistical information is also presented in real-life contexts. Students in this tier demonstrate a high level of cognitive ability.

2.1.1.2 The Statistical Literacy Construct of Watson and Callingham

When Watson and Callingham (2003) conducted a longitudinal study, they observed that the context was largely influential in understanding information and developing statistical thinking. Thus, they worked on Watson's three-tier framework and expanded it to "six hierarchical levels" (Yolcu, 2014, p.2).

When the "six hierarchical levels" construct is examined, it is seen that the sequential levels are distinguished by highlighting progressive skills that align with Watson's three-tiered framework. For example, at the first level, called idiosyncratic, students should be able to show statistical skills at a fundamental level, such as reading values in a table, and by improving these basic skills at the second level, referred to as informal, students are expected to successfully perform basic one-step calculations of values obtained from tables, graphs, and probabilities.

The statistical literacy construct of Watson and Callingham including six hierarchical levels is presented in Figure 2.1.

Level	Brief characterization of step levels of tasks
6. Critical Mathematical	Task-steps at this level demand critical, questioning engagement with context, using proportional reasoning particularly in media or chance contexts, showing appreciation of the need for uncertainty in making predictions, and interpreting subtle aspects of language.
5. Critical	Task-steps require critical, questioning engagement in familiar and unfamiliar contexts that do not involve proportional reasoning, but which do involve appropriate use of terminology, qualitative interpretation of chance, and appreciation of variation.
4. Consistent Non-critical	Task-steps require appropriate but non-critical engagement with context, multiple aspects of terminology usage, appreciation of variation in chance settings only, and statistical skills associated with the mean, simple probabilities, and graph characteristics.
3. Inconsistent	Task-steps at this level, often in supportive formats, expect selective engagement with context, appropriate recognition of conclusions but without justification, and qualitative rather than quantitative use of statistical ideas.
2. Informal	Task-steps require only colloquial or informal engagement with context often reflecting intuitive non-statistical beliefs, single elements of complex terminology and settings, and basic one-step straightforward table, graph, and chance calculations.
1. Idiosyncratic	Task-steps at this level suggest idiosyncratic engagement with context, tautological use of terminology, and basic mathematical skills associated with one-to-one counting and reading cell values in tables.

Figure 2.1. Statistical literacy construct of Watson and Callingham (2003, p.14)

At the first level of the statistical literacy construct, *idiosyncratic*, students use their personal experiences and beliefs while interpreting and analyzing statistical information. They have weak terminology usage and context engagement.

In the second level, *informal*, students have more engagement with context than in the first level. However, their usage of statistical information still depends on their beliefs and perceptions instead of connecting with the context. Also, at this level, students can make basic calculations considering the information in a table or a graph.

The third level, *inconsistent*, shows some features of the second tier of Watson's three-tiered framework. For example, students can establish a link between the context and statistical knowledge. Students can draw a suitable conclusion from the given statistical knowledge without justification. Also, they interpret statistical ideas with qualitative explanations.

In the fourth level, known as the consistent non-critical level, students demonstrate their successful understanding of all the objectives outlined in the second tier of Watson's framework (1997). They can engage with context without critical

questioning at this level and can use statistical terminologies, mathematical and statistical skills related to graphical features, and mean and basic chance concepts.

In the fifth level, *critical*, students finally show critical engagement in both familiar and unfamiliar contexts. They can analyze and interpret data sets and results more successfully in familiar contexts. At this level, appropriate usage of statistical terminologies and qualitative interpretations of probability concepts can be seen. Students can incorporate the concept of variance with a basic qualitative interpretation at this level.

In the last level, *critical mathematical*, students show critical engagement with context, whether it is familiar or not, similar to the fifth level. This level differentiates from the other when proportional reasoning, quantitative analysis, and interpretations become a part of students' statistical literacy activity. Students can separate central tendency scores and comprehend which one should be used when and in which data sets.

Following Watson's three-tiered and Watson and Callingham's six hierarchical statistical literacy frameworks, American Statistical Association Foundation felt the need for a statistical literacy framework based on the National Council of Teachers of Mathematics (NCTM) (2000) *Principles and Standards of School Mathematics*. They needed a statistical literacy framework to develop students' statistical literacy skills in Pre-K-12, starting from early grades, by incorporating statistical process components. Thus, a team of educators worked on a report and constructed GAISE Frameworks for statistics and data science education. The framework is examined in the next section.

2.1.1.3 GAISE Frameworks for Statistics and Data Science Education

The GAISE frameworks were developed based on the NCTM (2000) guidelines. While they share a hierarchical structure with Watson and Callingham's framework, some notable differences exist. For instance, other frameworks consider all students

across cultures and education systems, but the GAISE frameworks are designed specifically for the American educational system and include concepts and features tailored to Pre-K-12 grades (Sharma, 2017). Additionally, unlike other frameworks, the GAISE frameworks distinguish statistical literacy based on statistical process components and establish different levels accordingly. In the present study, the last two components of the statistical process are examined, making these frameworks essential for gaining insights.

The statistical process components are given in Figure 2.2.

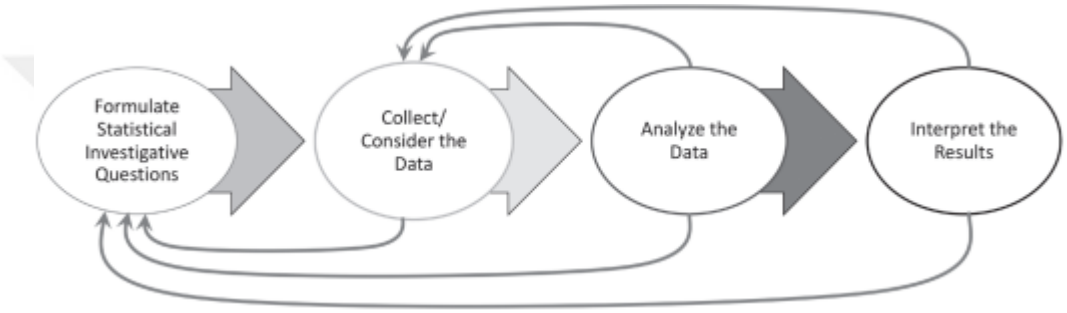


Figure 2.2. Statistical Process (GAISE II, 2020, p.13)

As seen in Figure 2.2, the statistical problem-solving process, or, in other words, the statistical investigation process, has four components: formulating a statistical investigative question, collecting data, representing and analyzing data, and interpreting results sequentially. Moreover, the figure illustrates various approaches to obtain feedback and make revisions in the process.

The frameworks aimed to provide a visionary framework that develops students' core skills in statistical reasoning. The first framework was developed in 2005, and underwent revisions in 2007. Then, in 2020, GAISE I was updated to incorporate multidimensional representations and displays, including current data sets, contexts, pictures, sounds, and videos, leading to the development of GAISE II.

The GAISE II framework was built on GAISE I by emphasizing the importance of prioritizing the statistical process components: formulating a statistical investigative question, collecting data, representing and analyzing data, and interpreting results.

In GAISE II, several modifications highlight the significance of planning the collection of data to address statistical investigative questions. These modifications are considering various data and variable types, selecting an appropriate sample size for representative results, managing missing values in the dataset, and determining the optimal analysis method for the data. In addition, the revised frameworks placed a greater emphasis on the role of probability and chance concepts, the integration of technology in statistical practice, and the practical application of technology in statistical analysis. When discussing the differences between GAISE I and II, it is worth noting that GAISE I primarily aimed to improve statistics standards in mathematics education and presented a framework for enhancing students' statistical reasoning skills through three levels. However, GAISE II builds on that foundation, incorporating updates that reflect the evolving statistical landscape. One notable difference is that GAISE II acknowledges expanding data types beyond quantitative and categorical variables. It also emphasizes the importance of questioning throughout the statistical problem-solving process, highlights multivariate thinking, and underscores the role of probabilistic thinking in quantifying randomness. Furthermore, GAISE II recognizes the integration of technology in statistical practice, highlights the significance of effectively communicating statistical information, and emphasizes the role of assessment in measuring students' conceptual understanding and statistical reasoning abilities. In GAISE II, communication with statistical messages and conceptual understanding during statistical education gained importance.

GAISE II includes three levels (A, B, C) for each statistical process component suitable for elementary, middle, and high school students, respectively. In this study, participants were determined as eight graders. The students are unable to reach Level C of the framework due to their grade levels. Therefore, it is important to ensure that the objectives of Levels A and B in the framework are aligned with the Turkish mathematics curriculum. However, the Turkish mathematics curriculum's objectives and frameworks do not directly relate to middle school students. For instance, the analysis of the data component in GAISE II requires students to represent variability

using boxplots or dot plots and calculate mean absolute deviation (MAD) at Level B. However, these concepts are not included in the elementary and middle school mathematics curriculum in Turkey.

After four years from GAISE I, with 2-year experiments, Sharma and her colleagues constructed a framework. This framework was inspired by Watson's and Callingham's (2003) construct (Sharma et al., 2017). The following section examined this framework.

2.1.1.4 Four Stage Framework of Sharma and colleagues

The last framework that is to be discussed was created by Sharma, Doyle, Shandil, and Talakia'atu in 2011. They needed to construct a new framework to address the feasibility of classroom settings and the students' need for scaffolding provided by the teacher. According to Sharma (2017), the four-stage statistical literacy framework helps teachers determine students' levels of statistical literacy and detect the problems students experience when they see a statistical message or concept because the framework takes the cognitive development theory of Biggs and Collis (1982) as a basis. Thus, students' improvement in statistical literacy can be examined in a clearer manner. The framework has four stages: Informal/Idiosyncratic, Consistent/Non-Critical, Early Critical, and Critical.

The first stage corresponds to the first two stages, idiosyncratic and informal, in Watson's and Callingham's construct. Students mostly have pre-structural and uni-structural thinking at this stage, which relies mainly on students' perceptions, intuitive ideas, and beliefs rather than statistical ideas and engagement with context. At this stage, guessing answers and inappropriate explanations can be frequently encountered. Similar to Watson and Callingham's (2003) framework, basic table and graph reading and basic one-step straightforward calculations can be seen.

The second stage is the inconsistent and non-critical stage, which involves finding results with no meaningful explanation. Students have uni-structural and multi-structural thinking at this stage.

Students move on to the third stage if some qualitative explanations of students include hidden quantitative statistical thinking. Relational thinking begins at this stage.

The final stage requires the same criteria as the critical-mathematical stage: critical engagement with any context, whether familiar to students or not, proportional reasoning, quantitative analysis, and interpretations. Students have abstract thinking at this stage (Sharma, 2017).

The assessment of students' statistical literacy levels in this study utilized the four-stage framework that Sharma and her colleagues developed. It was used to thoroughly analyze the coherence between the objectives of statistical investigation process components in the framework and the Turkish mathematics curriculum, as well as the improvement of students' statistical literacy in relation to their cognitive development.

The previous sections introduced four frameworks concerning statistical literacy. Experts were interested in understanding the factors that influence statistical literacy and exploring the relationships between these elements. Additionally, they discovered the significance of dispositional attitudes in relation to students' statistical literacy. Moreover, the fundamental and theoretic foundation was laid, yet the relation and the implication in the real world were unknown.

Consequently, in order to gain a deeper understanding, models were utilized to operationalize the elements that have an impact on statistical literacy and to demonstrate their relationships with each other (Nilsen, 2015). The models bring various capabilities on top of frameworks, such as giving researchers an effective tool to understand abstract concepts by representing systems, processes, or concepts. In other words, through visualization of abstract concepts, models help

comprehension and analysis. As opposed to the broader structure of frameworks, models focus on representing specific objects or phenomena for organizing and understanding information within a specific domain.

In this study, statistical literacy frameworks were used to assess students' level of understanding in a given concept. Based on this assessment, their abilities and corresponding proficiency levels were determined. However, models provide detailed information about the representation of the elements which construct the statistical literacy concept and the relationship between the elements. Also, the models contain the dispositional elements for which the importance is highlighted. Thus, the models should be examined to comprehend statistical literacy and the relationship between the elements of statistical literacy, and to determine how dispositional elements are included in the research.

The next section discusses models of statistical literacy.

2.1.2 Models of Statistical Literacy

In this section, two models of statistical literacy, the two elements model of Gal and Watson's statistical literacy model, are presented.

2.1.2.1 Two elements Model of Gal

Following Watson's three-tiered framework (1997), Gal worked on statistical literacy and thought that the element of disposition was as significant as cognitive elements in statistical literacy. Thus, Gal (2004) developed a two-element model involving knowledge and dispositional elements. The model is presented in Figure 2.3.

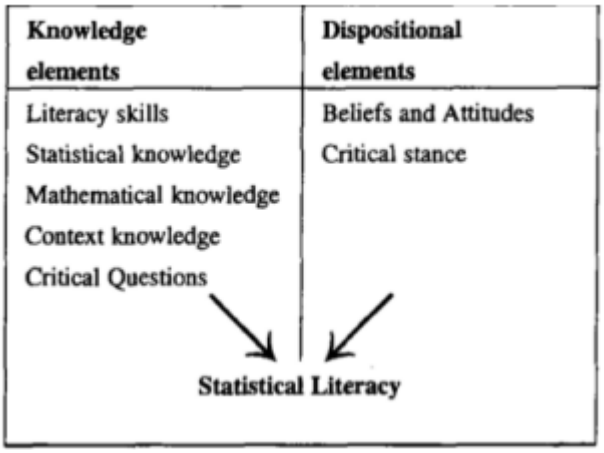


Figure 2.3. Gal's Model of Statistical Literacy (2004, p.4)

As seen in Figure 2.3, the model indicates that statistical literacy is comprised of two key components: knowledge elements and dispositional elements. The dispositional elements pertain to critical stances, attitudes, and beliefs, while knowledge elements include literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions.

Statistical literacy encompasses a range of skills, including literacy, numeracy, familiarity with statistical concepts, contextual interpretation, and critical thinking. However, the role of disposition is often overlooked. Even though Watson (1997) developed a framework that considered affective domains, disposition elements are still relatively new. As Gal (2004) pointed out, these elements are critical for developing critical thinking skills. By asking "worry questions" when statistical messages are encountered, individuals can gain a deeper understanding of the situation and avoid falling prey to deception and misinformation.

After two years of Gal's statistical literacy model, Watson also noticed that dispositional elements are effective in gaining statistical literacy. Thus, she modeled statistical literacy, its elements, and their relations in 2006. In the next section, the statistical literacy model of Watson is examined.

2.1.2.2 Watson's Statistical Literacy Model

Following extensive research on statistical literacy, Watson (2006) developed a model inspired by Gal's statistical literacy model. This model incorporated insights from previous studies that utilized Watson's three-tiered framework (1997) and Watson and Callingham's six-hierarchical framework (2003). This model presents the significant elements of statistical literacy and their relationship with each other. These elements are literacy skills, mathematical/statistical skills, context, task motivation, task format, and data and chance curriculum. This model is presented in Figure 2.4.

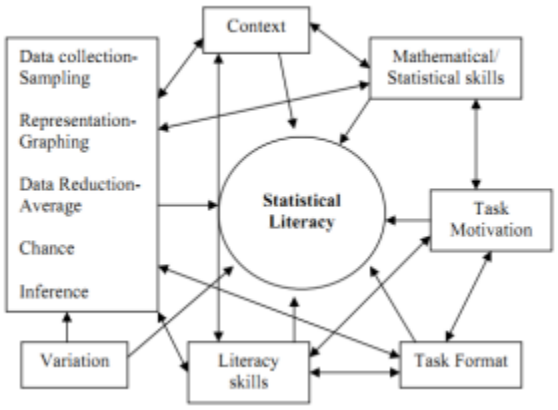


Figure 2.4. Watson's Model of Statistical Literacy (2006, p.248)

While the elements of literacy skills, mathematical and statistical skills, and context remained the same, the elements of data and change concepts, task motivation, and task format were added.

The data and chance curriculum element was placed on the left-hand side of the model. This element includes data collection/sampling, representation/graphing, data reduction/average, chance, and inference. The data and chance curriculum element of the model is similar to the statistical knowledge element in Gal's model (2004), yet as can be seen in the model, this element is explained in more detail. In terms of data representation, students are expected to comprehend messages

conveyed through graphical displays, discern any misleading information, and interpret the data accurately. For the concept of average, students must grasp its meaning in a given context and be able to interpret the effectiveness of various measures of central tendencies. Similarly, for sampling, students need to comprehend the significance of representative samples and identify any possible biases in sampling. Additionally, analyzing graphical representations, drawing inferences, and questioning the validity of media claims are essential skills for the concept of inference. In this study, when the data collection tool is prepared, these topics would consider how students approached them when they solved and interpreted the questions.

In addition to these concepts, the meaning of variation, the relation of variation, and other concepts and their usage when analyzing data are placed into data and chance curriculum part of the model (Watson, 2006).

Mathematical and statistical skills element includes conceptual understanding and applying mathematical and statistical knowledge to questions using the knowledge in the context. Students' inadequate mathematical skills, such as percentages, decimals, and proportions, prevent their analysis and interpretation (Ben Zvi & Garfield, 2004). Furthermore, statistical skill involves statistical analysis, like correctly using mean, standard deviation, and probability. This element is also included in Sharma and her colleagues' statistical literacy framework, and Sharma (2017) asserted that mathematical and statistical skills should be interconnected with a literate individual. In this study, the utilization of Sharma and her colleagues' framework highlights the notion that mathematical and statistical skills should be regarded as complementary to each other or as interconnected elements, similar to Watson's model.

Context is another vital element. This element is included in Gal's (2004) and Watson's (2006) models as an inevitable point to consider. Watson stated three types of contexts: isolated, familiar, and unfamiliar. Examples that students encounter in their daily lives and in textbooks or lecture notes are familiar and isolated contexts,

respectively. Apart from stereotype examples and statistical messages in their daily life, examples such as statistical messages in media are among unfamiliar contexts. Watson argued that unfamiliar contexts provide the best opportunities for enhancing students' statistical literacy skills. Accordingly, in this study, the data collection tool was designed to encompass two distinct real-life contexts: COVID-19 and daily diet. COVID-19 can be considered an unfamiliar context, whereas the daily diet represents a familiar context. Therefore, this element holds significant importance in the study and its potential impact on the results.

Literacy skills are of utmost importance, as suggested by its name (Watson, 2006). Gal (2004) establishes a correlation between Kirsh and Mosenthal's (1996) model and the association between literacy and statistical literacy. Furthermore, Watson (2006) links the Four Resources Model of Luke and Freebody (1997) to underscore the crucial role of literacy in comprehending and interpreting written materials and drawing inferences from them. These models highlight the indispensable nature of possessing literacy skills. This element is another critical component of the study because the data collection tool would be prepared as a contextual task, not obtain separate questions. Thus, students should be able to read, understand and use the information for all questions. In other words, they should be literate to show evidence of statistical literacy.

Task format is another element of the model that is related to the assessment of statistical literacy. According to Watson (2006), while multiple-choice tasks are more appropriate when the question aims to establish the required information from graphs or calculate statistical concepts, open-ended questions are more appropriate to explain or transform critical thinking. This study's data collection tool was prepared as a real-life contextual task, including open-ended questions considering context, literacy, and task format element.

The last factor task motivation relates to is disposition elements in Gal's model. In the model, one element represents disposition factors, which Gal emphasized as crucial for developing statistical literacy ability.

In conclusion, the theoretical framework of the literature review on statistical literacy has introduced numerous frameworks and models. Each of these models possesses distinctive traits while also sharing some similarities. The aim of this study is to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. Based on the aim of the study and features of the frameworks and models described above, Sharma and her colleagues' framework (2011) and Watson's statistical model (2006) were used in this study because of the coherence and emphasis on the curriculum, the clearness of the expected verbs for objectives, and including dispositional elements.

In the following section, relevant studies that align with the objectives of the study are presented.

2.2 Related Studies

Concerning the aim of this study, in this part, studies on statistical literacy levels, studies on context familiarity, and then studies on statistical concepts are reviewed in a more comprehensive manner.

2.2.1 Studies on Statistical Literacy Levels

Several studies have explored statistical literacy, mainly focusing on students in both international and Turkish contexts.

Firstly, Moritz and Watson (2000) investigated students' statistical literacy in the international context using Watson's three-tiered framework. They gave students in third, sixth, and ninth grades an instrument with 11 items with misleading graphs and statistical messages to measure their critical thinking in statistics, and they found

that only ten percent of the students could correctly and appropriately evaluate these graphs. They repeated the test within two and four years. After four years, they observed that while sixty percent of the participants enhanced their level, seven percent of them had a decreased level of statistical literacy. They concluded that it was possible for a student to improve knowledge of statistical concepts over time.

Another international study completed with 3000 students whose grade 3 to 9 by Watson and Callingham (2003) was a longitudinal using their six hierarchical levels framework. They found that most of the students were at the first four levels. As mentioned, students adhere to their perceptions in the first four levels and neglect contextual information. In addition, their justifications were qualitative explanations rather than quantitative and mathematical ones. Only a small percentage of the students were at the critical and critical mathematical level.

Secondly, in Turkey, Yolcu (2012) focused on statistical literacy by examining 1074 eighth graders' level of statistical literacy, using Watson's three-tiered framework and Watson's model. The instrument was developed by Yolcu, who found similar results to Watson. The researcher concluded that the lowest number of students was at the third stage. Thus, it can be said that students' answers were generally qualitative, personal, and empirical explanations.

Further research conducted by Çatman-Aksoy and Işıksal-Bostan (2020) examined the statistical literacy levels of 164 seventh-grade students in Ankara, focusing on the concepts of average and variation in graphical representation within social and scientific contexts. The study utilized the six-hierarchical level model proposed by Watson and Callingham (2003), with objectives including defining, interpreting, and evaluating statistical concepts. The findings revealed that students performed better in understanding the concept of average. However, consistent with the findings of Yolcu (2014) and Watson and Callingham (2003), students generally fell within levels 3 and 4 for the concept of average, indicating a limited presence at higher levels. Regarding the concept of variation, the results were less favorable, with most students remaining at levels 1 and 2, indicating a lower level of understanding.

Shifting the focus to a broader perspective, Wardat et al. (2022) conducted a study aimed at investigating school factors that influence students' achievements in the Trends in International Mathematics and Science Study (TIMSS) within schools in the Emirate of Abu Dhabi, United Arab Emirates. The study sample consisted of 4838 eighth graders and 156 schools participating in TIMSS 2015. The five factors from the school questionnaire were general school resources, school discipline and safety, parental support, principal experience and education, and library and instruction resources. After multiple regression models were implemented, the models demonstrated a significant linear relationship between students' achievement in TIMSS 2015 and the variables related to school factors.

Alaçacı and Erbaş (2010) investigated changes in students' literacy in Turkey by year and school type, examining students' performances in PISA 2006. The results showed that educational equity is a crucial issue, as there was a significant achievement gap observed in Turkey, as noted by the researchers. The findings indicated that students from science and social sciences high schools demonstrated fundamental proficiencies in various literacy domains. Additionally, Anatolian high schools showed an improvement in performance. However, all types of schools in Turkey, except for science schools, exhibited lower levels of advanced proficiency.

Another study conducted by Suna, Tanberkan, and Özer (2020) in Turkey collected data on the prediction of academic achievement based on socioeconomic status and school type from two million students over a period of ten years. The data collection was updated with respect to the three national transition systems in Turkey. The results revealed that students in private schools had significantly higher achievement in language, math, and science tests. This finding highlights the importance of considering equity among schools.

Although statistical literacy is a relatively new area in the literature, the studies conducted so far show that statistical literacy is medium or low internationally with respect to statistical concepts. It was seen that some demographics, such as schooling type, could affect the statistical literacy level. In Turkey, schools in different regions,

even in the same city, could have huge differences in terms of opportunities and educational resources. Therefore, this study focuses on the demographic aspect of schooling differences and their impact on students' academic success by selecting students from various regions in Turkey. In line with previous research, the findings highlight the influence of statistical content domains and process components on students' statistical literacy levels. The following section presents studies investigating content domains.

2.2.2 Studies on Context Familiarity

As indicated by Bryce et al. (2001) and Gal (2002), statistical literacy requires the ability to analyze and interpret the statistical information and knowledge within a context that relates to real life. Furthermore, in order to gain a meaning and encourage students into class participation, the education of statistics should make use of contexts (Nikiforidou et al., 2010). The effect of the familiarity of the context has been a topic of discussion in the literature that provided evidence of a positive relationship between performance and context familiarity.

Watson (2006) stated three types of contexts: isolated, familiar, and unfamiliar. While examples that students encounter in their daily lives are familiar, examples in textbooks or lecture notes are determined as isolated contexts. Apart from stereotype examples and statistical messages in their daily life, examples such as statistical messages in media are among unfamiliar contexts. Watson argued that unfamiliar contexts provide the best opportunities for enhancing students' statistical literacy skills.

One of the earliest studies that consider context familiarity is conducted by Washburne and Osborne (1926a, 1926b). They conducted their research on students from 23 American schools from years 3 to 7, solving arithmetic problems. Although they find that students scored 80.5% in more familiar and 67.5% in less familiar contexts, they conclude that unfamiliarity is a small factor in problem solving.

Another study which establish the familiarity and higher performance is that Chipman et al. (1991) analyze the solving performance of 256 undergraduate students under familiar and unfamiliar contexts in an American university. 66 algebra problems that are asked which are categorized into four contexts: masculine, feminine, neutral familiarity and neutral unfamiliarity. They find that although the students did not score significantly poorer results in the context of the opposite sex when compared to their sex, they scored significantly better in familiar contexts as opposed to unfamiliar contexts.

Also, meta analysis by Hembree (1992) investigated four features of contexts and their effect on student performance using 44 studies. These features are abstract vs. concrete, factual vs. hypothetical, familiar vs. unfamiliar, and, imaginative vs. personalized. Out of these four features, only the familiarity of the context was found as a significant indicator of student performance.

Another study by Cooper and Dunne (1998), and Carraher, Carraher and Schliemann (1985, 1987) conduct empirical analysis on influence of socioeconomic background of the student on the activation of real-world knowledge. They found that through the activation created by the familiar context, students with a disadvantage socioeconomic status exhibited better performance and advance mathematical reasoning.

Lastly, Bibi et al. (2018) investigated the influence of context familiarity among 430 student at pre-university level solving differential equations. The authors analyzed the responses in three main stages of problem solving, that are: understanding, planning towards the solution, and getting answer. They used three different contexts with varying familiarity levels for the target group. The authors concluded that context familiarity positively affected problem solving.

Thus, in this study, the data collection tool was designed to encompass two distinct real-life contexts: COVID-19 and daily diet. COVID-19 can be considered as an unfamiliar context since it is not a constant part of students' lives, whereas the daily

diet is considered to be a more familiar context given that it is an integral part in students' lives.

2.2.3 Studies on Statistical Content Domain

Various studies have explored the relationship between students' statistical abilities and specific statistical content domains, such as central tendency scores and graphical displays. These studies provide valuable findings regarding students' proficiency in understanding and applying these statistical concepts. In this section, firstly, international studies and then studies completed in Turkey are presented.

2.2.3.1 Central Tendency Scores and Average Concept

The first content domain that has been extensively studied is central tendency scores, particularly focusing on the concept of average. Average, also known as the arithmetic mean, is a fundamental statistical concept used to derive information from a data set (Shaugnessy, 2007). However, studies have shown that students often have misconceptions about the concept of average and tend to equate it solely with the arithmetic mean (Toluk-Uçar & Akdoğan, 2009). This implies that students may have limited understanding of other central tendency scores such as median and mode.

Furthermore, according to the study completed with interviewing of 21 students by Mokros and Russel (1995) and another study completed with 598 middle-school students by Yolcu (2014), most students could not interpret the average even if they could calculate the average score procedurally. Educators also stated that students struggle in deciding which central tendency score could represent a data set better when the data set includes extreme values. Even in Mokros and Russel (1995)'s study, they found that the students did not think the average value was a representative value for the data set.

In addition to the calculation of an average from a data set with extreme values, Strauss and Bicher (1988) worked on students' comprehension ability of mean. They found that students have some understanding of how extreme values can impact the mean. However, they encounter difficulties when it comes to calculating and interpreting data sets that include extreme values. Strauss and Bicher (1988) noted that students are able to comprehend and calculate the mean of a data set that does not contain extreme values, but they face challenges when extreme values are present.

According to Konold and Pollatsek (2002), middle school students demonstrated a better understanding of central tendency concepts when they were presented in real-life contexts. Students were able to recognize the impact of extreme values and understood the importance of including them in the interpretation of the data set. They also demonstrated an understanding of different purposes of averages, such as the midpoint and mathematical point of balance, to represent the data set effectively. Based on these findings, Konold and Pollatsek (2002) emphasized the significance of real-life contexts in highlighting the representativeness of data sets using different central tendency scores, considering the different types of data and various purposes involved.

In the study conducted with 164 seventh grade students by Çatman-Aksoy and Işıksal-Bostan (2020) in Turkey, the focus was on statistical literacy levels related to the concepts of average and variation in graphical representation, specifically within social and scientific contexts. According to the study, students demonstrated improved performance in understanding the concept of average. However, their overall level was found to be between Levels 3 and 4, which aligns with the existing literature, indicating that the highest level of proficiency was not commonly observed.

The way the concept of average is taught in the Turkish curriculum may be the reason why students find it challenging to comprehend its significance. The emphasis placed on measures of central tendency and arithmetic mean, coupled with the lack of

emphasis on the average's representative value, could be contributing factors to this difficulty (Yolcu, 2012). In a recent study by Bütüner (2020), the presentation of the average concept in secondary school mathematics textbooks in Turkey was analyzed. The study investigated various aspects, such as the types of problems related to the average, their representation forms, and the solution strategies used to solve them. This is a crucial concept in the field of data processing learning. The researcher discovered a significant oversight in the two sixth-grade textbooks. It appears that the equilibrium and fair-share models, which are highly effective in understanding the arithmetic mean, have not been given adequate attention in the textbooks. In addition, the textbooks fail to explore the relationship between the mean and the elements of a data set and do not emphasize its role as a representation of the data set. The problem-solving methods presented in the textbooks are limited and primarily rely on the add-divide algorithm and arithmetic solutions, which offer students a shallow understanding of the arithmetic mean. This approach may impede students' ability to answer reasoning questions. It is crucial for textbooks to provide various forms of representation in problem solutions to ensure a comprehensive understanding of the mean.

In a content analysis study completed in Turkey, Kuş (2022) worked on a textbook analysis of measures of centers concept. The study investigated how mathematics textbooks in Australia and Turkey deal with the concepts of measures of center to support students' learning. The comparison of the selected textbooks from Australia and Turkey revealed that the sequence of the presentation of the concepts differed between the two countries. Both countries introduced measures of center formally, without starting with an informal understanding. Additionally, while Australian textbooks placed a significant emphasis on the statistical aspect of measures of center, the textbooks of Turkey focused more on the mathematical aspect of measures of center. Finally, Kuş (2022) reported the differences in the use of context, visual displays, and technological tools. Australian textbooks frequently utilized research scenarios about daily life and employed a variety of graphs to relate measures of center with technological methodologies, unlike Turkish textbooks.

These findings emphasized that curriculum materials in Turkey such as textbooks can be revised.

To summarize, students considering average as a typical value employ mathematical principles such as median and mode to solve real-life problems (Konold & Pollatsek, 2002). Furthermore, research indicates that teachers' understanding of the average concept is generally comparable to that of students, leading to difficulties distinguishing between mean, median, and mode. Therefore, it is crucial to implement effective teaching strategies that can bridge the gap between students' informal representation and formal concepts of average, ultimately enhancing their comprehension of its significance and practical applications (Watson & Moritz, 2000; Konold & Pollatsek, 2002; Yolcu, 2012).

As mentioned in this section, the average concept and central tendency scores of students are low and should be improved to increase their statistical literacy levels. Considering the studies conducted in international and national settings, it is important to examine the corresponding skills related to central tendency scores and the investigated components, namely, the representation and analysis of data, and the interpretation of results in order to gain insights on how to develop students' statistical literacy in these specific areas.

2.2.3.1.1 Weighted Average

Weighted average concept is the average of a data set that consists of many different weighted data or different sizes of sub-samples (Department of Mathematics at UTSA, 2021). Similar to the mean and variation, the definition shows that the sample size should also be considered during calculating and interpreting the weighted average; therefore, the sample size of a data set is essential for students to comprehend the other statistical concepts and make reasonable interpretations of the data set when the students analyze and interpret the weighted average.

In international research on statistical learning, Watson and Moritz (2000) found that students, who could not give related statistical ideas for the definition of the sample, were able to question claims in the sampling context.

Similarly, in Turkey, Yolcu (2012) has indicated that students perform better when asked to apply their knowledge of sampling and interpret statistical messages in a sampling context. However, they tend to underperform when asked to employ their sampling knowledge to draw conclusions in diverse contexts.

When examining the studies, it becomes apparent that students often encounter challenges in applying their sampling knowledge and statistical abilities. These difficulties manifest in tasks such as interpreting the sampling process of a data set within a different context or evaluating the representativeness of a statistical concept in relation to the given data set. On the other hand, in a question that asks them to evaluate the sampling of the data in a sampling context, students are likely to show a better performance.

As outlined in this section, it is evident that students' proficiency in statistical concepts is currently below satisfactory levels and requires improvement. To enhance their statistical literacy levels, it is crucial to analyze the relevant skills in national and international studies, such as data representation, data analysis, and interpretation of results. By examining these components, effective strategies can be developed to enhance students' understanding of statistical concepts.

2.2.3.2 Graphiacal Displays

Another content domain in which students have difficulty is graphical displays. Graphs are useful tools for displaying data efficiently and transforming important messages in a concise and effective way (Özgün-Koca, 2001). When data is presented in the form of graphs, it can highlight patterns and anomalies that may not be easily noticeable when presented in tables or written descriptions. With this

feature of graphs, Shaugnessy and Pfannkuch (2002)'s study revealed that the variation can be more clearly seen if the data is given with a graph.

Every graph has a different aim, and with respect to the aims, they have different features. Thus, students face different issues with each type of graph. Studies about students' issues while representing, analyzing, and interpreting each graph type and their comparison are presented below.

The first study by Pereira-Mendoza and Mellor (1991) was about reading and interpreting bar graphs. The participants were 4th and 7th graders. The findings of the study showed that although the students could read the graphs, they could not interpret the data by looking at the graphs. These results corroborate with previous research conducted by Kirsch and Mosenthal (1990), Bright and Friel (1998) as well as Capraro, Kulm, and Hammer (2005).

Capraro, Kulm, and Hammer (2005) conducted a study that aimed to measure students' representation and interpretation skills in a given data with 134 sixth grade students. They gave students data and asked them to draw a graph to find the typical number of the data. The results showed that the students could draw a graph using the representation of the data skills, yet they could not make a reasonable interpretation.

Line graphs are commonly used in observing the change and relations between data in the continuous data set (Van de Walle, 2009). Distinguishing between categorical data and continuous data is challenging for students, and as a result, they often struggle with selecting appropriate graph types for a given data set and justifying their selection (Shaugnessy & Zawojewski, 1999; Friel et al., 2001; Brasell & Rowe, 1993). For instance, in the study of Capraro, Kulm, and Hammer (2005), students preferred line graphs in the least percentage. Students have difficulty reading and interpreting them due to the data type and the effect of students' previous experience with other graphs (Boote & Boote, 2017).

Students' graphical skills have also been examined in the statistical literacy concept. Similar to the other statistical concepts, statistical literacy ability in graphical displays could not exceed lower levels. For example, the study completed by Watson and Moritz (1997a) with the three-tiered framework showed that students made analysis and interpretation considering their personal experiences and perceptions instead of using the statistical information in graphs. Similar to Watson and Moritz (1997a), Aoyama and Stephens (2003) stated that the students could read the graphs but had difficulties in critical evaluation them.

In a national context, Koparan (2012) conducted an experiment to enhance students' statistical literacy levels by utilizing Watson and Callingham (2003)'s construct. The traditional approach was compared to the project-based learning approach. While the control group followed the traditional method, the experimental group delved into research and real-world applications. The project-based learning approach was found to have a positive impact on data representation and increased students' statistical literacy levels. However, students struggled to interpret pie charts and line graphs. Overall, project-based learning was found to enhance statistical literacy, but it also highlighted the need for better graph interpretation. Additionally, students began to evaluate data representations more critically after the experiment (Koparan, 2012).

Based on the existing research, it can be concluded that students are capable of effectively reading data from graphs. However, accurately interpreting the information presented can often pose a challenge for them. Selecting an appropriate graph type can also be a daunting task for students, with pie charts and line graphs being the more challenging options. On the other hand, bar graphs are more familiar and easier for students to comprehend. It is worth noting that the use of graphs can have a significant impact on students' comprehension and interpretation of data. Additionally, the type of graphical representation employed can influence their understanding of crucial concepts such as average and variation. Thus, in this study, the data collection tool and the data analysis process were planned considering these issues with which students struggled and the aim of the study.

As discussed earlier, students need to improve their abilities in graphical representation, analysis, and interpretation to enhance their statistical literacy. To achieve this, a study should be conducted, taking into account international and national studies, as well as the graphical displays and components involved. The present study focuses on examining graphical displays in terms of data representation and analysis and interpreting the results to evaluate the statistical literacy of students attending schools in different regions of Turkey.

2.3 The Summary of Literature Review

The preceding section provides a literature review that is relevant to the objectives of our current study. To align with these objectives, the concepts of literacy and statistical literacy were initially defined. In addition, various theoretical frameworks and models concerning statistical literacy were examined. Subsequently, a summary of research on students' statistical literacy levels in international and national contexts, as well as their comprehension of the average, sample, and graphical displays, were presented. All this information provided a better understanding of the factors that could impact students' statistical literacy levels.

The literature review indicated that statistical literacy was a new area of research in mathematics education, and there was a concern for researching statistical literacy within the scope of school mathematics (Shaughnessy, 2007; Watson & Callingham, 2003). Since statistical literacy is a relatively new concept in the literature, there is no consensus on its definition. However, in this study, as mentioned in Chapter 1, Wallman's definition of statistical literacy, which is "Statistical literacy is the ability to understand and critically evaluate statistical results that permeate our daily lives" (1993, p.1), was accepted as a foundation. The four-stage statistical literacy framework developed by Sharma and her colleagues in 2011 and Watson's statistical model developed in 2006 were utilized. These were chosen due to their focus on curriculum coherence, the use of precise verbs for objectives, and the inclusion of dispositional elements. The four stages in the framework, namely

Informal/Idiosyncratic, Consistent/Non-Critical, Early Critical, and Critical, included understanding, representing, analyzing, interpreting, and critically evaluating statistical claims. In addition, the four stages were associated with diverse statistical concepts, and the dispositional elements were also taken into consideration while developing the contextual tasks and selecting the real-life contexts.

As revealed by the literature review, the findings of both international and national studies show that most students have lower levels of statistical literacy (Strauss & Bicher, 1988; Watson & Callingham, 2003; Yolcu, 2012; Çatman-Aksoy & Işıksal-Bostan, 2020), irrespective of which framework was used. Although students could generally demonstrate developed abilities in the average concepts, they had difficulties in the interpretation of a data set, including extreme values or unfamiliar context. In addition to the average concept, the findings of the studies show that sample size and graphical displays are also problematic areas for students to exhibit their statistical literacy skills in the representation and analysis of the data and interpretation of the results components. In the sample size context, students have difficulty applying their sampling knowledge and statistical abilities to draw conclusions in diverse contexts. They struggle with interpreting the sampling of a data set in different contexts and evaluating the representativeness of statistical concepts for the data set. However, students tend to perform better when asked to evaluate data sampling in a sampling context. Also, in the context of graphical displays, students face challenges in interpreting the data presented through various types of graphs. For example, they can read bar graphs but have difficulty interpreting the data. Similarly, students can draw graphs based on given data but struggle in making reasonable interpretations. Graph types pose challenges in terms of understanding the distinction between categorical and continuous data, choosing suitable graph types, and justifying their selection. Students also exhibit lower levels of statistical literacy in graphical displays, relying more on personal experiences and perceptions rather than utilizing statistical information. The data collection tool was prepared considering the aim of the present study and the findings in the literature, and these concepts were examined in a more detailed manner.

Additionally, it can be observed that statistical literacy studies vary based on demographics and investigate different concepts as branches of statistical literacy. PISA prepares some studies and reports on students' statistical literacy; however, the qualitative investigation of the topic is limited in the literature (Yolcu, 2014). Furthermore, the diversity of schooling in Turkey does not adequately reflect the educational environment in the country. Even though qualitative studies may not aim for generalization, it is important for the study to capture the essence of the target population's environment. To achieve this, the sample can be selected to include a diverse representation from the population. Such a study would be beneficial in providing insights to teachers working in different educational settings and informing stakeholders in making decisions about education across all regions of the country. In addition, the statistical literacy levels of students were investigated with frameworks; however, the statistical process components, especially the representation and analysis of the data and interpretation of the result, in which students mostly have difficulty, were not examined separately in statistical literacy concepts. The previous studies show that students can have difficulty in one component only (Koparan, 2012); therefore, it is also significant to investigate statistical literacy with respect to the statistical process components. Therefore, this study aimed to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results.

CHAPTER 3

METHODOLOGY

This study aims to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. Concerning the aim of the study, this section is dedicated to the study's methodology, including research design, population, and sample characteristics, the data collection tool and procedure used for data collection, data analysis, trustworthiness, the researcher's role and bias, and lastly limitations of the study.

3.1 Design of the Study

According to Fraenkel, Wallen and Hyun (2012), a qualitative survey research design involves studying real-world situations without implementing any predefined interventions, in order to delve deeper into the participants' perspectives and understanding of the variable under investigation. In this study, a deeper understanding of students' thought processes can be reached when they answer the statistical literacy tasks. Thus, in order to gain a deeper understanding of the statistical literacy of eighth graders, the design of this study is established as a qualitative survey design.

3.2 Sampling Procedure and Participants

With the objective of exploring the statistical literacy levels of students based on the last two statistical process components, participants were chosen from various

regions of Turkey. The participating students are enrolled in schools in the provinces of Ankara, İstanbul, Kayseri, and Kars. Because of the ease of collecting data and the work situation of the researcher, the sampling procedure is convenience sampling.

To represent the educational diversity in Turkey, at least 50 eighth graders from at least two different schools and different educational environments, such as villages and public and private schools, were selected from each city. The data was collected from Bala, Etimesgut, and Çankaya districts in Ankara, from Ümraniye and Tuzla districts in İstanbul, from Melikgazi and Kocasinan districts in Kayseri, and lastly from Örnek, Atatürk, and Ağadeve districts in Kars. In total, 248 students volunteered to take part in the study, and the Statistical Literacy Task (SLT) was administered to these students. Table 3.1 displays the distribution of the sample across the cities where the participants are enrolled in schools.

Table 3.1 The distribution of the sample across the cities

	Ankara	*İstanbul*	*Kayseri*	*Kars*	*Total (N)*
Sample size (n)	83	50	57	58	248
Type of School	3 Public 0 Private	1 Public 2 Private	2 Public 1 Private	3 Public 0 Private	9 Public 3 Private

All participants in the study are eighth graders, ranging between 14 and 15 years old. According to information provided by the mathematics teachers who administered the task, the majority of the sample consists of students with moderate achievement levels. However, there are a few high-achieving and low-achieving students included as well.

Although there are some similarities among schools in terms of environments, class sizes, lecture materials, and the characteristics and socio-economic status of the students, there are inevitably some differences as well. For example, while two

schools in İstanbul are private and include students of high socio-economic status, all schools in other cities and one in İstanbul are public. The students enrolled in schools located in the Bala district of Ankara are characterized by a low socio-economic status. Similarly, students in Kocasinan district in Kayseri and Ağadeve district in Kars are of low socio-economic status. Significant differences can be observed in the schools and their settings, even within the same city. For example, all schools except the one in Ağadeve have smart boards. Some schools in metropolitans, like Istanbul and Ankara, have more mathematical materials and interactive whiteboards, whereas some schools in other cities, such as Kars, lack these resources. The government gives the textbooks used in lessons. On the other hand, the number and the variety of supplementary resources differ among schools.

3.3 The Data Collection Tool

Acquiring deeper information about the participants' experiences, perspectives, and thought processes have a significant role in a qualitative survey study. Therefore, data collection tools should be used to let the participants explain their thinking in detail through open-ended questions such as interviews, observations, and qualitative surveys (Fraenkel, Wallen & Hyun, 2012). Based on the aim of the study, the Statistical Literacy Task (SLT) survey involving real-life contextual tasks, COVID-19 and the daily diet, was used to collect data. The researcher devised a qualitative survey to administer to eighth-grade students.

The data collection tool involves two tasks with different real-life contexts to examine the influence of different contexts on students' statistical literacy levels since the literature review has shown that context familiarity affects students' performance. There may be variations in familiarity among the participating students due to their diverse cities and schools. Designing the data collection tool in two different contexts helps avoid potential misinterpretations of statistical literacy influenced by context familiarity. In addition, when the contexts were selected, the characteristics such as up-to-datedness and inclusiveness for the contexts were

pursued. For example, one of the contexts pertains to the COVID-19 pandemic, and the students had already lived through the pandemic when the data was collected. The other context is daily diet, which is also a relevant and timely topic related to health.

The tasks are designed as a comprehensive set, including additional information cards that contain statistical questions. These questions can be answered by utilizing the information provided in the tasks. The COVID-19 task involves information such as where and when the pandemic started, the materials aimed at preventing virus infections, and the decrease in the number of cases after vaccination. The daily diet task involves information on the types of nutrition and their kcal intake per gram, daily kcal intake for a daily diet, and the recommended daily nutrient intake for each type of nutrition. The questions in each task are related to this given information.

When designing the data collection tool, the researcher took into account the objectives of the Turkish National Middle School Mathematics Education Curriculum, the standards in the NCTM (National Council of Teachers of Mathematics), and related research in the literature. The table of specifications concerning the objectives of the Turkish mathematics curriculum is presented in Table 3.2.

Table 3.2 Table of specifications concerning the objectives in the curriculum

Objectives (MoNE, 2018)	*Grade Level*	*Covid-19*		*Daily Diet*	
		Representation and Analysis of the Data	*Interpretation of Results*	*Representation and Analysis of the Data*	*Interpretation of Results*
M.5.3.1.3. Students should be able to interpret the data which is represented with a table or bar graph	5	Q1	Q2 Q6	Q1	Q2 Q5
M.6.4.1.1. Students should be able to represent the data from two different groups in a table or a bar graph	6			Q4	
M.6.4.2.2. Students should be able to calculate the mean	6	Q1			
M.6.4.2.2. Students should be able to interpret the mean	6	Q5			Q6
M.7.4.1.2. Students should be able to compute the mean, the median, and the mode of a data set	7	Q5 Q3			Q6
M.7.4.1.2. Students should be able to interpret the mean, the median, and the mode of a data set	7	Q5			Q6
M.7.4.1.2. Students should be able to interpret the pie chart for a data set	7	Q3			Q3 Q5
M.7.4.1.2. Students should be able to represent the data with a bar graph, line graph, or pie chart and transform between the suitable graph types.	7	Q4		Q4	
M.8.4.1.2. Students should be able to construct a bar graph, line graph, or a pie chart	8		Q2		Q3

When preparing the data collection tool, the researcher considered that the students had completed all the necessary objectives before the tasks were implemented. Thus, there were no objectives that would limit their ability to answer. As one of the objectives specifically pertained to eighth-grade students, the tasks were implemented on students in the eighth grade.

The questions in the data collection tool were formulated based on the last two components of the statistical investigation process: representing and analyzing the data and interpreting the results. Each objective has the same number of questions in each task.

Only the last two components were selected because the students in Turkey have difficulties with the representation and analysis of the data. They exhibit intermediate to high levels of proficiency in interpreting the results (Öz, 2019). On the other hand, Batur (2021) stated that among the components of the statistical process, the highest number of objectives are about the representation and analysis of the data component, while the number of objectives about the interpretation of the results is significantly low in the Turkish National Middle School Mathematics Education Curriculum. Based on these intriguing results, the statistical literacy tasks were developed.

Finally, after the preparation of the tasks, the opinions of two experts who are mathematics educators were taken, and the necessary changes were completed. For example, the experts indicated that some questions were prepared as yes or no questions. Based on their recommendations, the questions in both tasks were revised to be more explanatory in nature. Furthermore, the experts suggested making edits to the COVID-19 task. Specifically, they noted that the graph in the second question (Q2) did not have a blank space for December and January. They recommended adding a blank space in the graph for December and January to make Q2 clearer. Another suggestion was about the informative paragraphs. Some paragraphs, such as the introduction paragraphs, contained context-related information that was not necessary for answering the questions since the tasks were presented as information

cards. The experts suggested that informative paragraphs should be kept simple and short to relieve the students from extra information. Thus, the revisions were made according to these suggestions. The last version after revision is presented below.

3.3.1 The COVID-19 Task

The COVID-19 task was adapted from the COVID-19 pandemic report of Hacettepe University (İskit, Tanrıöver & Uzun, 2021) and an article discussing the utilization rates of COVID-19 protection methods (Akyüz et al., 2020). You can find the entire COVID-19 task in Appendix B.1

The table below presents the specifications of the questions in the COVID-19 task, focusing on the last two components.

Table 3.3 Table of specifications of the questions in the COVID-19 task, focusing on the last two components of the statistical investigation process

	Covid-19 task					
	Q1	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*
Representing and analyzing the data	x		x	x	x	
Interpretation of the results		x				x

The COVID-19 task includes six open-ended questions. Table 3.3 indicates that the first, third, fourth, and fifth questions were designed to assess the representation and analysis of the data component. The second and the last questions were designed to assess the component of interpretation of the results.

The task starts with a short paragraph about the COVID-19 pandemic. Then, preceding the first question (Q1), a bar graph is given. The purpose of the question is to evaluate the student's ability to read and comprehend the graph and determine the average based on the given data. In this question, firstly, students are asked to evaluate the data on the graph. The bar graph about the number of COVID-19 cases between March to November 2020 and the first question are presented in Figures 3.1 and 3.2, respectively.

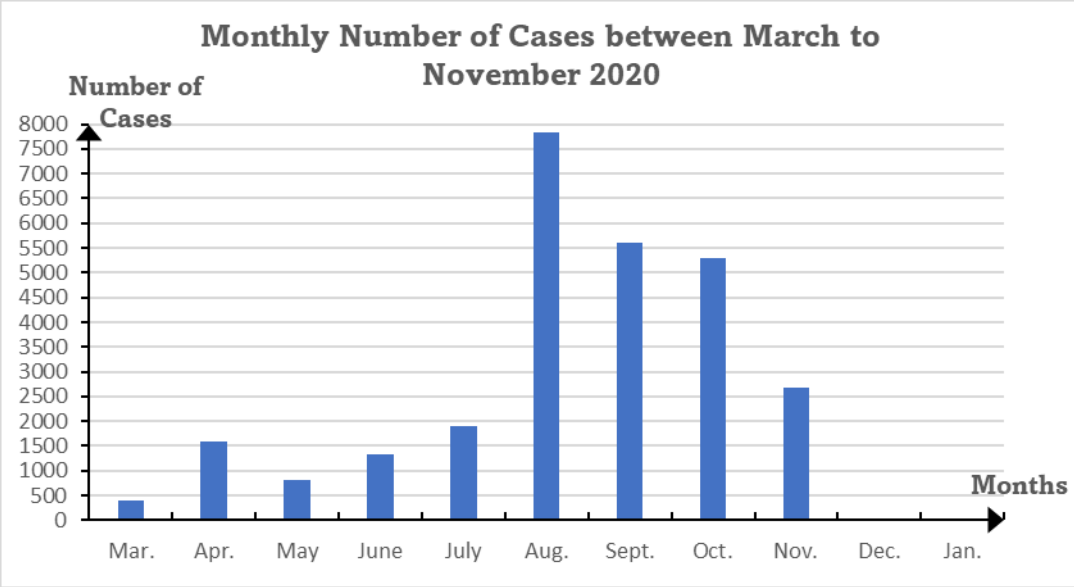


Figure 3.1. The graph for both Q1 and Q2.

1) Evaluate the changing monthly number of cases from 20th of March to 20th of November. What do you think is the average number of monthly cases for these 9 months? How did you come to this conclusion? Explain.

Figure 3.2. The first question of the COVID-19 task.

In the first question (Q1) above, the students are expected to represent and analyze the data. More specifically, the average number of cases in nine months is asked; however, when the students look at the graph, they decide which average concept they should use among measures of central tendency: mean, median, and mode. As the graph is examined, it can be seen that there are some extreme values; therefore, the primary objective of the first question is to evaluate the students' ability to

identify the extreme values and make a decision to use the median for calculating the average. Thus, in this question, the students are expected to evaluate the extreme values in the data and decide to use the median for the average value.

After the first question, students continue with the second one. The second question is given below in Figure 3.3.

2) When you observe the graph, how do you think it would have continued in December 2020 and January 2021? Explain why.

Figure 3.3. The second question of the COVID-19 task.

In question two (Q2) given above, the students are expected to understand the graph, then interpret its results. In question 2 (Q2), students are tasked with interpreting the bar graph presented in Figure 3.1. They are required to make estimations about how the graph would continue in the months of December and January, and provide a detailed explanation of their thought processes. The students are prompted to answer the question by observing the downward trend in the graph during the last four months. Then, the expected answer from students is to state that the number of cases should decrease from November to December and then decrease more from December to January, observing the decreasing trend in the last four months.

Then, after an informative paragraph about the importance of using a mask, a pair of gloves, and sanitizer to prevent the transmission of COVID-19, the students find two graphs about the usage of masks and gloves for both question three (Q3) and question four (Q4). The difference between these two graphs is gender, where one belongs to male participants and the other to females. The first and second pie charts can be found in Figure 3.4 and Figure 3.5, respectively.

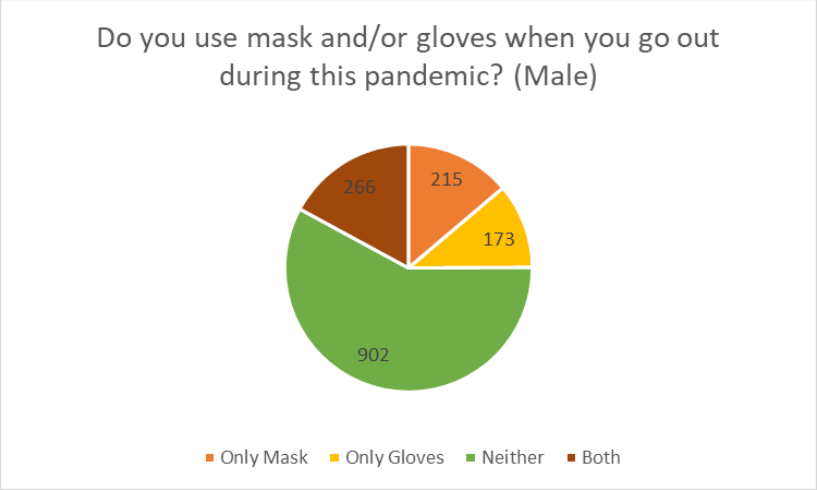


Figure 3.4. The first pie chart of the third and fourth questions

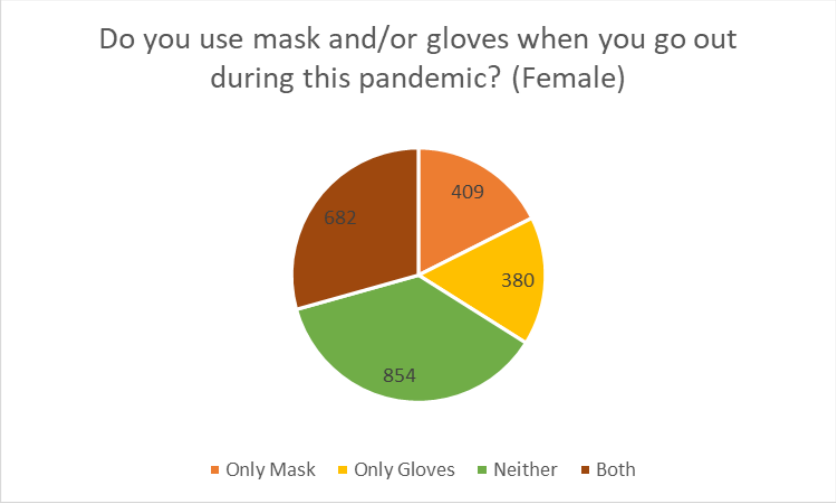


Figure 3.5. The second pie chart of the third and fourth questions

When the graphs are examined, it can be seen that the numbers on the graphs represent the number of participants, not the percentage of participants or the degree of the central angle. Furthermore, when the students add up these numbers, they should notice that the number of female and male participants is not equal. Therefore, they should calculate the ratio for each category to make a correct evaluation. Each pie chart has four colors representing the different categories for mask and glove

usage: red for neither gloves nor mask users, blue for both glove and mask users, purple for only mask users, and green for only glove users.

The third question (Q3) is given in Figure 3.6.

3) By looking at the graphs 2 and 3, what can you say about the use of masks and gloves by male and female participants during the first month of the pandemic? Looking at these graphs, which gender is the more hygienic one?

Figure 3.6. The third question of the COVID-19 task

In Q3, given above, the students are expected to represent and analyze the data. More specifically, once the students understand the question, they should consider measuring the ratio or percentage of the gender categories due to the variation in the number of participants between the two graphs. Lastly, they should compare their findings and solve the question. Another way to solve this question is calculating the red category, neither mask nor glove users. If they only calculate this category, they can analyze how many participants did not care about the protection methods, and thus, they know which gender is more hygienic. The comparison of graphs, evaluating the pie chart, and calculating the ratio and the percentage are seventh-grade objectives. Thus, eighth graders have completed these objectives in the previous academic year.

After the third question, the students continued with the fourth one. The fourth question (Q4) is presented below.

4) If you wanted to show the data in graphs 2 and 3 in one graph, what kind of a graph would you prefer? Why?

Figure 3.7. The fourth question of the COVID-19 task

In question four (Q4), the students are expected to represent and analyze the data. Q4 measures students' knowledge of transmission among the graphs. In Q4, the graphs in Figures 3.4 and 3.5 were used, and the students were asked to determine which type of graph they would choose if they were to merge the data from these

graphs into one. This question assesses students' ability to understand and represent data using different graph types, thereby measuring their data representation skills.

Following Q3 and Q4, an informative paragraph about COVID-19 cases and the number of patients that applied to policlinics is given. A table displaying the number of COVID-19 patients who visited the outpatient clinics is provided, organized by months. This table can be found in Figure 3.8.

Months	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Number of Applicants	396	1598	811	1334	1899	7984	6537	6475	3372

Figure 3.8. The table displaying the number of COVID-19 patients who visited the outpatient clinics, organized by months

Then, the second bar graph of the task follows the table. The graph can be seen in Figure 3.9.

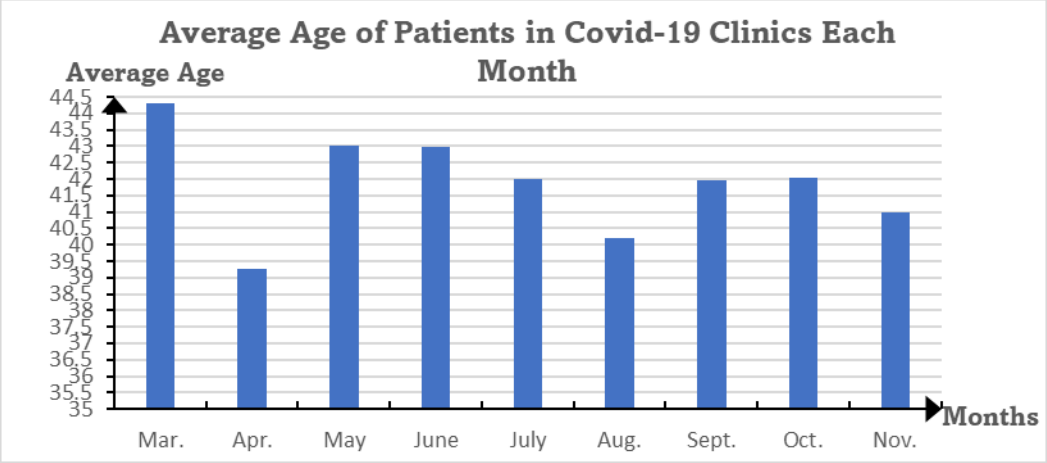


Figure 3.9. The distribution of the average age of the patients who stayed in Covid-19 policlinics in terms of months

This bar graph represents the average age distribution of patients who stayed in COVID-19 outpatient clinics for various months. While the vertical axis represents the average age, the horizontal axis represents months.

In the COVID-19 task, question five, presented in Figure 3.10, is placed under the table and the graph.

5) What is the average age of patients in Covid-19 clinics for the months March, May and August based on the information provided in Table 1 and Graph 4? Explain how and why you have come to this conclusion.

Figure 3.10. The fifth question of the COVID-19 task

In question five (Q5), the students are expected to represent and analyze the data. The table in Figure 3.8 and the bar graph in Figure 3.9 are used to inquire about the average age of the patients who stayed in COVID-19 outpatient clinics during the months of March, May, and August. As the first question in the task, the students must decide which method to use to find the suitable central tendency score. In addition to calculating the score, the reasoning behind their choice is significant for this question.

In the graph in Figure 3.9, the average age is already given; however, it is important for the students not to directly utilize these given average ages. The variation in sample sizes among different months is the reason behind this caution. When the average is calculated, the number of participants should be used. When the students solve Q5, they should use the sample size from the table as the weight of the averages. First, they should calculate the total age of participants each month by multiplying the average age and the number of patients. Then, the total age of three months should be divided by the total sample size of the three months to find the average age of participants who have applied to outpatient clinics during these months.

After discussing the patients who were hospitalized due to the severity of their conditions, there is an informative paragraph about more severe symptoms and the risk of death from the virus. The paragraph mentions that vaccination helps get better quickly and decreases the risk of death from the virus. The table is given in Figure 3.11 and is used for the last question of the task.

	Deceased/Total monitored number of patients.
March	0/111
April	1/216
May	1/103
June	0/115
July	0/144
August	2/265
September	8/185
October	3/123
November	2/49
Total	**17/1365 (1.2%)**

Figure 3.11. The second table about the ratio of deaths to observed patients for each month in the COVID-19 task

The table is about the ratio of deaths to the number of patients and is observed before the next question. The last question of the COVID-19 task is presented in Figure 3.12.

6) Looking at Table 2, comment on the effectiveness of the vaccination in each month in terms of which ones are higher, which one are lower.

Figure 3.12. The sixth question in the COVID-19 task

In question six (Q6) given above, the students are expected to understand and evaluate the table, and then interpret the results from the table. In Q6, regarding the information in the previous paragraph and Table 2 in Figure 3.11, the students are asked to decide when the effect of vaccination had more impact on people and when the effect of vaccination had less impact on people. When deciding, they should first analyze the table. Then, they should simplify the table so that the data includes ratios, not raw numbers, and then compare these ratios to interpret the results. Since the ratio represents the number of deaths divided by the number of patients, the students should recognize that a lower ratio indicates a more favorable outcome in terms of the vaccination effect.

3.3.2 The Daily Diet Task

The second task is about daily diet. For this task, the information was taken from a report called Statistical Reasoning over Lunch (Selmer, Bolyard & Rye, 2011) by the National Council of Teachers of Mathematics (NCTM). Like the COVID-19 task, the daily diet task was also designed as an information card containing statistical questions that assess the students' abilities in representing and analyzing data, as well as interpreting the results based on graphs, tables, and provided data. You can find the entire daily-diet task in Appendix B.2.

The table below displays the specifications of the daily diet task's questions related to the last two components.

Table 3.4 Table of specifications of the daily diet task's questions regarding the last two components of the statistical investigation process

	Daily Diet task					
	Q1	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*
Representing and analyzing the data	x			x		
Interpretation of the results		x	x		x	x

The daily diet task includes six open-ended questions. Table 3.4 shows that the first and fourth questions were designed to assess the representation and analysis of the data component. The second, third, fifth, and last questions were developed to assess the interpretation of results component.

Like the COVID-19 task, the daily diet task starts with an informative paragraph. This paragraph provides information about the different categories of nutrition and

provides examples of foods that belong to each category. It also includes the energy intake of each category based on the weight of the food in grams, measured in kcal. After the paragraph, a table that includes a student's breakfast with nutrients and portions is given, and the energy intake column of the table is left blank on purpose. This table is presented below.

Nutrient Types	Portion (gram)	Energy Intake (kcal)
Bread	50 g	
Eggs	50 g	
Milk	200 g	
Oil	10 g	
Honey	15 g	
Butter	10 g	

Figure 3.13. Nutrients that are taken by a student at breakfast and their portions

After the table, the first question is presented in Figure 3.14.

1) Find the calorie intake for the student for each nutrient in Table 1 and calculate the total calorie that the student has gained from the breakfast once they finish it.

Figure 3.14. The first question in the daily diet task

Representing and analyzing the data is involved in the daily diet task's first question (Q1). In Q1 given above, the students are asked to determine the calorie intake of each food item in the meal, expressed in kcal. They are required to refer to the information provided in the paragraph above the table and consider the food portions specified in the table. To find the calorie intake for each food, first, the students should multiply the portion of the food by per gram energy intake of nutrition types. After calculating the energy intake of each food item based on their respective portions, students are then prompted to determine the total calorie intake of the student whose breakfast is presented in the table.

Q1 also serves the purpose of a warm-up question. The skills required for the following questions are more complex than Q1. Thus, if a student answers the

question accurately, they can attain the maximum score corresponding to the second level in Sharma et al.'s (2011) statistical literacy framework, used when scoring and analyzing the data.

Table 1 in the daily diet task is also used in the second question (Q2). After the first question, students would go on to the second one. The question can be found in Figure 3.15.

2) Based on the breakfast in Table 1 and the Note on a healthy diet, which of the below could be the energy intake of the student?

A)	**B)**	**C)**	**D)**
Noon: 720 kcal Evening: 360 kcal	Noon: 1440 kcal Evening: 1440 kcal	Noon: 430 kcal Evening: 520 kcal	Noon:350 kcal Evening:350kcal

Figure 3.15. The second question in the daily diet task

In question two (Q2) given above, the students are expected to understand the note and interpret the results from the table in the first question. The note mentions that the suggested calorie intake in a day for a healthy daily diet is not to exceed 2200 kcal. In Q1, the students should find 1440 kcal for a student's calorie intake at breakfast. Thus, the participant student should think that the student in Q2 can take a maximum of 760 kcal for lunch and dinner. Q2 asks students to evaluate the suitable hypothetical calorie intake for lunch and dinner based on the calorie taken at breakfast and the note given after Q1. When the students sum the calorie intakes in lunch and dinner for each alternative placed below the question, they can see that the correct answer is D.

Before continuing with the third question, there is another informative paragraph about the acceptable macro nutrition ratios. For a healthy diet, people should take 45 – 65% of their total energy from carbohydrates, 10 – 35% from proteins, and 20 – 35% from fats. The paragraph is presented below.

Acceptable macro nutrition ratios, or in other words, recommended daily nutrient intake based on the type are given as follows for a healthy person:

- Carbonhydrates should be 45% - 65% of the daily total energy intake.
- Proteins should be 10% - 35% of the daily total energy intake.
- Fats should be 20% - 35% of the daily total energy intake.

Figure 3.16. An informative paragraph about the acceptable macro nutrition ratios

After providing the relevant information, Figure 3.17 contains the third question.

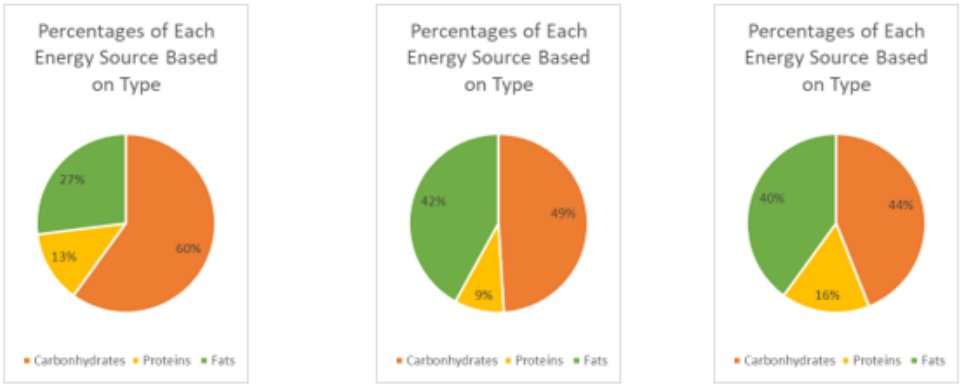
3) Plot the appropriate graph showing the energy intake of a student from each type of nutrient in Table 1. Looking at the graph based on this information, comment on the suitability of the energy intake sources to the ratios that are provided above.

Figure 3.17. The third question in the daily diet task

The third question (Q3) given above was designed to assess the component of interpretation of the results. More specifically, the paragraph in Figure 3.16 and Table 1 completed by the students in Q1 are used. The question contains three steps. The first step is deciding on the appropriate graph type based on the data and the information. The second step is calculating macro nutrition ratios for the data taken from Table 1 and drawing a graph. The last step is looking at the graph and the macro nutrition ratios, comparing the acceptable range for total energy intake and the ranges of macro nutrition ratios for the data in Table 1 and interpreting the comparison results.

Following the third question, students continue with Q4 presented below.

4) Below, you may find the graphs depicting the energy intake of three students divided into different types of nutrients. If we wanted to compare these three students based on their diets, which type of graphic would be the most appropriate one? Why?



First Student Second Student Third Student

Figure 3.18. The fourth question in the daily diet task

The fourth question (Q4) was designed to assess the component of representation and analysis of the data. In Q4, there are three pie charts about the daily percentages of each source based on the nutrition type of three students. The charts are separated into three categories representing different nutrition types: orange for carbohydrates, green for fats, and yellow for proteins. The purpose of the question is to have the students choose the most appropriate graph type to compare the diet of the students whose daily diet graphs are presented below the question. This means that students should examine the graphs and decide which type of graph they should use to represent all the data they have regarding whether the data type is categorical or continuous.

After the fourth question, students continue with the fifth one. The graphs in Q4 are used in Q5 given in Figure 3.19.

5) In the fourth question, the graphs showing the percentages of energy intake sources from different types of nutrients are given for three students. Based on the information provided above, determine whether the students' diets are healthy or not and explain why.

Figure 3.19. The fifth question of the daily diet task

The fifth question (Q5) given above was developed to assess the component of interpretation of the results. Q5 is a continuum because the questions are about the same graphs; however, solving Q5 is not dependent on solving Q4. In Q4, students are tasked with determining the appropriate graph type for comparing the data, which pertains to the representation of data in the statistical literacy framework. Q5, on the other hand, asks students to interpret which students' diets are healthy based on the range of macro-nutrient ratios, focusing on the interpretation component of the framework. Thus, the question measures whether students can decide whether the data obtained from the pie charts as percentages are in the range of macro nutrition ratios or not.

The students' explanations are important because they should clearly state whether the nutrition types are proper for each macro nutrition ratio. If some students whose diets are given on the graphs do not have a healthy diet, the participants should state which nutrition type does not fit the ranges.

After the fifth question, the daily diet task concludes with the sixth question (Q6), which presents a table displaying the daily total calorie intake of fifteen students. The table is presented in Figure 3.20.

Student No.	Taken kcal
1	2639,1
2	2157,4
3	1721,0
4	1803,1
5	2620,2
6	2315,1
7	2046,1
8	2400,0
9	2600,1
10	2250,0
11	1876,4
12	1852,0
13	2548,0
14	2384,0
15	2215,0

Figure 3.20. The second table about the total daily kcal per student in the daily diet task

The table contains two columns: one for students' rank and the other for the daily total kcal intake per student. The question and the table are next to each other in the task. The question can be found in Figure 3.21.

6) Table 2 given on the right shows the daily kcal intake for fifteen students. Based on this data, comment whether the students here have a balanced diet. Do you think the amount of energy intake for this group of students is healthy compared to the recommended daily energy intake?

Figure 3.21. The sixth question in the daily diet task

The last question above was designed to assess the component of interpreting the results. Question six asks the students to make an interpretation of a group of people's daily diet based on the table next to it and the note which mentions the limit of total daily calorie intake for a healthy diet. The note states that the limit of the total calorie intake for a healthy diet is 2200 kcal per day. When answering the question, students should consider the note, which is not reiterated in the task, as they should have already learned this while solving the other questions.

The aim of the sixth question is to assess the student's ability to identify the appropriate approach for solving the problem. To determine whether the group of students had a healthy diet or not, the students should calculate the average calorie intake for the group. However, the question does not explicitly mention this. Once the students understand the need to calculate the average for the group, they should determine which type of central tendency would be appropriate. After calculating suitable central tendency, students reach the most crucial part of the question, combining the result and the information from the note and interpreting whether the group has a healthy daily diet or not considering their daily calorie intake.

In conclusion, the students are tested with an instrument containing two real-life contextual tasks: COVID-19 and daily diet. Both tasks include six open-ended

questions, while one is a multiple-choice question in the daily diet task that requires an explanation. The researcher prepared the questions based on the objectives of the Turkish mathematics curriculum and the last two components of the statistical investigation process. The average scores are derived from the analysis of the results obtained from the tasks. The scores are based on the stages of the statistical literacy framework by Sharma et al. (2011).

3.4 Pilot Study

The pilot study was conducted with the aim of identifying and addressing potential issues related to the clarity and comprehension of the instrument, as well as any issues that may arise during the administration of the tests, such as time constraints for answering all the questions and ensuring the validity and reliability of the study. (Fraenkel, Wallen & Hyun, 2012). The data for the pilot study was collected from students in Şanlıurfa and Şırnak and used to identify potential issues that could arise during data collection, as well as to assess the comprehensibility and clarity of the study materials.

The pilot study was conducted with ten students, seven from Şanlıurfa and the remaining from Şırnak, in the spring semester of 2022. Since the participants in the fall semester learned all the necessary objectives of the instrument involved, they were also ready to test in the pilot study. The students and their schools have several characteristics in common such as grades and educational settings. The teachers of the students conducted the tests and collected the answer sheets. Thus, the data collection and pilot study followed the same procedure.

After the pilot study, the necessary revisions to the procedure were made. During the pilot study, it was observed that the instruments were printed in black-and-white, resulting in decreased clarity for certain questions. As a result, adjustments were made to ensure that the graphs and visuals used in the study were suitable for black-and-white printing. This was done to maintain the clarity and comprehensibility of

the materials, even when printed in black-and-white format. The instrument was applied after taking experts' opinions. Following the pilot study, the students had no difficulty understanding the questions. Thus, there was no need to revise the data collection tool again.

3.5 Data Collection Procedure of the Study

The researcher prepared the data collection tool in the fall semester of the 2021-2022 academic year, and it was ready after the experts' approval. Then, after applying to the Middle East Technical University Human Subjects Ethics Committee, permission was sought to ensure the ethical feasibility of the study and the data collection process. After obtaining the necessary approval, the data was collected in the spring semester of the 2021-2022 academic year (see Appendix A). The time schedule of the study is presented in Table 3.5.

Table 3.5 Time schedule of the study

Date	*Tasks*
December 2021-February 2022	Preparation of the instrument
March 2022	Receiving the permission
April 2022	Pilot study
April-May 2022	Data Collection
June-August 2022	Data Analysis

After obtaining permission from the school principals and the parents of the participating students, each task was administered to the voluntary students within a forty-minute timeframe over the course of two consecutive weeks. Additionally, with the consent of the school principals and the parents, the mathematics teachers at the selected schools allocated two math lessons for the implementation of the data

collection tool. This ensured that the students had sufficient time and the necessary classroom support to complete the tasks effectively. Before collecting data, the researcher told every teacher who implemented the tasks how to implement the tasks, to tell the students what is expected of them, and the points to consider. Thus, equality in testing was ensured.

The teachers asked the students to answer all the questions by describing their thought processes. The data was collected from 248 students in Bala, Etimesgut, and Çankaya districts in Ankara, in Ümraniye and Tuzla districts in İstanbul, in Melikgazi and Kocasinan districts in Kayseri, and lastly in Örnek, Atatürk, and Ağadeve districts in Kars.

3.6 Data Analysis

The objective of this study is to examine the statistical literacy levels of eighth-grade students attending schools in various regions of Turkey. The focus is on their proficiency in statistical literacy within the contexts of COVID-19 and daily diet, specifically related to two components of the statistical process: representation and analysis of the data, and interpretation of the results. In this study, content analysis was performed to address the research question.

During the data analysis phase of the study, the four-stage statistical literacy framework proposed by Sharma et al. (2011), as discussed in Chapter 2, was utilized. See Appendices D and E in order to understand how this framework is used to create a rubric and evaluate the answers of the students. This framework serves as a guide to assess and interpret the statistical literacy levels of the participating students. The stages of the framework are “Informal/idiosyncratic” for Level 0-1, “Consistent non-critical” for Level 2, “Early critical” for Level 3, and “Advanced critical” for Level 4, and all of these stages involve some objectives that determine the level of statistical literacy of students. As mentioned earlier, one of the reasons why the framework of Sharma et al. (2011) was chosen as the data analysis method is that

the framework is based on Watson and Callingham's (2003) and Watson's (2006) statistical literacy construct that is fundamental for statistical literacy. On the other hand, it is more up-to-date compared with them. The framework aims to help teachers scaffold and assess students. Thus, by employing the Sharma et al. (2011) framework, it becomes possible to assess the statistical literacy of students based on the objectives expected to be achieved by students completing middle school. This framework allows for the measurement of students' statistical literacy in a manner that is appropriate for their age, rather than evaluating them based on the statistical literacy of an average adult. The last significant point is that the gaps between the level are not fully separated or far apart from each other like in other frameworks. Thus, students' statistical literacy development can be examined much more easily (Sharma et al., 2011).

The framework is presented in Table 3.6.

Table 3.6 The objectives to complete the stages of the framework (Sharma et al., 2011, pp.125-126-127)

The Stages	General Characteristics of the Stages	The Objectives of the Stages
Level 0-1 Informal/idiosyncratic	Pre-structural or, at most, Uni-structural thinking	There is only an informal engagement with context, often reflecting intuitive non-statistical ideas and belief Due to reading or writing difficulties, students cannot explain their thinking and often guess answers. Concerning statistical terminology, students provide random or inappropriate explanations. When making inferences, students focus on imaginative storytelling or inappropriate aspects. Students use subjective reasoning to describe measures of center or spread of data. Questions are not based on the data or focused on irrelevant contextual issues. Students are successful at some basic table and graph reading, as these require an understanding of single elements and essential one-step straightforward reading.
Level 2 Consistent non-critical	Uni-structural and Multi-structural thinking	Students focus on a single relevant aspect or attempt to attend to one or more relevant aspects of the data but have difficulty integrating the aspects. Appropriate but non-critical engagement with context. Proper use of statistical skills associated with simple statistics and graph characteristics. Single or partially accurate comparisons are made within a data, table, or graph. General or single statements made about the data collection methods and validity of findings with no reference to context. Questions asked are valid but based on one aspect of data.

Table 3.6 (continued)

Level 3 Early critical	Relational Thinking (more than one relevant aspect of the data and beginning to integrate the aspects.)	There is critical engagement in familiar contexts. There is selective engagement with unfamiliar contexts with some justification. There is an appropriate use of terminology, qualitative interpretation of chance, and appreciation of variation. Students demonstrate awareness of relevant features of displays and measures of center and spread; however, these are primarily based on the data or the context, not both. Questions asked of the data are based on more than one aspect of the data task but are not always connected. Students are likely to relate several elements together about data collection methods and graphing; they can manage two variables at the same time.
Level 4 Advanced critical	Integrate Statistical and Contextual Knowledge that exhibits extended Abstract thinking (relate several aspects of a task together to use as the basis for prediction, generalization, reflection, or creation of new understanding.)	There is a critical, questioning engagement with context. There is an understanding of the purpose of the data, data displays, measures of center, and inferences made. There is a critical evaluation of data collection methods, choice of measures, and validity of findings that show appreciation of variation and the need for uncertainty in making predictions. Sophisticated statistical and mathematical skills are associated with success at this stage, especially in media contexts. There is the ability to interpret subtle aspects of language. Questions asked are based on relevant features of the data and the context using multiple perspectives.

Table 3.6 shows the four-stage statistical literacy framework of Sharma et al. (2011), the general features of the stages, and the corresponding objectives that reflect the desired statistical abilities of the students. These objectives serve as a reference when evaluating the students' answer sheets to assess their level of statistical literacy.

As shown in Table 3.6, the general characteristics of Level 0-1 can be described as "Pre-structural or, at most Uni-structural thinking." These characteristics imply that students at this level struggle to explain their thinking or provide accurate explanations, often resorting to guessing. In terms of the representation and analysis of data component, the table indicates that students demonstrate basic proficiency in reading tables and graphs that involve single elements and straightforward one-step interpretations. However, when it comes to interpreting the results component, students tend to focus on imaginative storytelling or may provide inappropriate perspectives.

The general characteristics of Level 2 of the framework are “Uni-structural and Multi-structural thinking”. As seen in Table 3.6, students focus on a single relevant aspect at this level and have difficulty integrating the aspects. They have appropriate but non-critical engagement with the context. In the representation and analysis of the data component, Table 3.6 indicates that they accurately use the statistical skills associated with simple statistics and graph characteristics. However, they can make single or partially correct comparisons within a data table or graph (Sharma et al., 2011).

Level 3, according to Biggs (1999), marks the transition to relational thinking, where learning outcomes involve making connections and students are able to achieve objectives such as comparing, analyzing, and explaining causation. As seen in the table, students can engage critically in familiar contexts at this level, and there is a selective engagement with unfamiliar contexts with some justification. In the representation and analysis of the data component, students can show awareness of relevant features of displays and measures of center and spread. However, the

awareness is based on the data or context, not both. Moreover, in interpreting the results component, students can use suitable terminology and make qualitative interpretations in chance and appreciation variation (Sharma et al., 2011).

The last and highest level expects the integration of statistical and contextual knowledge that exhibits extended abstract thinking. Students in Level 4 can "relate several aspects of a task together to use as the basis for prediction, generalization, reflection or creation of new understanding" (Sharma et al., 2011, p.125-126-127). They can have a critical, questioning engagement with context. The understanding of the purpose of the data, data displays, measures of center, and inferences can be made by students. In the representation and analysis of the data component, sophisticated statistical and mathematical skills can be successfully applied by students in the analysis of the data part, especially in media contexts. Lastly, in interpreting the results component, students can demonstrate the ability to interpret subtle aspects of language, critically evaluate information, and understand the value of variability and uncertainty in making predictions (Sharma et al., 2011).

The scoring was performed according to the objectives categorized by Sharma et al. and was investigated by another researcher from the Department of Elementary Mathematics Education. The rubric exhibits the characteristics of an analytic rubric, which provides detailed criteria for each objective that students are expected to demonstrate. The division into these levels is determined by assessing whether students have acquired the statistical skills to effectively communicate their understanding to other educators.

The scoring was completed concerning the framework stages and the pre-determined rules. For example, if the students gave incorrect responses, they were scored with 0 points. If the students gave the correct answer without an explanation or guessing the answer, they received a score of 1. Regarding the questions' features or the objective that the researcher wanted to investigate, if the students gave the correct answer with a reasonable explanation that is not statistical, they were awarded 2 points. If the students gave the correct answer with a reasonable statistical explanation without

any mathematical computation, they were awarded 3 points. The highest score 4 was given to the students who gave the correct answer with a reasonable statistical explanation and needed mathematical computation to solve the question. The levels of the students and their answer sheets were compared, and final scores were assigned based on the extent to which they aligned with the expected objectives.

After analyzing each student's answer to each question, the responses were categorized into their corresponding framework levels. Then, each student's quartile range and percentile were calculated. For example, the component of the interterpretation of the results contains four questions in daily diet task. It is possible to score at most Level 4 for all of them. Students can get a highest score of 16 when they answer all four questions, correctly. Thus, the range for the representation and analysis of the data 0 to 16. In this case, for interterpretations of the results component in daily diet task, the first quartile, the median and the third quartile can be determined as 4, 8 and 12, respectively. This makes the ranges for each quartile [0, 4], (4, 8], (8, 12] and (13, 16] respectively.

3.7 Validity and Reliability

The study aims to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. In every study, considering validity and reliability issues is significant (Merriam, 2009).

Validity is achieved when the test measures what it is supposed to measure (Fraenkel & Wallen, 2006). Validity was ensured with content validity evidence by checking the objectives in the curriculum prepared by the MoNE and the four-stage statistical literacy framework of Sharma et al. (2011). The questions were prepared in parallel with the curriculum objectives. Then, the statistical literacy task was examined by

two experts who gave opinions about the clarity and consistency of the questions with the specification table, which was prepared considering the last two statistical process components. The table of specifications for checking the coherence of the questions with the curriculum objectives and the validity of the data collection tool was placed in section 3.3 in Table 3.2.

The instrument's reliability is "the consistency of the scores obtained" (Fraenkel, Wallen & Hyun 2012, p.154). In this study, to ensure reliability, a co-coder who graduated from the Elementary Mathematics Education Department was informed about the purpose, the concept, and the framework of the study. The coder independently coded the answers of 100 participants, and the scores of the coders were compared. Then, after the analysis and scoring process, Cronbach's alpha coefficient of the data was calculated as 0.88 via SPSS. Fraenkel et al. (2012) stated that for an instrument to be considered reliable, it should have a coefficient of 0.70 or higher. Therefore, based on their statement, the instrument used in the study can be considered reliable.

3.8 Researcher Role and Bias

Researchers have an essential role in collecting and analyzing the data in a qualitative survey study (Merriam, 1998). In qualitative survey, the analyses of open-ended questions might be subjective and be affected by the researcher's perspective and bias (Gagliardi, 2016). Thus, it is vital to shape the procedure of data collection and interpretation of the results so that the validity and reliability of the study results is ensured.

The researcher's role in this study was quite limited. Firstly, the researcher did not know the participants and was not their teacher. Thus, there was no interaction between students and the researcher before and during the study.

Secondly, even though the researcher did not directly collect the data, the instructions about the implementation procedure were given to data collectors before

implementing the questionnaire. They were informed about the importance of strictly following these instructions in order to ensure the accuracy and reliability of the results and to maintain the integrity of the study.

Lastly, as mentioned before, including the co-coder and Cronbach's alpha analysis results showed that the study is credible.

3.9 Assumptions and Limitations of the Study

Before conducting the study, some assumptions were made. The first assumption was that students' statistical literacy can be measured in all aspects with the Statistical Literacy Task using the statistical process components and Sharma et al.'s (2011) statistical literacy framework. The second assumption was that the data collection tool was implemented for students under the same conditions. The third assumption was that the students were sincere, willing, and able to reflect all their thoughts about the questions on the data collection tools while responding to the questions. The last assumption was that their answers to the task were clear and understandable.

As for the limitations, one limitation is that it focuses on only two real-life contexts, namely COVID-19 and daily diet. This limited scope may restrict the generalizability of the findings to other contexts or domains of statistical literacy.

CHAPTER 4

FINDINGS

The study aims to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results.

This chapter is organized around the findings of eighth graders' statistical literacy in two real-life contextual tasks: COVID-19 and daily diet. In each subsection of the tasks, the last two statistical process components, representation and analysis of the data and interpretation of the results, were presented by considering the specific cities where the data was collected. After presenting the data and analyzing the students' responses, the findings regarding the examples of students' responses were discussed, and their corresponding statistical literacy levels were identified. In addition to identification of statistical literacy levels, the students' statistical literacy were examined in terms of the statistical content domains such as average and graphical displays. This information was then summarized in the findings chapter to provide an overview of the results obtained from the study.

4.1 The Findings pertaining to the COVID-19 Context

This part presents the findings regarding the students' statistical literacy in the COVID-19 task. The study focused on investigating the task in relation to the last two components of the statistical process: representing and analyzing the data and interpreting the results of statistical process components. The number of students in each level, considering the cities and the components for the COVID-19 task, was presented in Table 4.1.

Table 4.1 The number of students in each level, considering the cities and the components for the COVID-19 task

	Frequencies of Statistical Literacy Levels from the COVID-19 Task					
	Ankara	*İstanbul*	*Kayseri*	*Kars*	*Total*	*Percentage*
Representation and Analysis of the Data						
Level 0-1	75	35	50	32	192	77.42%
Level 2	8	14	7	25	54	21.77%
Level 3	0	1	0	1	2	0.81%
Level 4	0	0	0	0	0	0.00%
TOTAL	83	50	57	58	248	100.00%
Interpretation of the Results						
Level 0-1	66	44	45	50	205	82.66%
Level 2	17	5	12	7	41	16.53%
Level 3	0	1	0	1	2	0.81%
Level 4	0	0	0	0	0	0.00%
TOTAL	83	50	57	58	248	100.00%

Table 4.1 indicates the frequencies of students' statistical literacy levels in different cities and the corresponding percentages of students in each level for the components of the COVID-19 task.

When Table 4.1 is examined, it can be observed that 244 students (98.39%) were classified as having a low level of statistical literacy, while four students (1.61%) were classified as having a high level of statistical literacy.

Examining these students' levels in detail for representation and analysis of the data component, it can be observed that 192 students (77.42%) are in Level 0-1, 54 students (21.77%) are in Level 2, and 2 students (0.81%) are in Level 3. No students (0.00%) are in Level 4. Moreover, for interpretation of the results component, 205 students (82.66%) are in Level 0-1, 41 students (16.53%) are in Level 2, 2 students (0.81%) are in Level 3, and no students (0.00%) are in Level 4.

Additionally, when the frequencies of the last two statistical process components in the COVID-19 are examined, it can be stated that only 2 students (0.81%) have high statistical literacy skills in representing and analyzing the data component. There is no student (0.00%) in Level 4. Furthermore, two students (0.81%) have high statistical literacy skills in interpreting the results component. There is no student (0.00%) in Level 4. The findings show that the number of students interpreting the results component and representing and analyzing the data component is the same in the COVID-19 task.

Table 4.1 shows that many students in each city have low levels of statistical literacy. When the table is examined in detail, it can be stated that no students (0.00%) are in Level 4, and there are four students, two from İstanbul (4.00%) and two from Kars (3.45%), in Level 3. Thus, 0.00% of students from Ankara, 4.00% from İstanbul, 0.00% from Kayseri, and 3.45% from Kars have high-level statistical literacy. Therefore, the highest percentages belong to İstanbul and Kars, respectively.

Moreover, when the components are examined in detail across the cities, it is seen that in the representation and analysis of the data component, two students (0.81%) have high statistical literacy skills, while none (0.00%) of them are in Level 4. In the same task, there are two students (0.81%) in Level 3, and one is from Istanbul (2.00%) and one is from Kars (1.72%). This indicates that the highest percentage of

students with high statistical literacy in the representation and analysis of data component in the COVID-19 task is from Istanbul, followed by Kars.

In the interpreting the results component of the COVID-19 task, none of the students (0.00%) are in Level 4, indicating no students have achieved the highest level of statistical literacy in this component. However, there are two students (0.81%) in Level 3, with one student each from Istanbul (2.00%) and Kars (1.72%). This means that 2.00% of students from Istanbul and 1.72% from Kars demonstrate high statistical literacy in interpreting the results component. Therefore, the highest percentage of students with high statistical literacy in interpreting the results component in the COVID-19 task is from Istanbul.

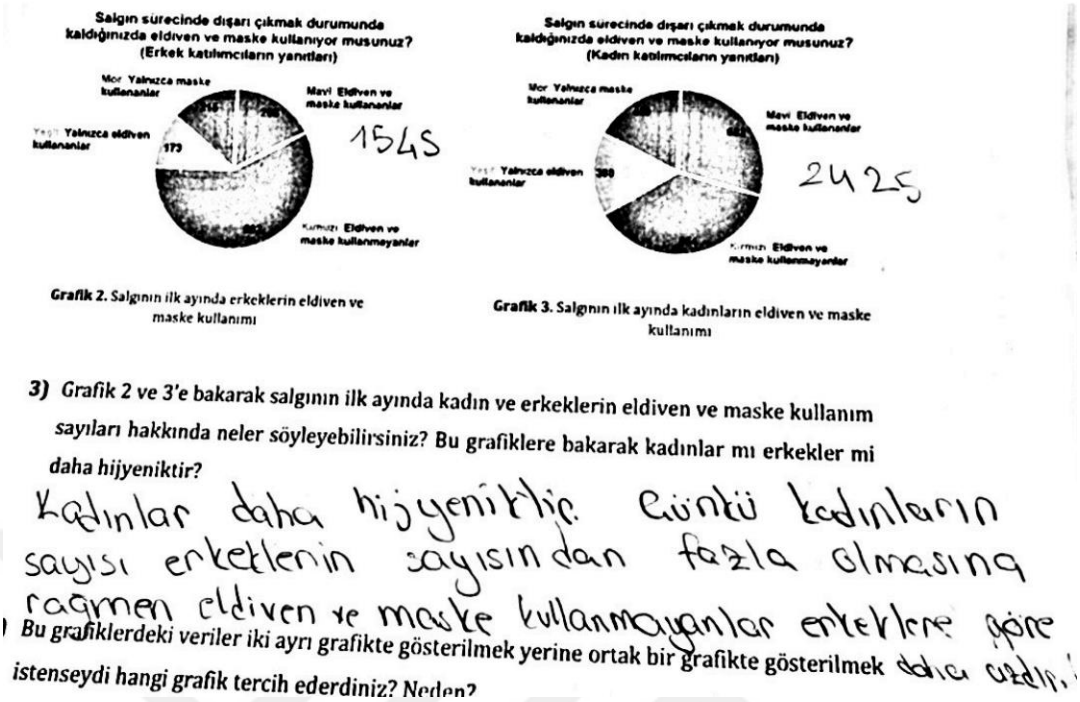
4.1.1 Sample Student Answers in the Context of COVID-19

This section presents sample student answers in two different subsections considering two statistical process components: representing and analyzing the data and interpreting the results.

4.1.1.1 Examples for the Representation and Analysis of the Data Component

The COVID-19 task involves four questions for the representation and analysis of the data component, which are Q1, Q3, Q4, and Q5. Sample student responses are given below concerning the determined statistical literacy levels.

Firstly, in the representation and analysis of the data component for the COVID-19 task, no student (0.00%) achieved Level 4. One sample answer for Level 4 is presented below.



Grafik 2. Salgının ilk ayında erkeklerin eldiven ve maske kullanımı

Grafik 3. Salgının ilk ayında kadınların eldiven ve maske kullanımı

3) *Grafik 2 ve 3'e bakarak salgının ilk ayında kadın ve erkeklerin eldiven ve maske kullanım sayıları hakkında neler söyleyebilirsiniz? Bu grafiklere bakarak kadınlar mı erkekler mi daha hijyeniktir?*

Kadınlar daha hijyeniktir. Çünkü kadınların sayısı erkeklerin sayısından fazla olmasına rağmen eldiven ve maske kullanmayanlar erkeklere göre

Bu grafiklerdeki veriler iki ayrı grafikte gösterilmek yerine ortak bir grafikte gösterilmek istenseydi hangi grafik tercih ederdiniz? Neden?

Figure 4.1. One student's response corresponding to Level 4 in the COVID-19 task

As mentioned in Chapter 3, this question asks students to compare the two graphs and think of measuring the ratio or percentage of the categories for women and men due to the difference in the number of participants.

In the answer in Figure 4.1, the student said, "Women are more hygienic than men because the number of women participants who use neither gloves nor masks are less than that of men. However, the sample size of women is larger than men."

The student calculated the sample size for two groups by adding the number of participants for all segments, which is mathematical evidence. The student explained the solution by emphasizing the contradiction that the sample size of women is more than women while the number of men who did not use gloves or masks is more than that of women. Comparing the sample size and emphasizing the contradiction are evidence of statistical skills. Thus, the explanation includes sophisticated statistical and mathematical skills for the context without using all segments in the pie charts or percentages to find the correct answer. Also, there is evidence of understanding the purpose of the data, data displays, and inferences made in this answer.

Secondly, for the representation and analysis of the data component, responses of 17 students (1.71%) out of 992 questions are in Level 3 in the COVID-19 task, while two students (0.81%) are in Level 3 according to the overall scores. One sample answer for Level 3 is given below.

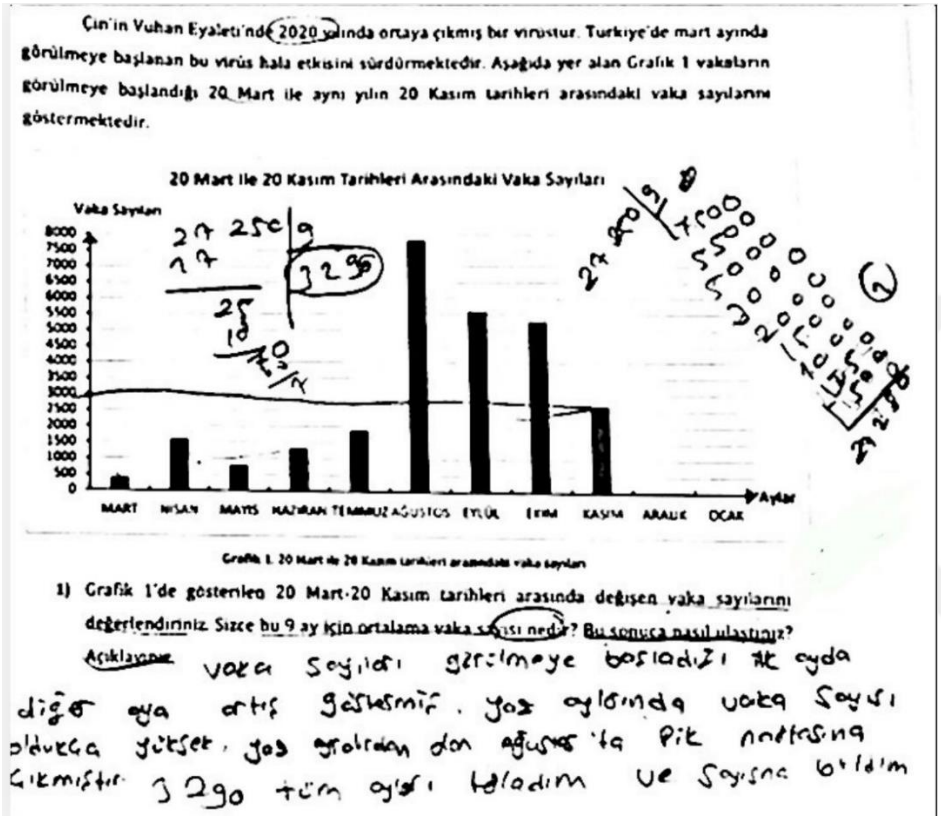


Figure 4.2. A student's answer for Level 3 in the Covid-19 task

As mentioned in Chapter 3, Q1 asks students to find the average number of patients using the graph. When a student solves the question, the type of central tendency should be considered.

In the answer in Figure 4.2, the student said, "The number of cases has increased since the start, especially in the summer months, and peaked in August." Then, the student added the number of cases for all months and divided it into nine, considering the number of given months in the graph.

According to the student's answer, it is clear that the mean score was used to calculate the average number of patients after analyzing the graph. However, the data contains outliers, such as the unusually high number of patients in August. This suggests that the student's statistical knowledge in data analysis was insufficient or inadequate. Sharma et al. (2011) stated that students are in Level 3 when they demonstrate awareness of relevant features of displays and measures of center; however, these are primarily based on the data or the context, not both. Thus, even though the mathematical part, calculating the mean score, was correct, the student's statistical literacy was determined as Level 3.

Another sample student answer corresponding to Level 3 is given below.

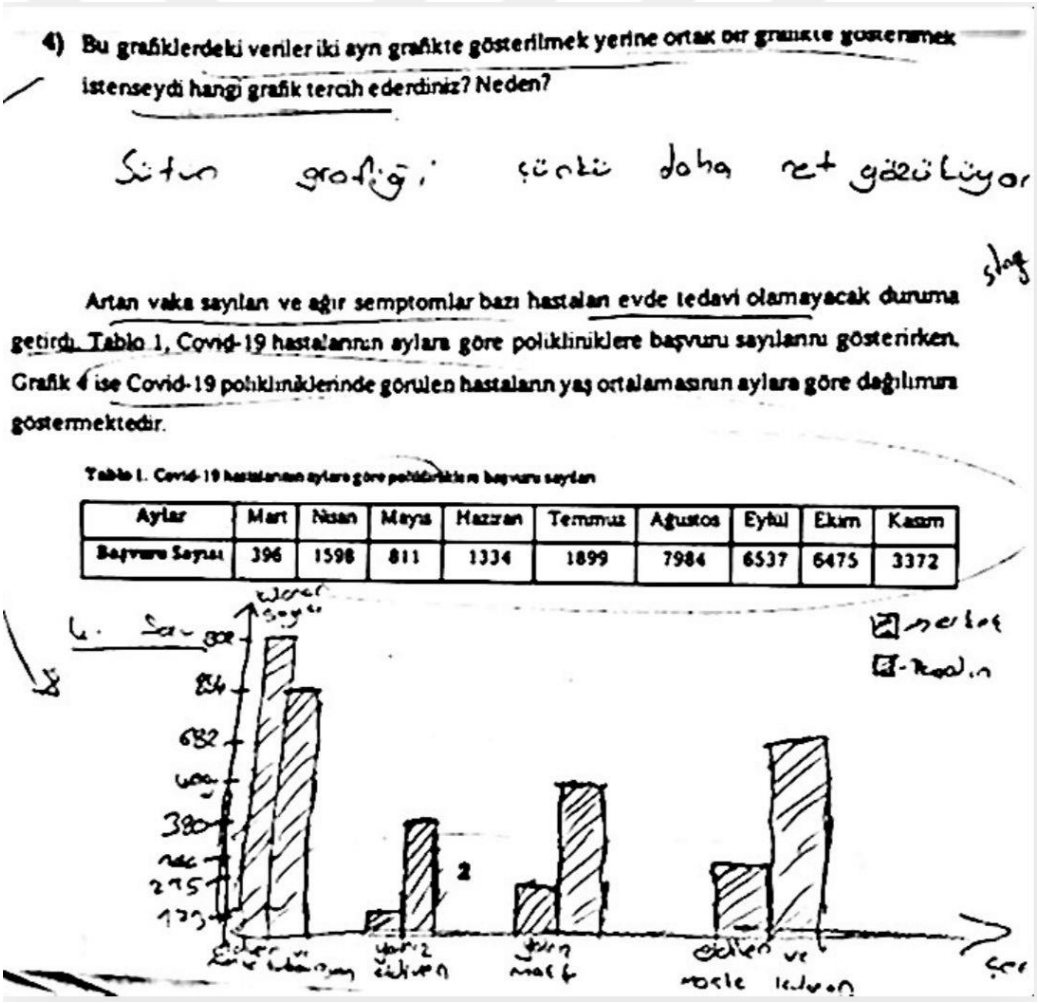


Figure 4.3. A student's answer for Level 3 in the Covid-19 task

As mentioned in Chapter 3, Q4 asks the students to determine which type of graph they would choose if they were to merge the data from Graphs 2 and 3 into one graph. This question assesses the students' ability to understand the features of different graph types and their proficiency in data representation and transmission.

In this question, students should consider two main features of the bar graph when two pie charts in Q3 are merged to form a bar graph. These features are the suitability for categorical data and the ease of comparison. The students are expected to answer the question, considering these features in Level 4.

When Figure 4.3 is examined, it is seen that the student answered the question by saying, “The suitable graph should be a bar graph since the data is seen clearer this way.” Also, they drew a bar graph to explain their thinking.

Even though the transformation of the graph and the answer were correct, the explanation provided needed revision. The student was able to handle the two groups appropriately during the graph transformation. However, it was necessary to mention the specific transformation required due to the features of the bar graph, such as its suitability for representing categorical data and facilitating comparison between the data. According to Sharma et al. (2011), students in Level 3 are likely to relate several elements together about data collection methods and graphing; they can manage two variables at the same time. Thus, the statistical literacy skill in the answer corresponds to Level 3.

Lastly, for the representation and analysis of the data component, the answers of 137 students (13.81%) out of 992questions are in Level 2, in the COVID-19 task, while 54 students (21.77%) are in Level 2 according to the overall scores. Sample student responses determined as Level 2 are presented below.

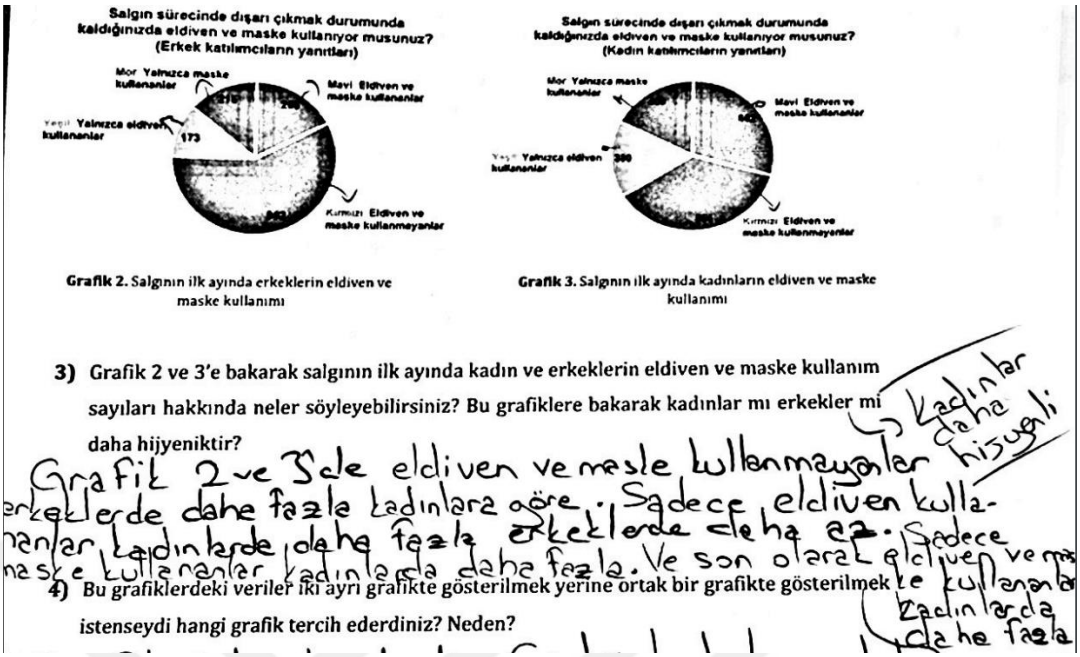


Figure 4.4. One student's Level 2 response in the COVID-19 task

This question is explained and exemplified with an answer determined as Level 4.

In Figure 4.4, the student said, "In graphs 2 and 3, the number of men who used neither gloves nor masks were higher than that of women. Also, the number of women who used just gloves, who used just masks, and both gloves and masks were higher than that of men. Thus, women were more hygienic than men."

Based on this response, it can be stated that the student solved the question by analyzing all segments. As mentioned earlier, using numbers instead of ratios is incorrect because of the unequal sample size of women and men. The student made the right decision by relating the information in the context. However, their statistical knowledge was inadequate as they directly compared two groups with unequal sample sizes, which is incorrect. As mentioned in Chapter 3, it is stated in Sharma et al.'s (2011, pp. 125-126-127) framework that "Students focus on a single relevant aspect or attempt to attend to one or more relevant aspects of the data but have difficulty integrating the aspects", which caused the student to be in Level 2. Thus, due to the lack of mathematical explanations and skills, and problems in integrating

the sample size while calculating the mean score, the student is in Level 2 in this question.

Another student response corresponding to Level 2 is presented below.

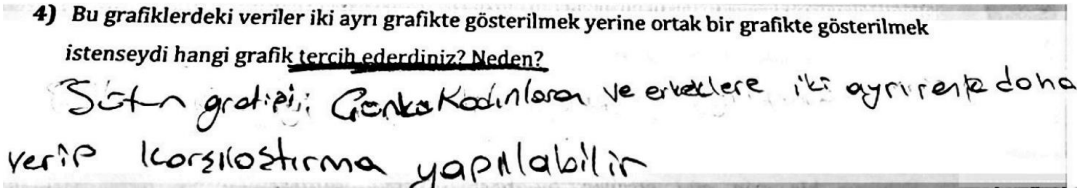


Figure 4.5. One student's response corresponding to Level 2 in the COVID-19 task

This question is explained and exemplified with a response determined as Level 4.

As seen in Figure 4.5, the student said, "The comparison can be made with a bar graph using two colors for women and men."

Although the student chose the proper graphical display, the explanation of the response included only one of the two main statistical knowledge. The student focused only on an appropriate display for the comparison. The student should have addressed the features of categorical data and displayed representation skills. As mentioned in Chapter 3, Sharma et al. (2011) stated that single or partially accurate comparisons are made within a data, table, or graph in Level 2. Thus, the student's statistical knowledge seems inadequate, and the statistical level was determined as 2.

Other sample student responses corresponding to Level 2 are presented below.

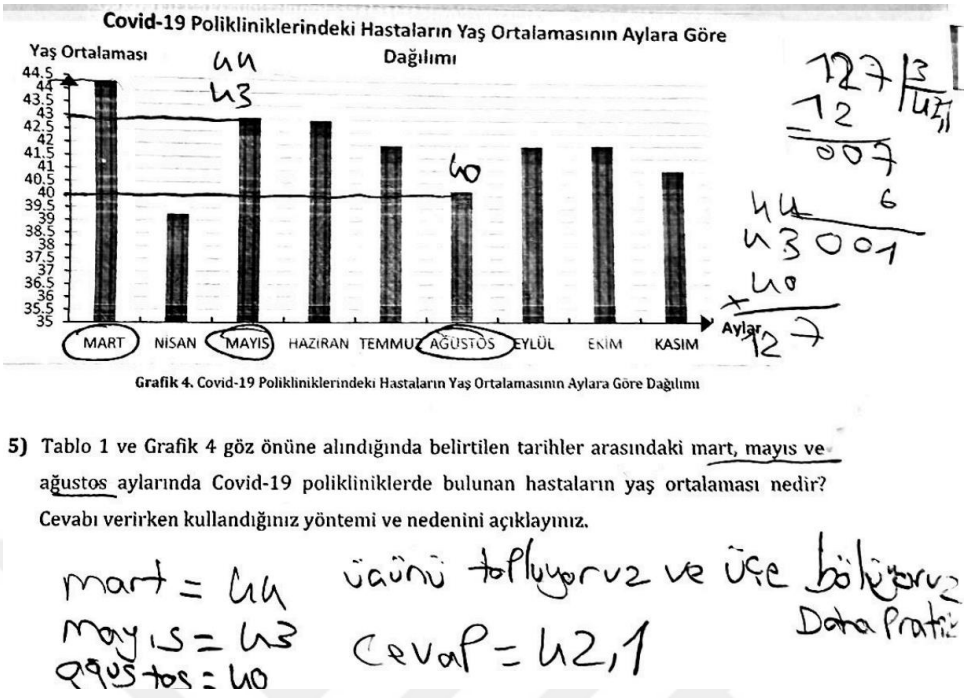


Figure 4.6. One student's response corresponding to Level 2 in the COVID-19 task

As mentioned in Chapter 3, in this question, students should calculate the total age of participants each month by multiplying the average age given in Graph 4 and the number of patients given in Table 1 in the COVID-19 task. Then, the total age of three months should be divided by the total sample size of the three months to find the mean age of the participants who have applied to outpatient clinics in March, May, and August.

In Figure 4.6, the student answered the question by writing the data corresponding to the asked months and said, "These data were added and divided into three for ease." However, in Q5, the students used Table 1 and Graph 2 in the COVID-19 tasks, which are about the monthly sample size of the applicants to outpatient clinics and the monthly mean age of patients who stayed there, respectively. The mean age for all patients in the group is asked, and students should calculate it by considering the different sample sizes, as mentioned in Chapter 3. The mean should be selected as the measure of central tendency since there are no outliers present in the data.

In Figure 4.6, the student focused only on the "mean" part of the question. The table, which should be used to include the sample size to calculate the mean score, was ignored by the student. The student found the mean age for the three months, yet the question asked the mean age of the patients. Focusing on one point only without using the necessary information in the task is Level 2 according to Sharma et al. (2011). Thus, the student's statistical literacy level for this question was 2.

A different sample student response to the same question is presented in Figure 4.7.

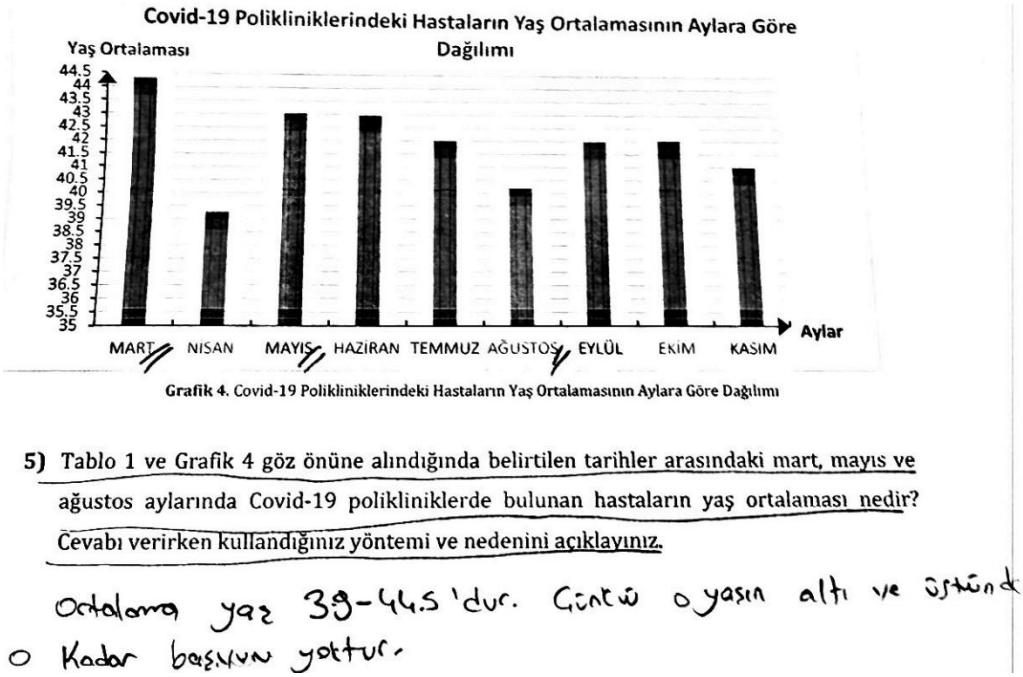


Figure 4.7. One student's response corresponding to Level 2 in the COVID-19 task

In Figure 4.7, the student said, "The mean age is 39-44.5 since there are no participants below or above this range." The student did not use values for the asked months either in the table or the graph. The student interpreted the question with a holistic approach. In other words, the graph's maximum and minimum values are approximately 44.5 and 39 for March and April, respectively. The student did not consider the months in the question, and the answer did not involve any mathematical skills or knowledge. The answer has only one point of view: the mean cannot be

higher or lower than the maximum or minimum value in the data set. The statistical literacy level is 2 for this answer.

There are no students whose statistical literacies were determined as high-level in this question. This finding suggests that the students had difficulties using a group's sample size while calculating the mean score. Thus, exercises including sample sizes for different groups while calculating the mean score can be used to improve students' sample size comprehension.

4.1.1.2 Examples for the Interpretation of the Results Component

Examples for the representation and analysis of the data in the COVID-19 task are given above. In this part, examples for interpreting the results component are presented.

The COVID-19 task involves two questions for interpreting the results component, which are Q2 and Q6. Sample student responses are given below considering the determined statistical literacy levels.

Firstly, for the interpretation of the results component, two students (0.81%) were classified as Level 3 based on their overall scores. Sample answers for Level 3 are presented below.

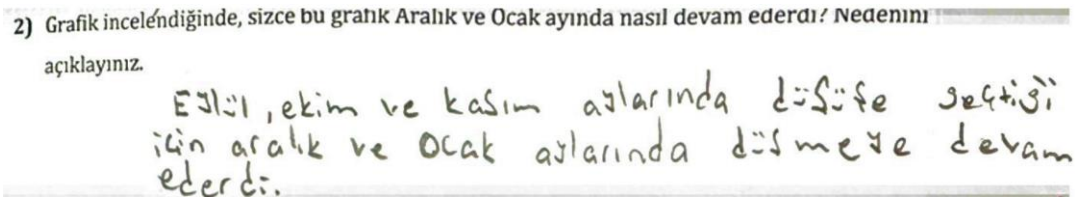


Figure 4.8. One student's answer corresponding to Level 3 in the COVID-19 task

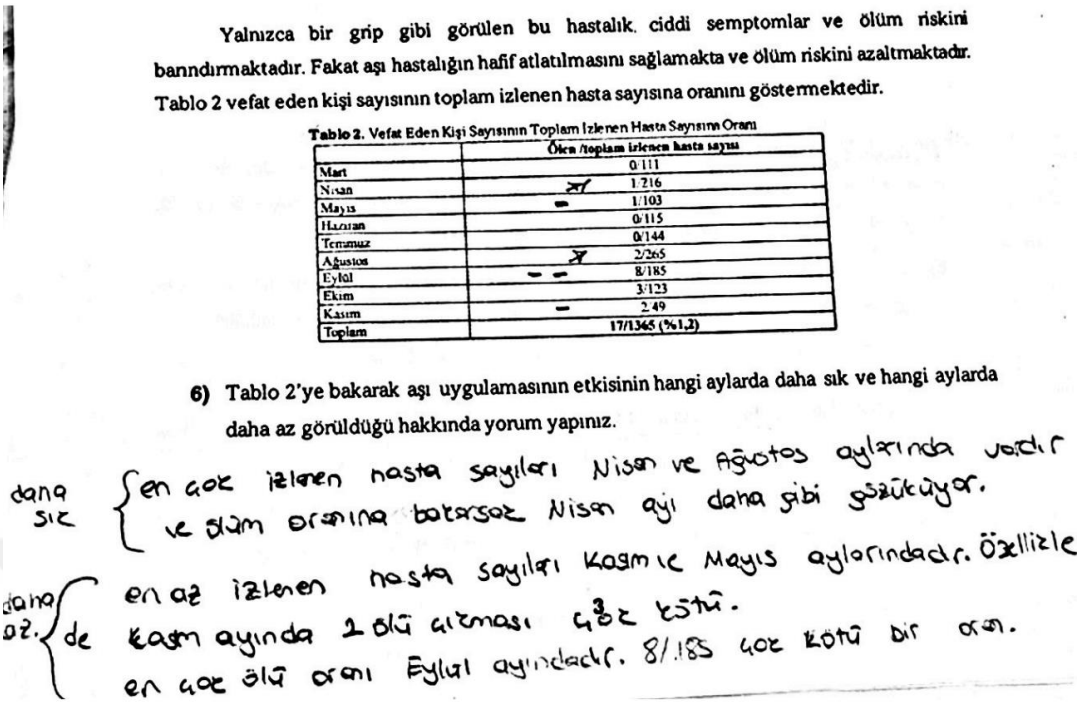
As mentioned in Chapter 3, in Q2, the students were asked to interpret the bar graph in Graph 1, estimate how the data represented in the bar graph would continue in the months of December and January, and elaborate on their thinking processes. The students were asked to answer the question by examining the graph that shows a

decrease over the last four months. Then, the expected answer from students is to state that the number of cases decreases from November to December and then decreases more from December to January, observing the trend of decrease in the last four months.

As seen in Figure 4.8, the student said, “The graph would continue to decrease in December and January because it started to decrease during the months of September, October, and November.”

The student answered the question by considering the decrease in the last months as expected. The statistical knowledge about the interpretation of the graphical display is seen in the answer. However, the interpretation of the results was made as narrative explanations. The student needs to show evidence of merging mathematical knowledge with statistical ones. Sharma et al. (2011) state that merging these is essential for Level 4. Thus, the student is not in Level 4. However, the student demonstrated awareness of relevant features of displays and measures of center, so according to Sharma et al. (2011), the student’s answer is a Level 3 answer.

Another sample student answer for Level 3 is given below.



Yalnızca bir grip gibi görülen bu hastalık, ciddi semptomlar ve ölüm riskini barındırmaktadır. Fakat aşı hastalığın hafif atlatılmasını sağlamakta ve ölüm riskini azaltmaktadır. Tablo 2 vefat eden kişi sayısının toplam izlenen hasta sayısına oranını göstermektedir.

Tablo 2. Vefat Eden Kişi Sayısının Toplam İzlenen Hasta Sayısına Oranı

	Ölen /toplam izlenen hasta sayısı
Mart	0/111
Nisan	1/216
Mayıs	1/103
Haziran	0/115
Temmuz	0/144
Ağustos	2/265
Eylül	8/185
Ekim	3/123
Kasım	2/49
Toplam	17/1365 (%1,2)

6) Tablo 2'ye bakarak aşı uygulamasının etkisinin hangi aylarda daha sık ve hangi aylarda daha az görüldüğü hakkında yorum yapınız.

daha sık { en çok izlenen hasta sayıları Nisan ve Ağustos aylarında vardır ve ölüm oranına bakarsak Nisan ayı daha iyi gözüküyor.

daha az. { en az izlenen hasta sayıları Kasım ve Mayıs aylarındadır. Özellikle de Kasım ayında 2 ölü olması çok kötü.
en çok ölü oranı Eylül ayındadır. 8/185 çok kötü bir oran.

Figure 4.9. One student's answer corresponding to Level 3 in the COVID-19 task

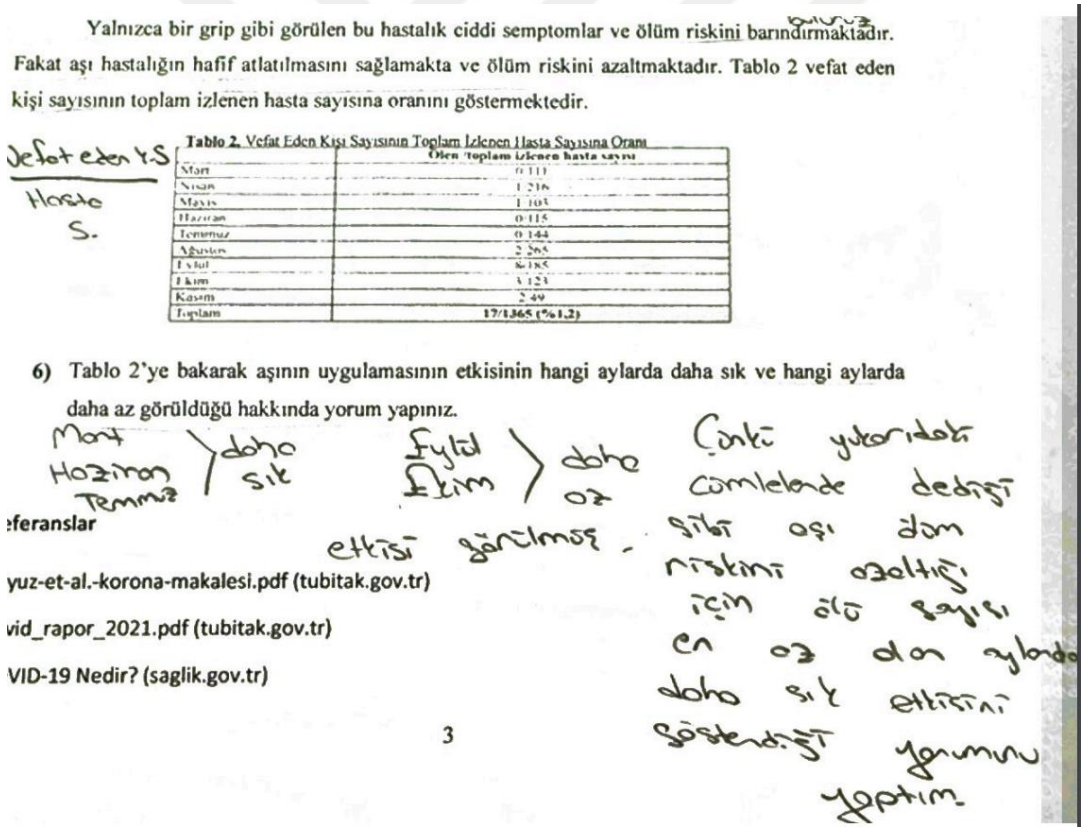
In Q6, according to an informative paragraph preceding the question, a low ratio of deaths to the number of monitored patients should be maintained to enhance the effectiveness of vaccination, and vice versa.

As mentioned in Chapter 3, the students were asked to determine when the impact of vaccination was more significant on people and when it was less significant. When deciding, they should first analyze the table. Then, they should simplify the table so that the data includes ratios, not raw numbers, and then compare these ratios to interpret the results. Since the ratio is the number of deaths to the number of patients, the students should see that the lower ratio is better regarding the vaccination effect.

In Figure 4.9, in the first paragraph labeled as "more frequent", the student said, "April and August had the highest number of monitored patients. However, based on the ratio of deaths, April had a better outcome". In the second paragraph labeled as "less vaccination", the student stated, "The lowest number of monitored patients were in November and May, and particularly the two deaths in November were tragic. Also, the student added in the second paragraph that, "September had the highest number of deaths, with an alarming ratio of 8/185."

In Figure 4.9, the student analyzed the table focusing on two main aspects: the lower number of deaths and the higher number of monitored individuals. The answer is correct and related to the context. However, mathematical knowledge that compares ratios could be more robust in this answer. The student should think that if the ratio is small, then the effect of vaccination increases, and then the comparison of the ratios is completed. Mathematical skills need to be improved for the answer. Thus, due to the qualitative interpretation of the results, the student is in Level 3 (Sharma et al., 2011).

Secondly, for the interpreting the results component, 41 students (16.53%) are in Level 2 according to the overall scores. Sample student answers for Level 2 to the same question are below.



Yalnızca bir grip gibi görülen bu hastalık ciddi semptomlar ve ölüm riskini barındırmaktadır. Fakat aşı hastalığın hafif atlatılmasını sağlamakta ve ölüm riskini azaltmaktadır. Tablo 2 vefat eden kişi sayısının toplam izlenen hasta sayısına oranını göstermektedir.

Vefat eden Y.S
Hasta S.

Tablo 2. Vefat Eden Kişi Sayısının Toplam İzlenen Hasta Sayısına Oranı

	Ölen /toplam izlenen hasta sayısı
Mart	0/111
Nisan	1/216
Mayıs	1/103
Haziran	0/115
Temmuz	0/144
Ağustos	2/265
Eylül	8/185
Ekim	3/123
Kasım	2/49
Toplam	17/1365 (%1,2)

6) Tablo 2'ye bakarak aşının uygulamasının etkisinin hangi aylarda daha sık ve hangi aylarda daha az görüldüğü hakkında yorum yapınız.

Mart Haziran Temmuz > daha sık
Eylül Ekim > daha az
etkisi görülmüş.

Çünkü yukarıdaki cümlelerde dediği gibi aşı ölüm riskini azaltığı için ölü sayısı en az olan aylarda daha sık etkisini göstendiği yorumunu yaptım.

:feranslar

yuz-et-al.-korona-makalesi.pdf (tubitak.gov.tr)

vid_rapor_2021.pdf (tubitak.gov.tr)

VID-19 Nedir? (saglik.gov.tr)

3

Figure 4.10. One student's answer corresponding to Level 2 in the COVID-19 task

The student's response was as follows: "The frequency of vaccination was higher in March, June, and July compared to September and October." Furthermore, the

student added, "As the vaccination reduced the risk of deaths, it demonstrated its effectiveness during the months with the lowest number of fatalities, as stated in the informative paragraph."

The last question in the COVID-19 task, Q6, examined the students' interpretation of a table that included ratios. To solve the question, students should grasp the concepts of fractions and ratios, and then interpret the table with their statistical knowledge by relating the information in the context.

In Figure 4.10, the student's interpretation included the relationship between the solution and the context. However, the student answered the question considering only the number of deaths. Neither the ratio nor the number of monitored patients was included in the response. Also, there is no evidence of mathematical knowledge in the explanation. Focusing on one point with a narrative explanation is determined as Level 2 in the framework. Thus, the answer corresponds to Level 2.

Lastly, for the interpreting the results component, 205 (82.66%) are in Level 0-1 according to the overall scores. One sample student response corresponding to Level 0-1 is given in Figure 4.11.

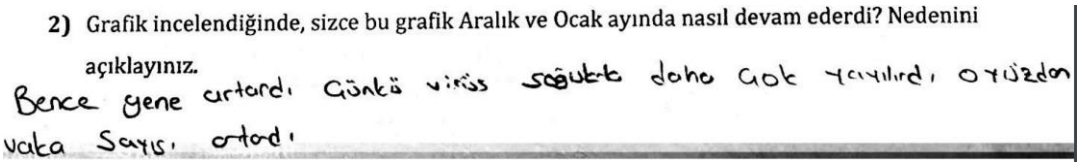

2) Grafik incelendiğinde, sizce bu grafik Aralık ve Ocak ayında nasıl devam ederdi? Nedenini açıklayınız.
Bence yine artardı. Çünkü virüs soğukta daha çok yayılırdı, o yüzden vaka sayısı artardı.

Figure 4.11. One student response corresponding to Level 0-1 in the COVID-19 task

This question is explained and exemplified with an answer determined as Level 3.

In Figure 4.11, the student wrote, "I think the graph would continue to increase in December and January because the viruses would spread more, causing an increase in the number of cases."

In Q2, seventy student answers out of two hundred forty-eight students irrelevant information about their daily lives that did not relate to context. Thus, the answer

shows that the student used their daily life information instead of the information in the task. There is no evidence that the student used statistical or mathematical knowledge to interpret the results. Thus, the student is determined to be Level 0-1.

4.2 The findings pertaining to the Context of Daily Diet

This part presents the findings related to the students' statistical literacy in the daily diet task. The task was examined considering the last two components: representing and analyzing the data and interpreting the results of statistical process components. The number of students in each level, considering the cities and the components for the daily diet task, is presented in Table 4.2.

Table 4.2 The number of students in each level, considering the cities and the components for the daily diet task

	Frequencies of Statistical Literacy Levels for the Daily Diet Task					
	Ankara	*İstanbul*	*Kayseri*	*Kars*	*Total*	*Percentage*
Representation and Analysis of the Data						
Level 0-1	67	11	18	34	130	52.42%
Level 2	13	36	38	22	109	43.95%
Level 3	2	2	1	2	7	2.82%
Level 4	1	1	0	0	2	0.81%
TOTAL	83	50	57	58	248	100.00%
Interpretation of the Results						
Level 0-1	72	36	43	49	200	80.65%

Table 4.2 (continued)

Level 2	9	12	8	7	36	14.52%
Level 3	2	1	5	2	10	4.03%
Level 4	0	1	1	0	2	0.81%
TOTAL	83	50	57	58	248	100.00%

In Table 4.2, one can observe the frequencies of students' statistical literacy levels in terms of cities and the percentage of students in each level for each component of the daily diet task.

Table 4.2 shows that while 227 (91.53%) have low-level statistical literacy, 21 students (8.47%) have high-level statistical literacy.

Examining these students' levels in detail for the representation and analysis of the data component, it can be observed that 130 students (52.42%) are in Level 0-1, 190 students (43.95%) are in Level 2, 7 students (2.82%) are in Level 3, and 2 students (0.81%) are in Level 4. Moreover, for the interpretation of the results component, 200 students (80.65%) are in Level 0-1, 36 students (14.52%) are in Level 2, 10 students (4.03%) are in Level 3, and 2 students (0.81%) are in Level 4.

Additionally, when the frequencies of the last two statistical process components in the daily diet task are examined, only 9 students (3.63%) were found to have high statistical literacy skills in representing and analyzing the data component. Only two of them (0.81%) are in Level 4. Furthermore, 12 students (4.84%) have high statistical literacy skills in interpreting the results component. Only two of them (0.81%) are in Level 4. By examining these findings, it can be concluded that the interpretation of the results component has a higher number of students performing at a high level compared to the representation and analysis of the data component for the daily diet task.

Table 4.2 shows that many students in each city were at a low level. When the table is examined in detail, it can be seen that there are four students, one from Ankara (1.21%), two from İstanbul (4.00%), and one from Kayseri (1.75%), in Level 4. In comparison, there are 17 students, four from Ankara (4.82%), three from İstanbul (6.00%), six from Kayseri (10.53%), and four from Kars (6.90%), in Level 3. Thus, 6.02% of the students from Ankara, 10.00% from İstanbul, 12.28% from Kayseri, and 6.90% from Kars were found to have high-level statistical literacy. Therefore, the highest percentages belong to Kayseri and İstanbul, respectively. Although Kars seems to have higher percentages than Ankara, their percentages are very close.

Moreover, when the components are examined in detail across the cities, students' statistical literacy in the representation and analysis of the data component shows that nine students (3.63%) have high statistical literacy skills. Two (0.81%) of them are in Level 4, where one student (1.21%) is from Ankara, and the other (2.00%) is from İstanbul. In the same task, there are seven students (2.82%) in Level 3, where six are from Ankara (2.41%), Istanbul (4.00%), and Kars (3.45%), and one is from Kayseri (1.75%). Therefore, considering these findings, it can be concluded that for the representation and analysis of the data component, 3.62% of the students from Ankara, 6.00% from İstanbul, 1.75% from Kayseri, and 3.45% from Kars have high statistical literacy. The highest percentage belongs to İstanbul in the representation and analysis of the data component for the daily diet task.

As for the students' statistical literacy in the interpretation of the results component across the cities, two students (0.81%) are in Level 4, where one student (2.00%) is from İstanbul, and the other (1.75%) is from Kayseri. In the same task, there are ten students (2.82%) in Level 3, where four of them are from Ankara (2.41%) and Kars (3.45%), one (2.00%) is from İstanbul, and five (8.77%) are from Kayseri. Therefore, considering these findings, it can be stated that for interpreting the results component, 2.41% of students from Ankara, 4.00% from İstanbul, 10.53% from Kayseri, and 3.45% from Kars have high statistical literacy. The highest percentage belongs to Kayseri in interpreting the results component of the daily diet task.

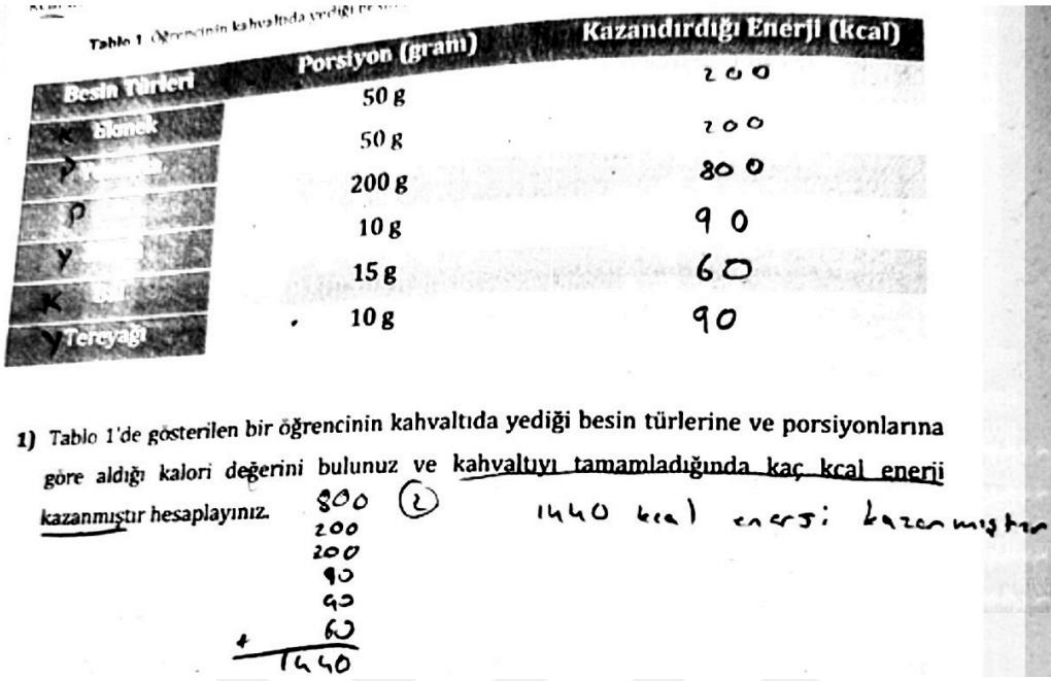
4.2.1 Sample Student Answers Pertaining to the Context of Daily Diet

In this section, sample student answers are presented in two different subsections considering two statistical process components: representing and analyzing the data and interpreting the results.

4.2.1.1 Sample Answers for the Representation and Analysis of the Data Component

The daily-diet task involves two questions related to the representation and analysis of the data component, which are Q1 and Q4. As mentioned in Chapter 3, due to the skills required to solve Q1, the answer can be at most at Level 2. Sample student responses are given below.

For Q1, 104 student (41.94%) are in Level 2 in the daily diet task. One sample answer corresponding to the highest level, Level 2, in Q1 is presented in Figure 4.12.



Besin Türleri	Porsiyon (gram)	Kazandırdığı Enerji (kcal)
[illegible] Ekmek	50 g	200
[illegible]	50 g	200
[illegible]	200 g	800
[illegible]	10 g	90
[illegible]	15 g	60
[illegible]	10 g	90
Tereyağı		

1) Tablo 1'de gösterilen bir öğrencinin kahvaltıda yediği besin türlerine ve porsiyonlarına göre aldığı kalori değerini bulunuz ve kahvaltıyı tamamladığında kaç kcal enerji kazanmıştır hesaplayınız. 800 (2) 1440 kcal) enerji kazanmıştır

200
200
90
90
60
+ 1440

Figure 4.12. One student's answer at Level 2 for Q1 in the daily diet task

As mentioned in Chapter 3, the students were asked to determine the calorie intake of each food item in the meal, expressed in kilocalories (kcal), based on the information provided in the paragraph above the table and the portion sizes specified in the table. To find the calorie intake for each food, first, the students should multiply the portion of the food by per gram energy intake of nutrition types which are given before the informative paragraph. Then, after calculating the energy intake for each food item based on their portion sizes, the students were instructed to determine the total calorie intake that the student, whose breakfast was provided in the table, obtained from the breakfast.

As seen in Figure 4.12, the student could separate the types of nutrition and fill in the table correctly, considering the information in the task, which is the statistical part of the question. Then, the data in the table are summed up to find the total calorie intake, which is the mathematical part. The answer has no errors from either the mathematical or the statistical aspect. The student filled in the table using correct mathematical knowledge by relating the question to the context. Thus, the answer was determined as Level 2, the highest level for this question.

For the other question for the representing and analyzing the data component, three students (1.21%) of 248 are in Level 4 in the daily diet task, while two students (0.81%) are in Level 4 according to the overall scores. Sample answers for Level 4 are presented below.

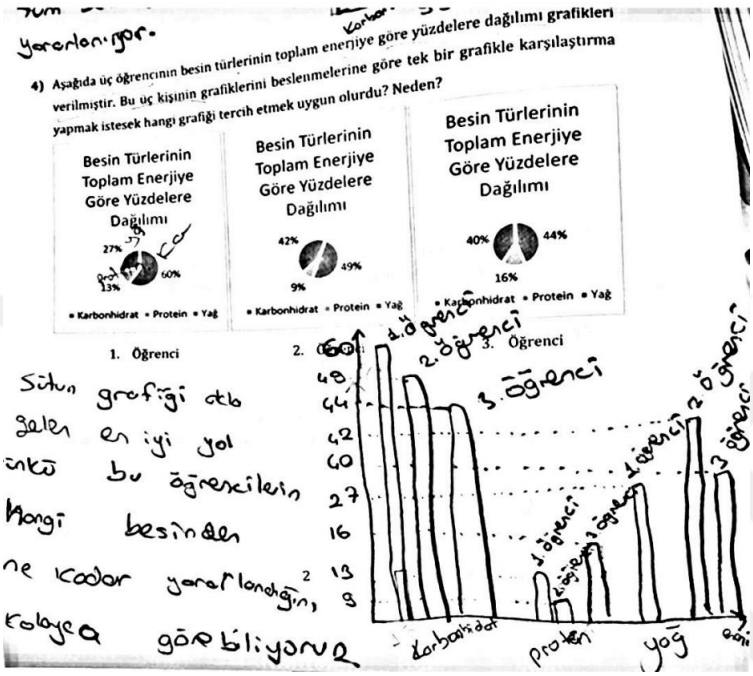


Figure 4.13. One student's answer for Level 4 in the daily diet task

As mentioned in Chapter 3, the purpose of the question is to have the students choose the most appropriate graph type to compare the diet of three students whose daily diet graphs are presented below the question.

As seen in Figure 4.13, the student said: "A bar graph is the best option because we can easily see which students benefitted from which nutrition." Then, the student drew a bar graph that he thought suited the question.

When answering the question, the student needs to consider the two main features of the bar graph when pie charts are merged to form a bar graph. These features are the suitability for categorical data and the ease of comparison. It can be seen in the answer that the drawing of the bar graph included these features. Thus, it is understood that the student can use statistical skills in a contextual question and

understand the aim of the graph types. The graph shows that the student can differentiate between the categorical and continuous data. Furthermore, this answer shows that the student can achieve the objective of being able to represent the data with a bar graph, line graph, or pie chart and transform between the suitable graph types. According to Sharma et al. (2011), if there is evidence of an understanding of the purpose of the data, data displays, and inferences made, the answer is placed in Level 4. Thus, the student's answer is in Level 4

However, for a student who chose not to draw any graphs, the evaluation of choosing the right graph needs to be included; and statistical literacy should be determined as lower level considering the answer and the explanations.

For representing and analyzing the data component, 12 students (4.84%) are in Level 2, in the daily diet task, while 109 students (43.95%) are in Level 2 according to the overall scores. One sample answer to the same question corresponding to Level 2 is given in Figure 4.14.

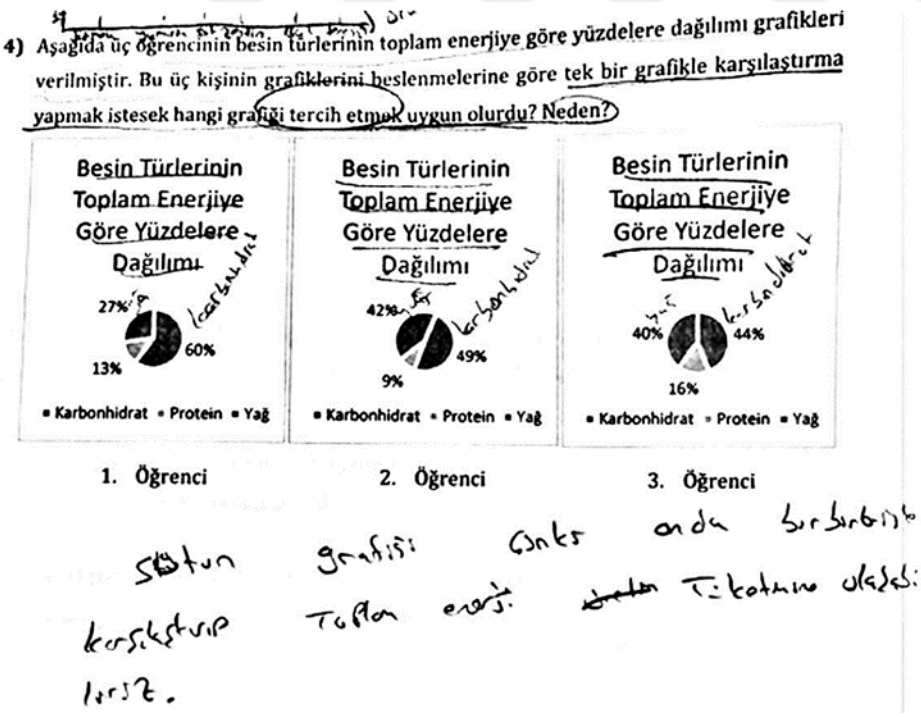


Figure 4.14. One student response corresponding to Level 2 in the daily diet task

As seen in Figure 4.14, the student wrote, “The bar graph is suitable because the total kcal can be compared and reached with a bar graph.”

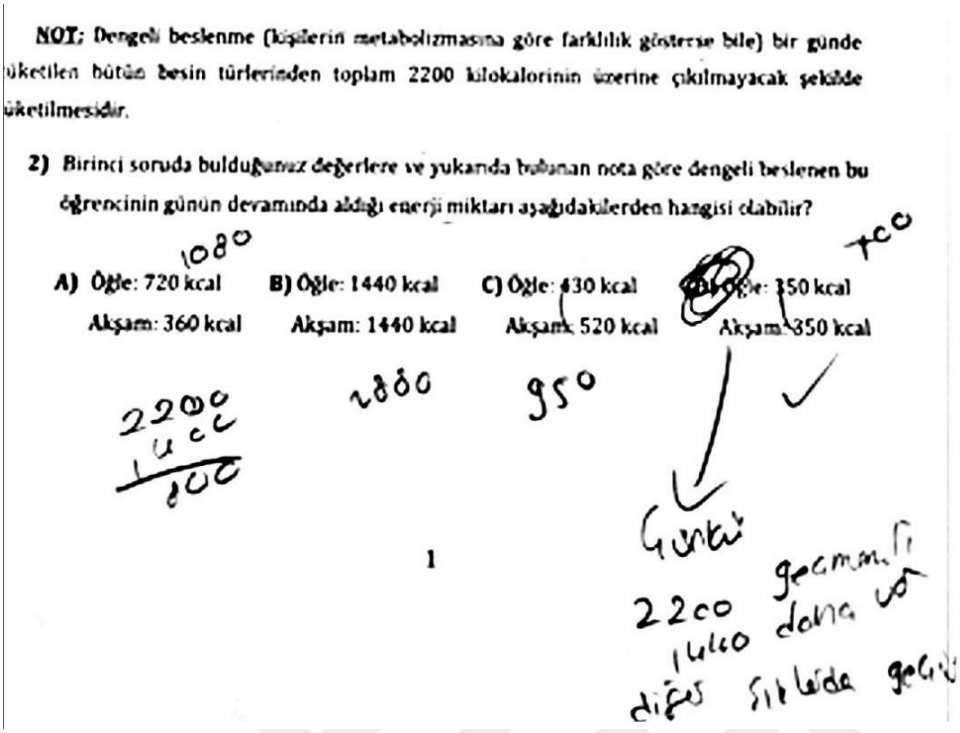
In the question, the student needed to draw a suitable graph to compare acceptable macro nutrition ratios and the energy intake of three students. Moreover, the student has yet to consider one of the two main features: suitability for categorical data. The student answered the question by considering only the comparison part of the question. The student could not use statistical and mathematical knowledge from a context. Sharma et al. (2011) stated that if students focus on a single relevant aspect or attempt to attend to one or more relevant aspects of the data but have difficulty integrating them, they are in Level 2. Thus, the student’s statistical literacy level was labeled as 2.

4.2.1.2 Examples for the Interpretation of the Results Component

Examples for the representation and analysis of the data component for the daily diet task are given above. In this part, examples for interpreting the results component are presented.

The daily-diet task involves four questions for the interpreting the results component, which are Q2, Q3, Q5, and Q6. Sample student responses are given below.

Firstly, for interpreting the results component, two students (0.81%) are in Level 4 according to the overall scores. Sample answers for Level 4 are presented below.


NOT: Dengeli beslenme (kişilerin metabolizmasına göre farklılık gösterse bile) bir günde tüketilen bütün besin türlerinden toplam 2200 kilokalorinin üzerine çıkılmayacak şekilde tüketilmesidir.

2) Birinci soruda bulduğunuz değerlere ve yukarıda bulunan nota göre dengeli beslenen bu öğrencinin günün devamında aldığı enerji miktarı aşağıdakilerden hangisi olabilir?

A) Öğle: 720 kcal Akşam: 360 kcal

B) Öğle: 1440 kcal Akşam: 1440 kcal

C) Öğle: 430 kcal Akşam: 520 kcal

D) Öğle: 350 kcal Akşam: 350 kcal

1

Figure 4.15. One student's answer corresponding to Level 4 in the daily diet task

As mentioned in Chapter 3, Q2 asks students to evaluate the suitable hypothetical calorie intake for lunch and dinner based on the calorie taken at breakfast and the note given before Q2. The students should think about how much kcal can be taken without exceeding 2200, information in the note, onto the kcal taken in breakfast, 1440 from Q1. The student in Q2 can take a maximum of 760 kcal for the total kcal of lunch and dinner. When students sum the calorie intake at lunch and dinner for each multiple-choice alternative placed below the question, they can see that the only answer which did not exceed 760 is 700 kcal for the total kcal of lunch and dinner, which is option D.

In Figure 4.15, firstly, the student subtracted 1400 from 2200 to find how much kcal can be taken as an upper limit. Then, the student added kcal from lunch and dinner for each option, selected option D, and explained the choice by saying, "The limit is exceeded in other options.".

Figure 4.15 shows that the student answered the previous question correctly with 1440 kcal. Then, the student selected the correct answer by finding the sum of kcal for the other two meals, considering whether the total daily kcal intake exceeded 2200 kcal. The calculation of the result is the mathematical part, and the interpretation of the options is the statistical part of their statistical literacy skills. When the student answered the question, she used statistical and mathematical knowledge in the context by using the information from the table in Q1 and finding the results with mathematical operations. Also, the student considered more than one point at a time. Thus, since the answers feature a critical, questioning engagement with context and statistical and mathematical skills associated with success is placed in Level 4 by Sharma et al. (2011), the answer was determined as Level 4.

Some correct answers without an explanation were classified as Level 0-1 due to the possibility of a guessed answer and the significance of explanations.

Another sample student answer for Level 4 is given in Figure 4.16.

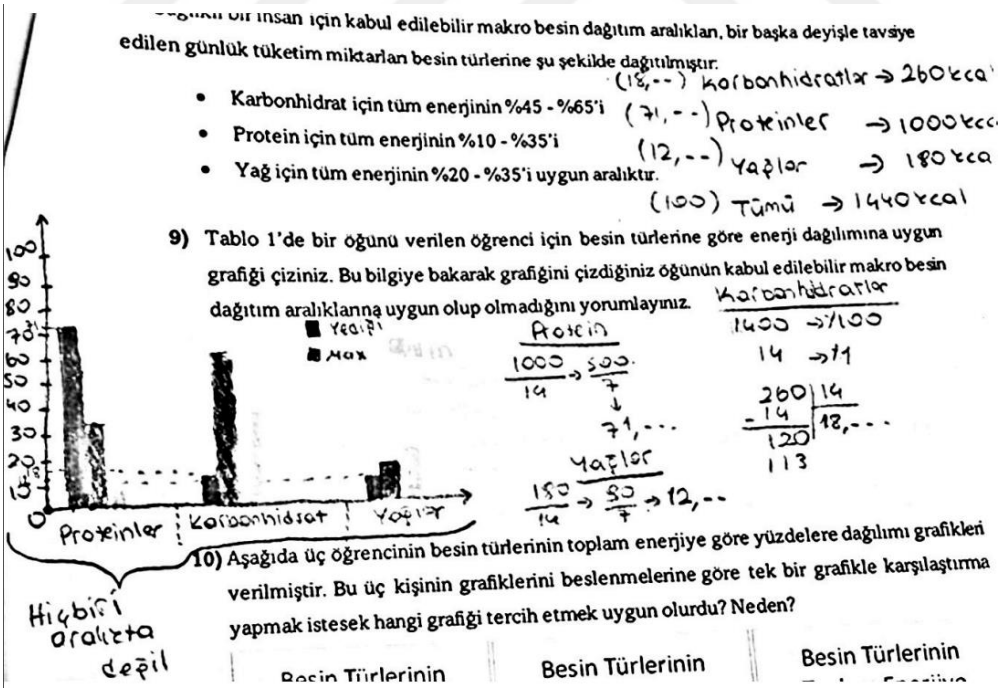


Figure 4.16. One student's answer corresponding to Level 4 in the daily diet task

As mentioned in Chapter 3, this question depends on the informative paragraph about macro nutrition ratios for each nutrition type in Figure 3.18 and Table 1 completed by the students. The question can be solved in three steps. The first step is deciding on the appropriate graph type based on the data and the information. Then, the second step is calculating macro nutrition ratios for the data taken from Table 1 and drawing a graph. The last step is looking at the graph and the macro nutrition ratios, comparing the acceptable range for total energy intake and the ranges of macro nutrition ratios for the data in Table 1, and interpreting the comparison results.

As see in Figure 4.16, the student first calculated the percentages corresponding to nutrition types. Then, considering these percentages, the student drew a bar graph for the nutrition types and the percentages. In this question, the students were expected to draw a suitable display for the table in Q1. Then, they were expected to interpret whether the meal was healthy regarding the informative paragraph given preceding Q3.

The suitable display in this question is a pie chart; the correct interpretation is that the meal was unhealthy. However, when the answer to the question is examined, it is seen that the student selected another display for categoric data and correctly calculated the ratios of students' macro nutrition ranges in Q1 by using the information in the context. Moreover, the bar graph was used in the answer. The student included the maximum and minimum limits to compare the kcal with the number it was supposed to be, and the display was suitable for the categorical data. As seen in Figure 4.16, the student drew the bar graph with three categories for each nutrition type and then used three colors to establish the min, max, and data values. If the black bars are in between the purple and the yellow, then the nutrition is in the range and acceptable. The student could calculate the ratios successfully, which shows sophisticated mathematical skills, and draw and interpret a bar graph, which shows sophisticated statistical skills. Even if the selection of the graph type seems to be wrong initially, the presentation of the information in the bar graph and the interpretation of the results are correct. The student could associate **s**ophisticated statistical and mathematical skills with success, and there is an understanding of the

purpose of the data, data displays, measures of center, and inferences made. Thus, the student is in Level 4.

One sample answer to Q6, corresponding to Level 4, is given in Figure 4.17.

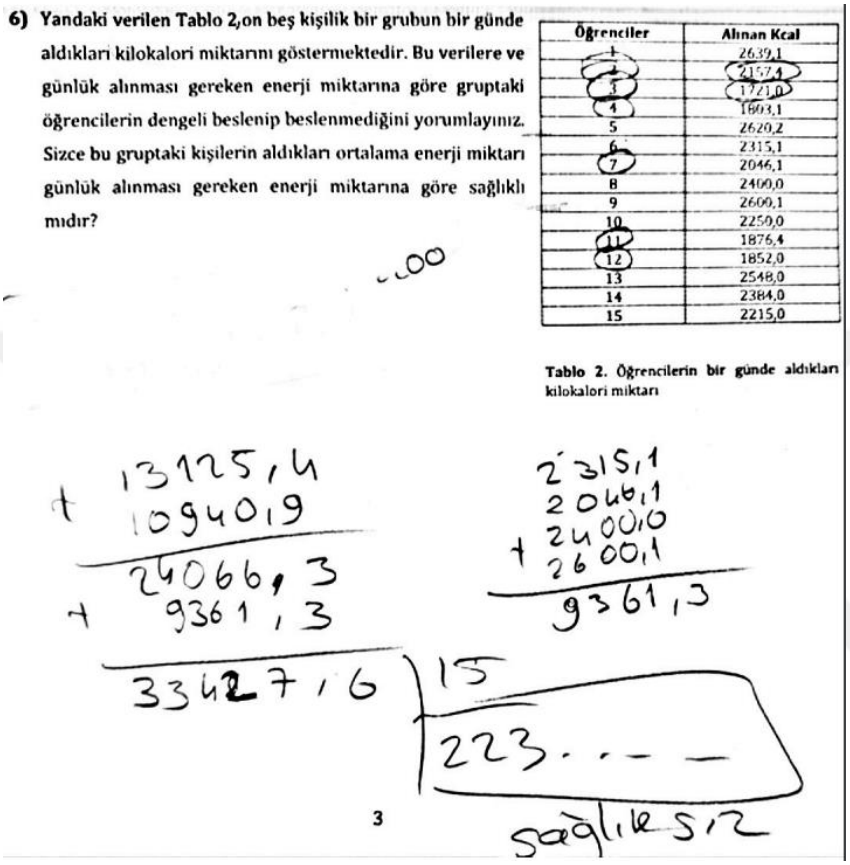


Figure 4.17. One student's answer corresponding to Level 4 in the daily diet task

As mentioned in Chapter 3, Q6 asks the students an interpretation of a group of people's daily diet based on the table next to it and the note which mentions the limit of total daily calorie intake for a healthy diet which is 2200 kcal.

As seen in Figure 4.17, the student calculated the mean score. To answer this question correctly, students should consider whether there are any outliers to decide which central tendency score should be used. Then, the mean score and interpretation calculations should be completed by considering the limit of total kcal intake for a day to be placed in Level 4.

Figure 4.17 shows that the student calculated the mean to find the average score. Deciding on the mean was correct because no outliers showed statistical knowledge and skills. After finding the mean score, the result was compared with 2200, the limit of total kcal intake for a day showing mathematical knowledge and skills. The student's answer and explanation include adequate mathematical and statistical evidence. **S**ophisticated statistical and mathematical skills are associated with success, and thus, the answer was determined to be a Level 4 response.

Secondly, for interpreting the results component, ten students (4.03%) are in Level 3 according to the overall scores. Some sample answers corresponding to Level 3 are given below**.**

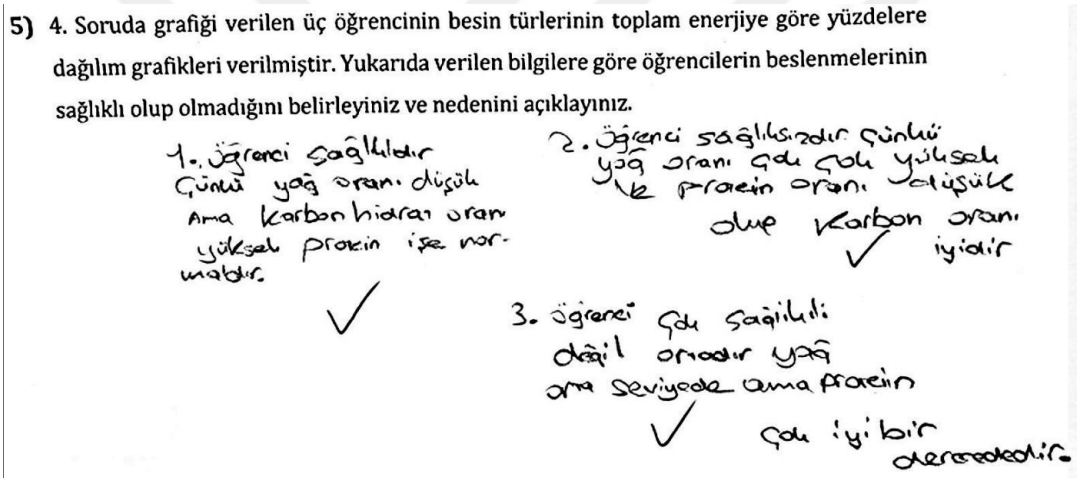


Figure 4.18. One student answer corresponding to Level 3 in the daily diet task

As mentioned in Chapter 3, the question asks students to decide whether the data obtained from the pie charts in Q4 as percentages are in the range of macro nutrition ratios or not. The participants should state which nutrition types do not fit the ranges and which ones fit.

As seen in Figure 4.18, the student examined each graph one at a time and said, "The student with the first pie chart was healthy because the fat ratio was low, the carbohydrate was high, and the protein ratio was normal." Secondly, the student in the study stated, "The student with the second pie chart was unhealthy because the fat ratio was very high, the carbohydrate was normal, and the protein ratio was low."

Finally, the student stated, “The student with the third pie chart was also unhealthy because the fat ratio was low, and the protein ratio was excellent.”

In this question, the students should consider the given percentages of types of nutrition kcal intakes in the pie charts of three students in the previous question and interpret them considering the acceptable macro nutrition ratios.

As seen in Figure 4.18, the student answered the question with only narrative explanations. The categorization of labels such as high, low, or normal should be determined in students’ explanations with mathematical ranges. Mathematical skills need to be improved for the answer even if the information on the graphs was taken and interpreted successfully, showing statistical knowledge. Explanations should be included in mathematical results. Thus, although the answer is correct, due to the qualitative interpretation of the results, according to Sharma et al. (2011), the level for this answer is 3.

One sample answer corresponding to Level 3 is given in Figure 4.19.

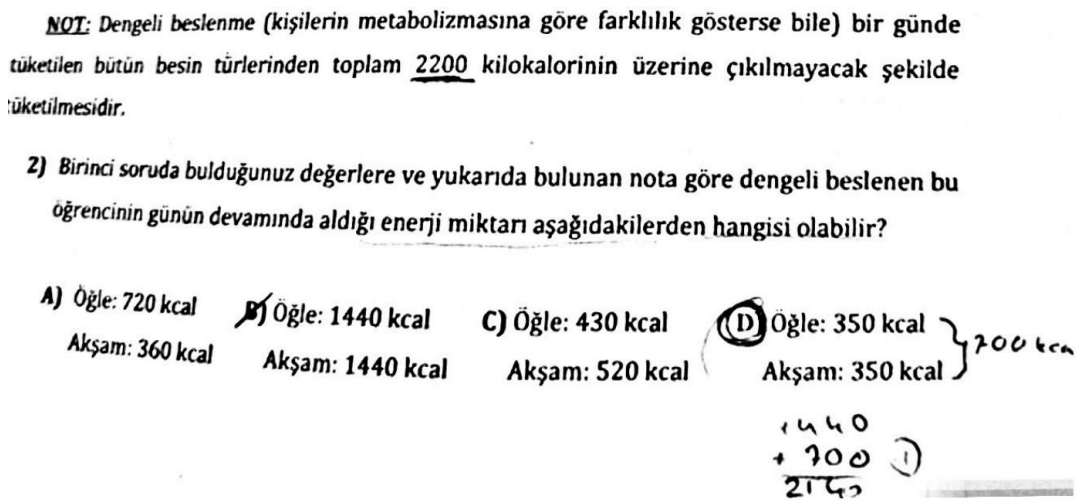


Figure 4.19. One student’s answer corresponding to Level 3 in the daily diet task

This question is explained and exemplified with an answer determined as Level 4.

As seen in Figure 4.19, the student first summed the 350 kcal for lunch and 350 kcal for dinner in option D, and then the summation of the result of the previous question and the first calculation in the question was checked to see whether it exceeded 2200.

As seen in Figure 4.19, the answer is correct, which is 350 kcal for lunch and 350 kcal for dinner; however, the student needed to explain after finding the daily kcal intake. Although the student can use statistical and mathematical knowledge to find the answer, the information in the note and the context should have been mentioned in the explanation. Sharma et al. (2011) stated that there is selective engagement with unfamiliar contexts with some justification to be placed in Level 3. Thus, the answer was determined as Level 3.

Another sample answer to Q3 for Level 3 is given in Figure 4.20.

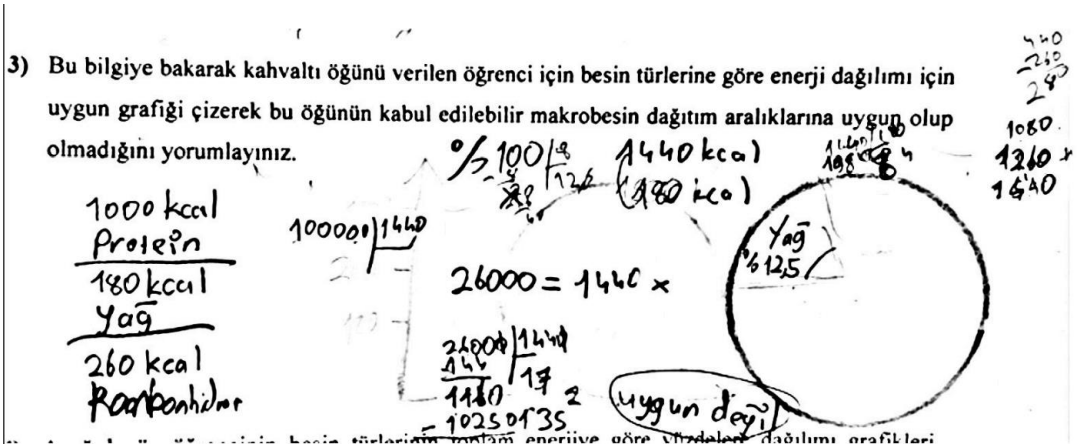


Figure 4.20. One student answer for Level 3 in the daily diet task

This question is explained and exemplified with an answer determined as Level 4.

As seen in Figure 4.20, the student used the corresponding results of the nutrition types found in the previous question. Then, the student calculated the percentage of fat and carbohydrates. When the student noticed that the fat and carbohydrate percentages did not fit the range, she said, “The meal was not healthy”.

As seen in Figure 4.20, the student drew a pie chart and separated the segment for fat to show the fat ratio, which is 12.5%. The drawing showed that the student chose a pie chart as a suitable display; however, the drawing was not completed. The answer shows that the student can select a suitable graphical display for this question which shows statistical knowledge. Also, the calculation of the fat ratio is correct,

which shows mathematical knowledge; however, the calculations for all nutrition types still had to be completed. The explanations regarding the informational paragraph should have been given. There is a clue for mathematical and statistical knowledge, but the interpretations related to the context still need to be included. Sharma et al. (2011) stated that students in Level 3 demonstrate awareness of relevant features of displays and measures of center and spread; however, these are primarily based on the data or the context, not both. Thus, the student is in Level 3.

Furthermore, some of the correct answers, including the correct mathematical calculations without the graphical display, are determined as Level 3 due to the missing statistical knowledge related to the context.

Another student's answer corresponding to Level 3 is given in Figure 4.21.

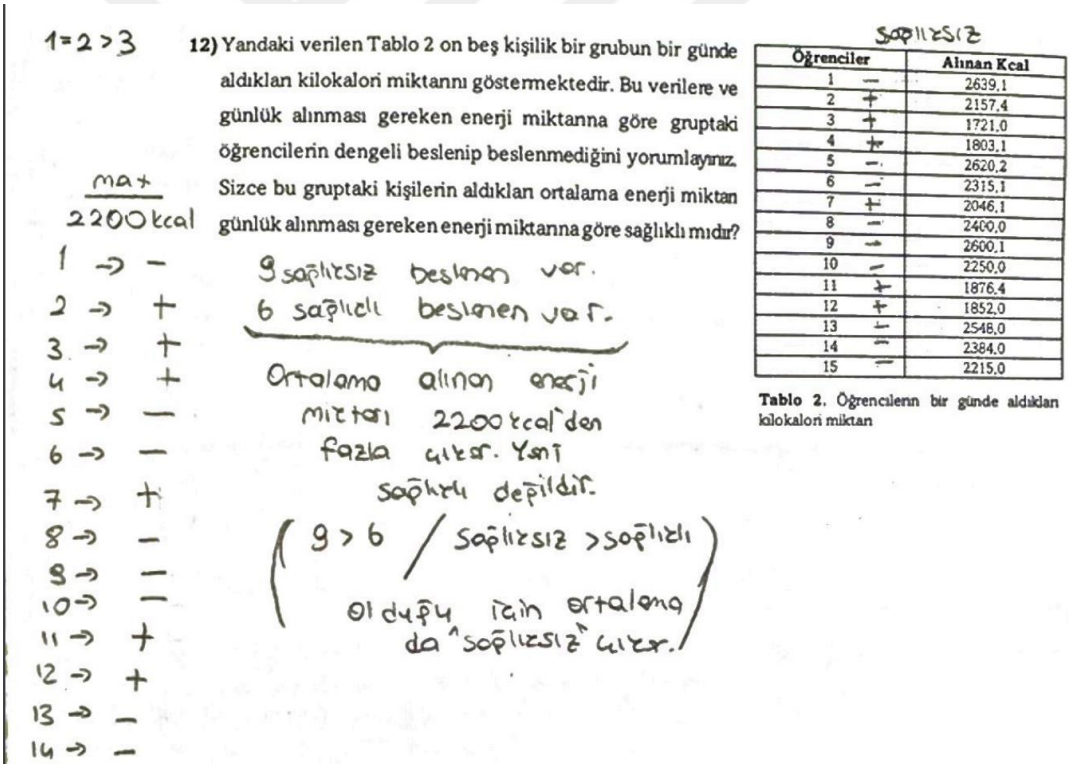


Figure 4.21. One student's answer corresponding to Level 3 in the daily diet task

This question is explained and exemplified with an answer determined as Level 4.

In Figure 4.21, the student marked each kcal of students using a minus and plus sign to show which was healthy and which was not, emphasizing that the max kcal should be 2200. Then, by looking at the results, the student concluded that nine students were unhealthy and six were healthy. Finally, the student interpreted the results saying that "The average would be higher than 2200 since most students took higher kcal than 2220" and decided that this group was unhealthy.

The student used the statistical knowledge of mean, the average of the given data, by observing that the data points exceeding the limit were more than those that stayed under the limit. Furthermore, the statistical interpretation is that the mean score would exceed the limit for a healthy diet. However, there needs to be evidence of mathematical knowledge of this interpretation. Even though the student reached the correct answer, the mathematical branch of the explanation fell short of placing the answer in Level 4. Thus, the response is in Level 3.

Lastly, for interpreting the results component, 36 students (14.52%) are in Level 2 according to the overall scores. One sample answer corresponding to Level 2 is given in Figure 4.22.

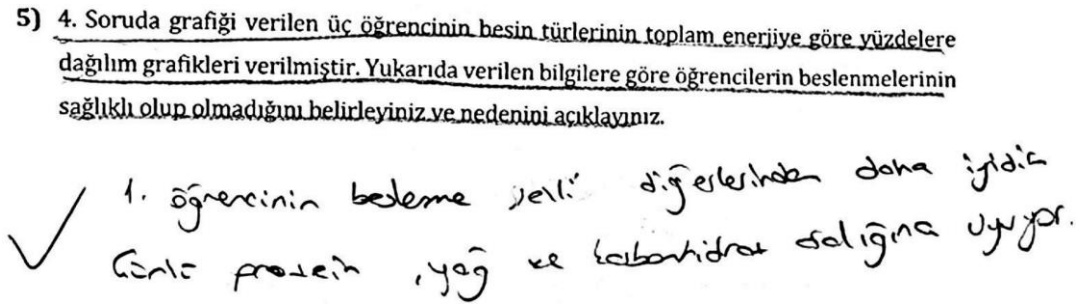


Figure 4.22. One student answer corresponding to Level 2 in the daily diet task

This question is explained and exemplified with an answer determined as Level 3.

As seen in Figure 4.22, the student wrote: "The first student's diet is healthier than others because every nutrition type fitted the range."

As seen in Figure 4.22, some students answered the question by considering only one student's pie chart in Q4. This kind of answer was determined as Level 2 due to the answer focusing only on one point.

4.3 The Summary of the Findings

This part of the chapter summarizes the findings related to students' statistical literacy in the COVID-19 task and the daily diet task.

Table 4.3 The Frequencies of the Students' Answers regarding the Correctness

	Wrong Answers (Level 0)	**Partially Correct Answers (Levels 1-2-3)**	**Correct Answers (Level 4)**
Daily Diet			
Q1	129	119	0
Q2	118	85	45
Q3	233	11	4
Q4	197	48	3
Q5	186	56	6
Q6	131	113	4
COVID-19			
Q1	145	103	0
Q2	123	124	1
Q3	37	207	4
Q4	136	111	1
Q5	137	111	0
Q6	180	68	0

Table 4.3 which indicates the frequencies of the students' answers regarding the correctness show that the frequencies of correct answers are higher in daily diet while the frequencies of partially correct answers are higher in COVID-19.

In the COVID-19 task, 98.39% of students were found to have low-level statistical literacy, while 1.61% were found to have high-level statistical literacy.

Additionally, for the COVID-19 task, 0.81% of the students had high statistical literacy skills in representing and analyzing the data component. There was no student (0.00%) at Level 4. Furthermore, 0.81% of the students were found to have high statistical literacy skills in interpreting the results component. There was no student (0.00%) at Level 4. The findings show that the number of students for the interpreting the results component and representing and analyzing the data component is the same for the COVID-19 task.

Moreover, 0.00% of students from Ankara, 4.00% from İstanbul, 0.00% from Kayseri, and 3.45% from Kars have high-level statistical literacy. Therefore, for the COVID-19 task, the highest percentages belong to İstanbul and Kars, respectively.

When considering the findings of the analyzed cities in terms of the components, it was found that 2.00% of students from Istanbul and 1.72% from Kars demonstrated a high level of statistical literacy in the representation and analysis of data component. Hence, the highest percentage belonged to İstanbul in the representation and analysis of the data component in the COVID-19 task. In addition, 2.00% of the students from İstanbul and 1.72% from Kars were found to have high statistical literacy for the interpreting the results component. The highest percentage belonged to İstanbul in the interpreting the results component of the COVID-19 task.

In the daily diet task, 91.53% of the students were found to have low-level statistical literacy, while 8.47% had high-level statistical literacy.

Additionally, 3.63% of the students were found to have high statistical literacy skills in the representing and analyzing the data component for the daily diet task. 0.81% of them were in Level 4. Furthermore, 4.84% were found to have high statistical literacy skills in interpreting the results component. 0.81% of them were in Level 4. The findings revealed that there are more students with high statistical literacy skills

in the interpretation of the results component than the representation and analysis of the data component for the daily diet task.

Moreover, 6.02% of the students from Ankara, 10.00% from İstanbul, 12.28% from Kayseri, and 6.90% from Kars were found to have high-level statistical literacy. Therefore, the highest percentages belong to Kayseri and İstanbul, respectively. Although Kars seems to have higher percentages than Ankara, their percentages are very close.

When the findings pertaining to the cities are examined considering the components, it can be stated that for the representation and analysis of the data component, 3.62% of the students from Ankara, 6.00% from İstanbul, 1.75% from Kayseri, and 3.45% from Kars have high statistical literacy. Hence, the highest percentage belonged to İstanbul in the representation and analysis of the data component in the daily diet task. Furthermore, for interpreting the results component, 2.41% of the students from Ankara, 4.00% from İstanbul, 10.53% from Kayseri, and 3.45% from Kars have high statistical literacy. The highest percentage belongs to Kayseri in interpreting the results of the daily diet task.

In conclusion, when the real-life contextual tasks are compared, the number of students with a high statistical literacy level on COVID-19 task is lower than students with a high statistical literacy level on the daily diet task.

Furthermore, it is worth noting that the number of students with high statistical literacy skills is higher in Istanbul and Kayseri compared to other cities, despite having an equal number of students. On the other hand, the city with the lowest number of students demonstrating high statistical literacy levels is Ankara.

When the findings for the components are summarized, it can be stated that they are the same for the COVID-19 task. On the other hand, the students performed better in the interpreting the results component compared to the representing and analyzing the data component in the daily diet task.

When the responses are examined, it is seen that the students generally did not involve mathematical explanations in the statistical process. However, according to Sharma et al. (2011), it is essential that students provide mathematical judgments for their statistical interpretations and analysis.

The students' responses reveal a lack of consideration for context in their interpretation of the results. A notable number of students relied solely on their personal experiences and daily life knowledge to answer the questions.

Additionally, the students failed to provide their insights regarding the distinctions between the characteristics of central tendency scores and sample size concepts for various groups, despite being equipped with information on central tendency scores, graphical representations, and accessible data collection. The students' performances were lower in terms of determining how and when to use them.

Additionally, students in the lower levels struggled with choosing the appropriate type of graphical display for both categorical and continuous data sets. The majority of these students opted for bar graphs to represent the data, primarily because they found it easier to draw. However, they were unable to provide a reasonable explanation for their choice of bar graphs and the specific features that led them to this decision. Also, the answers show that the students frequently refrained from interpreting and analyzing the data in the form of ratios and fractions and representing the data with a pie chart. The reason can be an inadequate conceptual and procedural understanding of percentages, ratios, and proportion concepts.

CHAPTER 5

DISCUSSION AND CONCLUSION

The aim of the study was to investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. This chapter presents a discussion of the findings in Chapter 4 with the contribution of the related studies in the Literature Review part in Chapter 2, implications for educational practices, and recommendations for further research.

5.1 Discussion of Findings

In this section, the findings related to students' statistical literacy levels are discussed in detail with respect to related studies. Then, students' statistical literacy in terms of context familiarity and content domains such as average and graphical displays are discussed.

5.1.1 Students' Statistical Literacy Levels

This study examined eighth graders' statistical literacy levels with SLT, including two data collection tools about two real-life contexts, COVID-19 and daily diet, concerning the components of representation and analysis of the data and interpretation of the results.

The findings of the study indicate that the statistical literacy levels of above ninety percent of the participants are notably low. When the students' statistical literacy levels from the two tasks are compared, it is observed that the number of students

with a high statistical literacy level on COVID-19 is lower than the number of students with a high statistical literacy level on the daily diet task.

The finding about students' low statistical literacy aligns with previous research conducted by Moritz and Watson (1997), Watson and Callingham (2003), as well as Çatman-Aksoy and Işıksal-Bostan (2020). In addition, the finding that students demonstrated higher levels of statistical literacy in the daily diet context compared to the COVID-19 context is consistent with the research conducted by Kuş (2022), who stated that educational systems, which integrate real-life examples and practical applications of their curriculum, tend to have a positive effect on students' statistical literacy levels.

Furthermore, this study examined the variation in statistical literacy performance among different regions with diverse schools and school environments. Specifically, the students in Istanbul and Kayseri demonstrated higher levels of performance, while the students in Ankara exhibited lower levels of performance. As stated in Chapter 3, the schools in İstanbul and Kayseri offer more educational opportunities to their students with respect to educational settings such as school resources. Since the educational settings in these schools, especially in İstanbul, is varied, students in these schools might have higher statistical literacy.

This finding aligns with the results of previous studies by Suna et al. (2020), Alaçacı and Erbaş (2020), and Wardar et al. (2022), which also emphasize the importance of sufficient school resources in enhancing students' achievements. The equity in education and the type of school students attend can also impact their performance in statistical literacy (Alaçacı & Erbaş, 2020). Factors such as school resources, discipline, safety, experience, and education level of the principals and school types might cause inequality in statistical literacy levels between different regions.

The findings of the study further indicate that the students' responses in interpreting statistical information predominantly rely on qualitative judgment rather than providing a mathematical explanation. However, according to Sharma et al. (2011),

it is essential that students provide mathematical judgments for their statistical interpretation and analysis.

The finding that the students' responses to questions frequently rely on qualitative judgment is consistent with the research conducted by Watson and Callingham (2003) and Yolcu (2012). Watson and Callingham (2003) stated that the prevalence of qualitative judgment in students' responses suggests they may lack a solid understanding of the underlying mathematical concepts and principles involved in statistical analysis. In the current study, the students might have had difficulties in the conceptual understanding of the mathematical concepts and principles and in including them in their statistical analysis and interpretations. This reliance on qualitative judgment alone might limit students' ability to evaluate and interpret statistical information accurately and critically. By demonstrating the relevance and utility of mathematical reasoning in real-world contexts, educators can encourage students to incorporate mathematical explanations into their interpretations. By promoting mathematical literacy and providing opportunities for meaningful application, educators can equip students with the necessary skills to critically analyze and interpret statistical information using qualitative and quantitative reasoning.

5.1.2 Students' Statistical Literacy in terms of Context Familiarity

In this part, the findings about students' statistical literacy abilities with respect to the context familiarity is discussed.

This study finds that the statistical literacy levels are higher in daily diet as opposed to COVID-19. As mentioned before, Watson (2006) classifies contexts into three: isolated, familiar and unfamiliar. In this study, a familiar and an unfamiliar context is used. Familiar contexts are the ones from the daily lives of the students, and unfamiliar contexts as statistical messages in media. Therefore, daily diet context is classified as a familiar context, and COVID-19 is classified as an unfamiliar context.

The finding that students have achieved a higher performance in a familiar context as opposed to an unfamiliar one aligns with the findings in the literature (Washburne and Osborne 1926a, 1929b; Chipman et al., 1991; Hembree, 1992; Cooper and Dunne, 1998; Carraher, Carraher, and Schliemann 1985, 1987; Bibi et al., 2018).

The finding that the statistical literacy levels are higher in familiar contexts such as daily diet compared to the COVID-19 context might be due to the fact that students can demonstrate their knowledge and skills more effectively with contextual tasks related to everyday life experiences (Watson & Sullivan, 2008). Following a similar line of reasoning, educational systems that do not adequately incorporate real-life examples, like the one in Turkey (Altay et al., 2020), may impede the development of students' statistical literacy skills. Thus, the discrepancy in performance between the two contexts underscores the importance of incorporating relevant and relatable real-life examples in educational settings such as textbooks and the tasks teachers use in their lessons. By integrating contextualized learning experiences that align with students' daily lives, educators can enhance students' engagement and understanding of statistical concepts.

The findings also show that students' responses reveal a lack of consideration for context in interpreting the results. A substantial number of them relied solely on their personal experiences and daily life knowledge to answer the questions. This observation is consistent with the research conducted by Watson and Moritz (1997a) and Yolcu (2012), which suggest that students' interpretations rely more on their personal experiences rather than their statistical knowledge in the given context. This finding highlights the importance of addressing the influence of personal experiences on students' interpretation of statistical results. Students may rely on their personal experiences and perceptions since textbooks often present statistical concepts without incorporating real-life contexts. In addition, by fostering a balanced approach that combines personal experiences with critical analysis regarding the context, educators might enhance students' ability to interpret statistical information accurately and objectively.

Comparing the findings of the components concerning the contextual tasks, the present study has revealed interesting findings regarding students' performance in statistical literacy within the COVID-19 and daily diet contexts. Specifically, the results indicate that the students demonstrated relatively similar levels of performance in both the interpretation of results and the representation and analysis of data components in the COVID-19 context. However, the students showed better performance in interpreting the results compared to representing and analyzing the data in the daily diet context.

The finding on the daily diet context contrasts with the results reported by Capraro, Kulm, and Hammer (2005) and Aoyama and Stephens (2003). The familiarity of the contextual task might be the reason why the study presents this different finding from the literature. In other words, the daily diet context is one that students frequently encounter in their daily lives, making it easier for them to interpret and evaluate statistical messages. Additionally, information about nutrition and daily diet is introduced to students in fourth grade as part of the Turkish science curriculum. Thus, the students are more familiar with the context of daily diet than with COVID-19. The discrepancy in findings across these studies highlights the complexity and multifaceted nature of statistical literacy. It suggests that students may possess different strengths and weaknesses in different aspects of statistical literacy, depending on the specific context and educational interventions employed.

5.1.3 Students' Statistical Literacy in terms of Content Domains

In this part, the findings about students' statistical literacy abilities with respect to the central tendency scores and average and graphical display concepts are discussed.

The study revealed that the students failed to provide their insights regarding the distinctions between the characteristics of central tendency scores and sample size concepts for various groups, despite being equipped with information on central tendency scores, graphical representations, and accessible data collection. Also, the

performance of the students was lower in terms of determining how and when to use them. In the sections below, these findings are discussed more in detail.

5.1.3.1 Central Tendency Scores and Average

When the first content domain, which is the average and central tendency scores, was examined, it was seen that the students' statistical literacy levels on the average concept are substantially low. It was also found that the students faced challenges in differentiating between various central tendency scores, such as mean, mode, and arithmetic average.

The research conducted by Mokros and Russel (1995) and Yolcu (2014) yielded similar findings. The mathematics curriculum might be a contributing factor to this issue. The lack of emphasis on the representative value of the average in the curriculum, while focusing more on measures of central tendency and arithmetic mean (Yolcu, 2012), might lead students to have a limited understanding of the concept. This highlights the need for a more balanced approach that emphasizes the representative nature of the average.

This finding that students have difficulty differentiating between various central tendency scores is also similar to the findings of Yolcu (2012). According to Yolcu (2012), in the Turkish curriculum, "average" and "mean" are often used interchangeably, leading to confusion among students. In this study, the confusion between average and mean might have led students to use mean whenever the average is asked in a question. Therefore, it would be better if these concepts were revised to resolve this confusion. Specifically, introducing the concept of mean in the 6th grade and covering all measures of central tendency in the 7th grade might cause confusion, as students may perceive the average and mean as the same concept and find it hard to distinguish between these terms.

Teachers often use traditional inquiry in their lessons to present statistical concepts, which is a common practice in the Turkish education system, aligned with the way

these concepts are given in textbooks and the curriculum (Kuş, 2022). The difficulties in distinguishing between different measures of the central tendency may also result from educators and poor instruction methods since these are integral parts of education (Firmender et al., 2014).

It was also found that the students had difficulty determining which measure of central tendency is appropriate to represent a given data set, specifically when there are extreme values. The finding that students often perceive the average as not being representative of the data set, especially when there are extreme values, is consistent with the study conducted by Mokros and Russel (1995). This observation is also consistent with the research conducted by Strauss and Bicher (1988), who noted that students face difficulties in calculating and interpreting data sets that include extreme values. The finding that students often perceive the average as not representative of the data set might be attributed to how textbooks discuss statistical concepts. Although textbooks play a significant role in shaping students' understanding of the average concept, they often neglect essential models, such as equilibrium and fair-share models, that are effective in teaching the concepts (Bütüner, 2020). Moreover, focusing only on calculating the arithmetic mean might leave students with a superficial understanding, without adequately addressing the representation aspect.

In addition to emphasizing diversifying the discourse of textbooks, this similar finding of Kuş (2022) highlights the differences in how these concepts are addressed in the curriculum. The Turkish curriculum tends to focus more on the calculation aspect. Thus, the reason why the students perceive the average as not being representative of the data set might be caused by the curriculum and establishing procedural understanding. This disparity suggests that adopting a more comprehensive and contextualized approach, as seen in the Australian curriculum, may enhance students' understanding of the average concept.

5.1.3.1.1 Weighted Average

As it is mentioned before, the weighted average is related to many statistical concepts, such as mean and sample. Hence, the average and sample size of a data set is essential for students to comprehend the weighted average and other statistical concepts and make reasonable interpretations of the data set. Due to mentioning the average concept above, the sample is discussed regarding the weighted average concept.

The findings of this study indicate that students face challenges in understanding and evaluating the concept of sample size when dealing with averages and weighted averages. These challenges revealed in the present study, along with the supporting research by Watson and Moritz (2000) and Yolcu (2012), highlight the importance of addressing students' understanding of sample size. The reason for this finding might be an inadequate focus on providing explicit instruction on the concept of sample size and emphasizing its role in drawing accurate conclusions and questioning claims based on statistical data by educators.

Moreover, Yolcu (2012) found that students face challenges in various contexts when attempting to draw conclusions based on the data, similar to the difficulties observed in the study concerning the interpretation of sample representativeness and graphs. Thus, students' confusion about the sample might be caused by not using various contextual tasks.

The finding suggests that addressing students' inadequate interpretation and analysis skills regarding weighted averages and samples in a data set can help mitigate students' inequalities and enhance their statistical literacy skills. This can be achieved through providing targeted instruction, contextualized examples, and clarification of terminology by educators, leading to a more robust understanding of the role of sample size in statistical content domain including the sample, such as weighted average and variation, and their analysis and inference.

5.1.3.2 Graphical Displays

Every graph has a different aim, and with respect to the aims, they also have different features. Thus, students face different issues with each type of graph. Studies on the issues faced by students while representing, analyzing, and interpreting each graph type and their comparison are presented below.

The findings of this study revealed that students had difficulties in the interpretation of graphs, yet they could read the graph. Also, particularly lower-level students had difficulties matching data with appropriate graph types. Many students tend to choose bar graphs because they perceive them as more effortless, yet they struggle to provide a logical explanation for their choice. Additionally, the study shows that students often refrain from making interpretations and conducting analyses, potentially indicating a weakness in their understanding of ratio and proportion concepts when faced with data including fractions or ratios.

The challenges students face in graphical representation extend to their ability to interpret graphs. Similar to the finding that students have difficulty in interpreting graphs, several studies found that students can read graphs but struggle with interpretation (Kirsch et al., 1981; Pereira-Mondeza & Mellor, 1991; Watson & Moritz, 1997a; Bright & Friel, 1998; Aoyama & Stephens, 2003; Capraro et al., 2005). Furthermore, in alignment with the finding of this study, Capraro, Kulm, and Hammer (2005) noted that students may be able to represent the data graphically but struggle to provide meaningful interpretations. Students' skills in analyzing and interpreting graphical data effectively might be caused by students' inadequate ability to form a relationship between the statistical information in the text and the real-life situations due to the inadequate real-life contextual examples and textbooks.

The findings regarding students' confusion in differentiating between categorical and continuous data, and their struggles in deciding which type of data set is appropriate, align with previous research by Shaugnessy and Zawojewski (1999), Friel et al. (2001), and Brasell and Rowe (1993), which also highlighted challenges students

face in selecting suitable graph types and justifying their choices. Furthermore, similar to the finding of the study, Çatman-Aksoy and Işıksal-Bostan (2020) noted that students are more successful at determining appropriate graph types for categorical data. Students' confusion on differentiating the categorical and continuous data might be caused by the frequency of usage of real categorical and continuous data in textbooks or teachers' examples. It might also be attributed to the fact that there is no objective that expects students to diversify categoric or continuous data in the curriculum. It would be beneficial to include the distinction between categorical and continuous data, as well as guidelines on which type of graph should be used for each data type, in the curriculum. This addition would enhance students' comprehension of the purpose, representation, and interpretation of graphs, and help them differentiate between different data types more effectively. Additionally, teaching graphical displays without contextual tasks might cause students to have difficulty understanding and evaluating different data types.

In this study, students face challenges when it comes to interpreting pie charts and line graphs. As we mentioned before, in Turkey, students have low achievement levels in proportional reasoning concept (Öztürk et al., 2021). Statistical literacy and mathematical knowledge are related, as seen in Watson's model of statistical literacy (2006). Thus, students' confusion in their choices about graphical displays might be caused by the lower level of achievement in proportional concepts.

These findings emphasize the importance of targeted instruction focusing on differentiating between graph types and data types, developing critical evaluation skills, and providing meaningful opportunities for students to apply and interpret graphical data. Also, developing other mathematical knowledge and using various real-life contexts is crucial to statistical literacy development.

5.2 Implications for Educational Practices

In this section, the identified gaps in statistical literacy call for the attention of educators, curriculum developers, and policymakers in relation to the findings and discussion of the findings of this study. Collaborative efforts are required to design and implement innovative teaching methods and learning experiences to effectively enhance students' statistical literacy levels. By doing so, educators can equip students with the necessary skills to analyze data critically and make informed decisions.

The findings of the study show that the students have higher achievement in a context that they can relate to in their daily lives. Thus, based on the findings, it is suggested that statistics instruction in schools should incorporate real-life data and media reports to enhance statistical literacy and facilitate the connection between real-life situations and statistical messages for middle school students.

Based on the findings of this study and the supporting evidence from Kuş (2022), it is evident that curriculum design and instructional practices play a crucial role in shaping students' statistical literacy. It would be better for education policymakers and curriculum developers to consider the integration of meaningful real-life contexts into the curriculum, as it can contribute to the development of students' statistical literacy skills. Such an approach can empower students to make informed decisions, critically evaluate data, and navigate the complexities of a data-driven society effectively. Thus, the integration of more real-life contexts into statistics teaching is recommended as statistical literacy deals with data in context and serves as a bridge between statistics and everyday life. Also, textbook writers could incorporate more updated familiar daily life scenarios such as Covid-19 into their materials to enhance students' understanding and attitude toward statistical literacy. It would be better that textbook questions include more diverse real-life situations which students are familiar in their daily lives such as daily diet to encourage the interpretation and assessment of statistical concepts.

It is imperative that statistical literacy takes precedence in the elementary mathematics curriculum, with a specific focus on statistics, chance, and probability at every grade in elementary schools. This requires setting clear objectives that prioritize representation and analysis of data and interpretation of results components. Also, the findings collected from different regions of Turkey show that the number of objectives regarding these components can be increased, and it would be better to allocate more lesson hours to improve students' statistical literacy.

Recent research highlights the difficulty students face in comprehending the wording and significance of "average" in Turkish. Incorporating a comprehensive understanding of the concept of average into the middle school mathematics curriculum is crucial. To address this issue, the curriculum should stress that mean, median, and mode are distinct types of averages and not interchangeable terms. Also, it would be better for textbook writers to dedicate an entire chapter to these concepts and provide ample real-life examples demonstrating the practical application of central tendency scores to avoid confusion. Before introducing measurements, it is essential to emphasize the meaning of the concept in textbooks. According to Bütüner (2020), utilizing the idea of fair sharing and center of balance when teaching the concept of arithmetic mean is necessary. Thus, it could be beneficial that textbooks include different methodologies to teach students the meaning of average.

Furthermore, with courses given by the MoNE, teachers can understand how crucial it is to use a critical thinking approach in the classroom to improve students' understanding of statistics. Rather than simply accepting the concepts and formulas without questioning, students can be encouraged to reflect, discuss, and evaluate statistical information. To achieve this, teachers may focus on providing contextual examples and tasks that require the interpretation and evaluation of statistical concepts. Thus, it would be better if teachers prepare tasks to enhance students' comprehension and evaluation of graphical displays in familiar contexts.

According to the findings of the present study, the students enrolled in schools that have more opportunities, such as educational settings and smaller class sizes, are at

higher statistical literacy levels, similar to the schools in İstanbul in the present study. As mentioned before, the type of school students attend and the educational opportunities can also impact their statistical literacy performance (Alaçacı & Erbaş, 2020). Thus, the educational settings and opportunities of schools should be made equal and enhanced without distinction among different regions of Turkey.

5.3 Recommendations for Further Research Studies

The current study examined investigate the statistical literacy levels of eighth graders enrolled in schools in different regions of Turkey regarding an unfamiliar real-life context such as COVID-19 and a familiar real-life context such as daily diet, using the last two statistical process components: representation and analysis of the data and interpretation of the results. This section provides recommendations for mathematics teachers, textbook writers, mathematics curriculum developers, and mathematics teacher educators based on the findings and discussions of the study.

Firstly, the sampling method for the current research is convenience sampling. Even though the participants were 248 eighth-grade students selected from different regions of Turkey, taking into account certain demographics that can influence the participants' statistical literacy, such as socio-economic status, educational settings of the enrolled schools, and their teachers' experiences, employing one of the random sampling methods would be more advantageous in generalizing the study's findings to all eighth-grade students in Turkey (Fraenkel et al., 2012). Also, the number of regions from which the participants were selected can be increased and varied so that the sample can represent the whole population.

Secondly, the study is completed with a qualitative survey design. With this research design, the students' statistical literacy levels can be examined in the short term. On the other hand, it can be useful to implement a longitudinal study to investigate the change in the statistical literacy levels and the students' thought processes over time.

In addition, interviews can be beneficial for an in-depth examination of students' opinions. Interviews allow students to explain their way of thinking, which they cannot express in writing. Based on their answers, possible issues, the statistical literacy levels of students, factors that affect their statistical literacy skills, and possible solutions can be determined. For example, one of the findings of the study is that the students could not establish the difference between the types of graphs in terms of data types. When a student chose a graph type for a given data set, the student did not consider whether the data were categorical or continuous. This might be caused by inadequate terminology, and the researcher can understand this when students describe the features of the data set using sentences that cannot be transferred to paper. Also, students' solutions and drawing with the explanations could be more understandable and carry more detailed information. During interviews, students may be asked to compare their solutions with their interpretations. This can help students recognize any inconsistencies between their explanations and interpretations.

Another suggestion for further studies is that the study can be done as a quantitative study. In this study, due to the use of the qualitative survey research method, factors influencing students' statistical literacy could not be determined. Thus, quantitative research can be conducted to identify which factors or demographics are influential on students' statistical literacy levels and to reveal the factors in different regions of Turkey that may contribute to inequality in the statistical literacy skills of students enrolled in schools across different areas of the country.

It is worth emphasizing that the study solely relied on the answer given to the questions in the data collection tool. For a more comprehensive outcome, it is imperative that upcoming research employ alternative tests or expand the data collection tool of the study to cover additional familiar and unfamiliar contexts and graph types to support the findings or contribute to the findings. It is strongly recommended that the data collection tool of the study undergo necessary improvements, including the integration of crucial elements such as data representation, analysis, and interpretation of results, which are vital to gaining a

thorough understanding of concepts like chance, probability, and variation. Additionally, essential changes should be made to the curriculum, textbooks, and teaching methodology to address these aspects effectively.

Lastly, the effect of teachers and their inquiry methodologies could not be included in this study. However, it is crucial to explore student and teacher-related factors to advance research in statistical literacy. Research on teacher-related factors may help understand which variables impact the statistical literacy levels of 8th graders and how significant teachers' contributions are. Different inquiry approaches instead of traditional teaching may enhance students' data representation skills, as observed in the study of Koparan (2012). Also, analyzing how teachers teach statistics at different grade levels would be valuable. For instance, the teaching methods for average concepts may differ from those for sample. A detailed examination of how instruction is delivered for these topics can provide richer insights into how the intended middle school mathematics curriculum is implemented. Thus, different statistical concepts can be examined using different instructional techniques.

To conclude, it is recommended to conduct further research on statistical literacy skills in different grade levels. Additionally, exploring various strategies to enhance students' comprehension and evaluation of statistical concepts, such as conducting in-depth examinations of these concepts and implementing innovative teaching techniques, can also be highly beneficial.

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APPENDICES

A. METU Human Subjects Ethics Committee Approval

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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14 NİSAN 2022

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Mine IŞIKSAL BOSTAN

Danışmanlığını yürüttüğünüz Sinem Elif Elma'nın "Türkiye'deki 8. Sınıf öğrencilerinin istatistiksel okuryazarlık seviyeleri" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **233-ODTUİAEK-2022** protokol numarası ile onaylanmıştır.

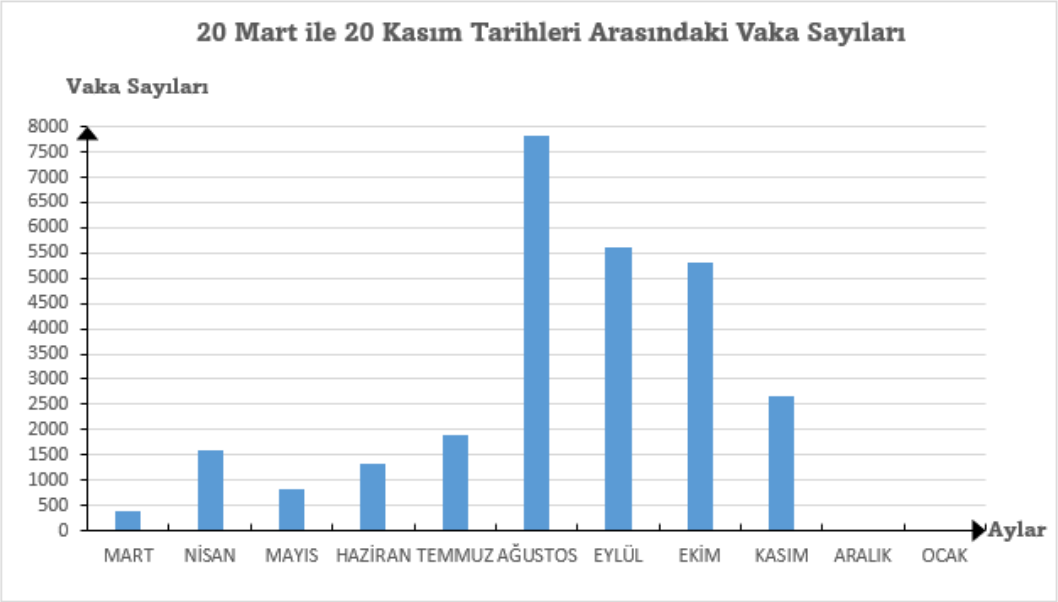
Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
İAEK Başkanı

B. COVID-19 Statistical Literacy Task

COVID-19 BİLGİ KARTI

Çin'in Vuhan Eyaleti'nde 2020 yılında ortaya çıkmış bir virüstür. Türkiye'de mart ayında görülmeye başlanan bu virüs hala etkisini sürdürmektedir. Aşağıda yer alan Grafik 1 vakaların görülmeye başlandığı 20 Mart ile aynı yılın 20 Kasım tarihleri arasındaki vaka sayılarını göstermektedir.

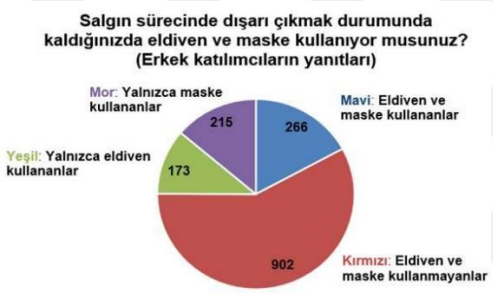


Grafik 1. 20 Mart ile 20 Kasım tarihleri arasındaki vaka sayıları

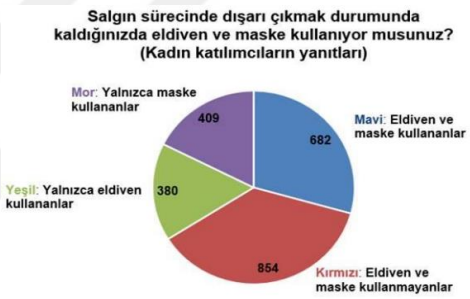
1) Grafik 1'de gösterilen 20 Mart-20 Kasım tarihleri arasında değişen vaka sayılarını değerlendiriniz. Sizce bu 9 ay için ortalama vaka sayısı nedir? Bu sonuca nasıl ulaştınız? Açıklayınız.

2) Grafik incelendiğinde, sizce bu grafik Aralık ve Ocak ayında nasıl devam ederdi? Nedenini açıklayınız.

Ülkemizde ilk vakanın görülmesiyle virüsten korunmak amacıyla maske, eldiven ve dezenfektan gibi hijyen sağlayacak materyaller kullanılmaya başlandı. Grafik 2 ve 3 salgının ilk ayında kadın ve erkeklerin eldiven ve maske kullanımını gösteren daire grafiklerini göstermektedir.



Grafik 2. Salgının ilk ayında erkeklerin eldiven ve maske kullanımı



Grafik 3. Salgının ilk ayında kadınların eldiven ve maske kullanımı

3) Grafik 2 ve 3'e bakarak salgının ilk ayında kadın ve erkeklerin eldiven ve maske kullanım sayıları hakkında neler söyleyebilirsiniz? Bu grafiklere bakarak kadınlar mı erkekler mi daha hijyeniktir?

4) Bu grafiklerdeki veriler iki ayrı grafikte gösterilmek yerine ortak bir grafikte gösterilmek istenseydi hangi grafik tercih ederdiniz? Neden?

Artan vaka sayıları ve ağır semptomlar bazı hastaları evde tedavi olamayacak duruma getirdi. Tablo 1, Covid-19 hastalarının aylara göre polikliniklere başvuru sayılarını gösterirken, Grafik 4 ise Covid-19 polikliniklerinde görülen hastaların yaş ortalamasının aylara göre dağılımını göstermektedir.

Tablo 1. Covid-19 hastalarının aylara göre polikliniklere başvuru sayıları

Aylar	Mart	Nisan	Mayıs	Haziran	Temmuz	Ağustos	Eylül	Ekim	Kasım
Başvuru Sayısı	396	1598	811	1334	1899	7984	6537	6475	3372



Grafik 4. Covid-19 Polikliniklerindeki Hastaların Yaş Ortalamasının Aylara Göre Dağılımı

5) Tablo 1 ve Grafik 4 göz önüne alındığında belirtilen tarihler arasındaki mart, mayıs ve ağustos aylarında Covid-19 polikliniklerde bulunan hastaların yaş ortalaması nedir? Cevabı verirken kullandığınız yöntemi ve nedenini açıklayınız.

Yalnızca bir grip gibi görülen bu hastalık ciddi semptomlar ve ölüm riskini barındırmaktadır. Fakat aşı hastalığın hafif atlatılmasını sağlamakta ve ölüm riskini azaltmaktadır. Tablo 2 vefat eden kişi sayısının toplam izlenen hasta sayısına oranını göstermektedir.

	Ölen /toplam izlenen hasta sayısı
Mart	0/111
Nisan	1/216
Mayıs	1/103
Haziran	0/115
Temmuz	0/144
Ağustos	2/265
Eylül	8/185
Ekim	3/123
Kasım	2/49
Toplam	**17/1365 (%1,2)**

Tablo 2. Vefat Eden Kişi Sayısının Toplam İzlenen Hasta Sayısına Oranı

6) Tablo 2'ye bakarak aşı uygulamasının etkisinin hangi aylarda daha sık ve hangi aylarda daha az görüldüğü hakkında yorum yapınız.

C. Daily Diet Statistical Literacy Task

NASIL BESLENMELİYİZ?

Besinler türlerine göre protein, karbonhidrat, yağ, vitamin, mineraller ve su olarak beşe ayrılır. Protein; et, süt, yumurta gibi besinlerde, karbonhidrat; ekmek, bal, makarna ve yağ; zeytin, kuruyemiş gibi besinlerde bulunur ve vücudumuzda enerji verici olarak kullanılır. Yağ içeren besinler gram başına 9 kcal enerji içerirken, karbonhidrat ve protein için enerji gram başına 4 kcal'dir. Tablo 1 bir öğrencinin kahvaltıda yediği besin türlerini ve porsiyonlarını göstermektedir.

Tablo 1. Öğrencinin kahvaltıda yediği besin türleri ve porsiyonları

Besin Türleri	Porsiyon (gram)	Kazandırdığı Enerji (kcal)
Ekmek	50 g	
Yumurta	50 g	
Süt	200 g	
Zeytin	10 g	
Bal	15 g	
Tereyağı	10 g	

1) Tablo 1'de gösterilen bir öğrencinin kahvaltıda yediği besin türlerine ve porsiyonlarına göre aldığı kalori değerini bulunuz ve kahvaltıyı tamamladığında kaç kcal enerji kazanmıştır hesaplayınız.

NOT: Dengeli beslenme (kişilerin metabolizmasına göre farklılık gösterse bile) bir günde tüketilen bütün besin türlerinden toplam 2200 kilokalorinin üzerine çıkılmayacak şekilde tüketilmesidir.

2) Birinci soruda bulduğunuz değerlere ve yukarıda bulunan nota göre dengeli beslenen bu öğrencinin günün devamında aldığı enerji miktarı aşağıdakilerden hangisi olabilir?

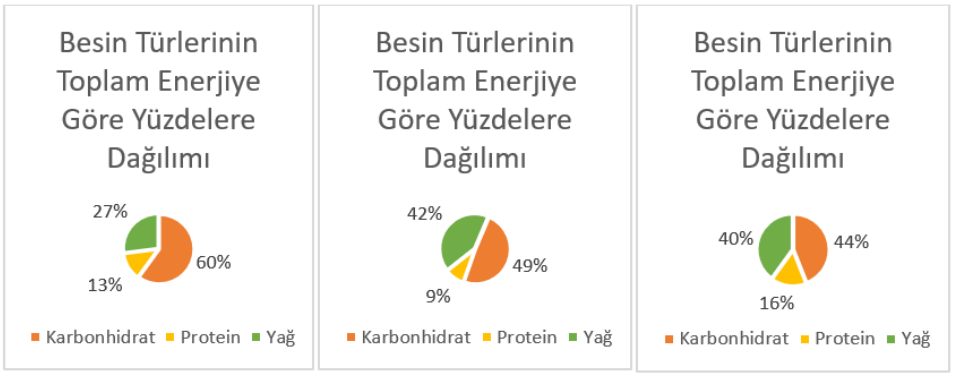
A) Öğle:720 kcal Akşam:360 kcal **B)** Öğle:1440 kcal Akşam:1440 kcal **C)** Öğle:430 kcal Akşam:520 kcal **D)** Öğle:350 kcal Akşam:350 kcal

Sağlıklı bir insan için kabul edilebilir makro besin dağıtım aralıkları, bir başka deyişle tavsiye edilen günlük tüketim miktarları besin türlerine şu şekilde dağıtılmıştır:

- Karbonhidrat için tüm enerjinin %45 - %65'i
- Protein için tüm enerjinin %10 - %35'i
- Yağ için tüm enerjinin %20 - %35'i uygun aralıktır.

3) Tablo 1'de bir öğünü verilen öğrenci için besin türlerine göre enerji dağılımına uygun grafiği çiziniz. Bu bilgiye bakarak grafiğini çizdiğiniz öğünün kabul edilebilir makro besin dağıtım aralıklarına uygun olup olmadığını yorumlayınız.

4) Aşağıda üç öğrencinin besin türlerinin toplam enerjiye göre yüzdelere dağılımı grafikleri verilmiştir. Bu üç kişinin grafiklerini beslenmelerine göre tek bir grafikle karşılaştırma yapmak istesek hangi grafiği tercih etmek uygun olurdu? Neden?



1. Öğrenci 2. Öğrenci 3. Öğrenci

5) 4. Soruda grafiği verilen üç öğrencinin besin türlerinin toplam enerjiye göre yüzdelere dağılım grafikleri verilmiştir. Yukarıda verilen bilgilere göre öğrencilerin beslenmelerinin sağlıklı olup olmadığını belirleyiniz ve nedenini açıklayınız.

6) Yandaki verilen Tablo 2 on beş kişilik bir grubun bir günde aldıkları kilokalori miktarını göstermektedir. Bu verilere ve günlük alınması gereken enerji miktarına göre gruptaki öğrencilerin dengeli beslenip beslenmediğini yorumlayınız. Sizce bu gruptaki kişilerin aldıkları ortalama enerji miktarı günlük alınması gereken enerji miktarına göre sağlıklı mıdır?

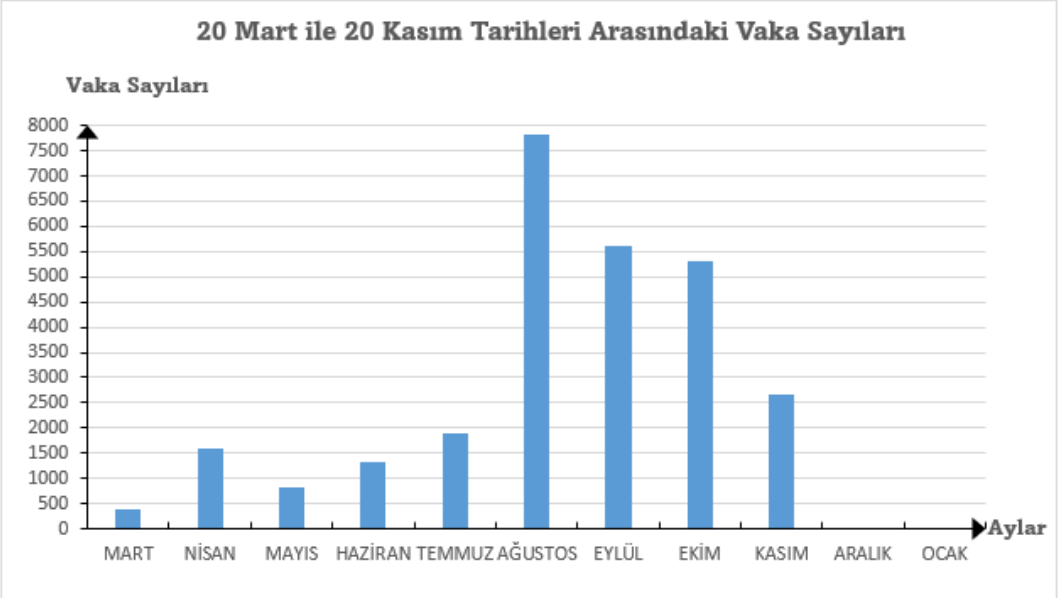
Öğrenciler	Alınan Kcal
1	2639,1
2	2157,4
3	1721,0
4	1803,1
5	2620,2
6	2315,1
7	2046,1
8	2400,0
9	2600,1
10	2250,0
11	1876,4
12	1852,0
13	2548,0
14	2384,0
15	2215,0

Tablo 2. Öğrencilerin bir günde aldıkları kilokalori miktarı

D. The Answer Sheet of Covid-19 Task

COVID-19 BİLGİ KARTI DERECELENDİRME ÖLÇEĞİ

Çin'in Vuhan Eyaleti'nde 2020 yılında ortaya çıkmış bir virüstür. Türkiye'de mart ayında görülmeye başlanan bu virüs hala etkisini sürdürmektedir. Aşağıda yer alan Grafik 1 vakaların görülmeye başlandığı 20 Mart ile aynı yılın 20 Kasım tarihleri arasındaki vaka sayılarını göstermektedir.



Grafik 1. 20 Mart ile 20 Kasım tarihleri arasındaki vaka sayıları

1) Grafik 1'de gösterilen 20 Mart-20 Kasım tarihleri arasında değişen vaka sayılarını değerlendiriniz. Sizce bu 9 ay için ortalama vaka sayısı nedir? Bu sonuca nasıl ulaştınız? Açıklayınız.

Level 4	Grafikteki 9 aylık vaka sayısı incelendiğinde, Mart-Nisan ayları arası artık gözlemlenirken Nisan-Mayıs arası bir düşüş görülmüştür. Daha sonra Eylül ayına kadar artış gözlemlenirken Ağustos ayında vaka

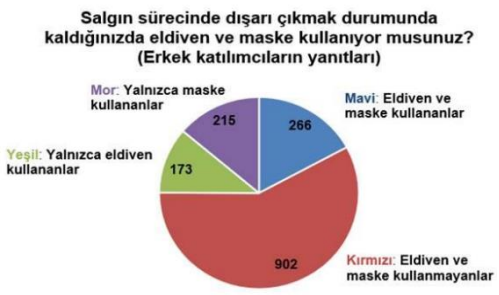
	sayısı zirveye ulaşmıştır. Daha sonra Son 3 aydaki vaka sayılarında, Ekim-Kasım ayları arasında büyük oranda olmak üzere, azalma görülmüştür. Bu veri grubu için ortalama hesaplanırken ortanca hesaplamak daha doğru olacaktır çünkü çok büyük ve çok küçük veri gruplarının bulunması aritmetik ortalamayı etkileyerek yanlış yorumlanmasına yol açar. Ortancayı bulurken aşağıdaki yol izlenebilir. Grafikteki verilerin yaklaşık değerleri sırasıyla: 400, 1600, 800, 1300, 1900, 7800, 5600, 5300, 2700 Grafikteki verilerin yaklaşık değerlerinin küçükten büyüğe düzenlenmiş hali: 400, 800, 1300, 1600, 1900, 2700, 5300, 5600, 7800 Ortanca işaretlendiği gibi 1900 çıkmıştır. Bu durumda vaka sayısı ortalaması yaklaşık olarak 1900 demek uygundur.
Level 3	**Cevap 1:** Grafikteki 9 aylık vaka sayısı incelendiğinde, Mart-Nisan ayları arası artık gözlemlenirken Nisan-Mayıs arası bir düşüş görülmüştür. Daha sonra Eylül ayına kadar artış gözlemlenirken Ağustos ayında vaka sayısı zirveye ulaşmıştır. Daha sonra Son 3 aydaki vaka sayılarında, Ekim-Kasım ayları arasında büyük oranda olmak üzere, azalma görülmüştür. Bu veri grubu için aritmetik ortalama kullanmak uygundur.” cevabını veren öğrenciler. (Grupta her sayı bir kez bulunduğu için tepe değeri yoktur, öğrenciler bu cevabı verirse direkt yanlış cevap söylemiş olacaktır.) A.O: 400+1600+800+1300+1900+7800+5600+5300+2700=27400 27400:9=3044 **Cevap 2:** Bu veri grubu için ortalama hesaplanırken ortanca hesaplamak daha doğru olacaktır çünkü çok büyük ve çok küçük veri gruplarının bulunması aritmetik ortalamayı etkileyerek yanlış

	yorumlanmasına yol açar. Ortancayı bulurken aşağıdaki yol izlenebilir. Grafikteki verilerin yaklaşık değerleri sırasıyla: 400, 1600, 800, 1300, 1900, 7800, 5600, 5300, 2700 Grafikteki verilerin yaklaşık değerlerinin küçükten büyüğe düzenlenmiş hali: 400, 800, 1300, 1600, 1900, 2700, 5300, 5600, 7800 Ortanca işaretlendiği gibi 1900 çıkmıştır. Bu durumda vaka sayısı ortalaması yaklaşık olarak 1900 demek uygundur.
Level 2	**Cevap 1:** Grafikteki 9 aylık vaka sayısı incelendiğinde, Mart-Nisan ayları arası artık gözlemlenirken Nisan-Mayıs arası bir düşüş görülmüştür. Daha sonra Eylül ayına kadar artış gözlemlenirken Ağustos ayında vaka sayısı zirveye ulaşmıştır. Daha sonra Son 3 aydaki vaka sayılarında, Ekim-Kasım ayları arasında büyük oranda olmak üzere, azalma görülmüştür. **Cevap 2:** "Bu veri grubu için aritmetik ortalama kullanmak uygundur." cevabını veren öğrenciler. (Grupta her sayı bir kez bulunduğu için tepe değeri yoktur, öğrenciler bu cevabı verirse direkt yanlış cevap söylemiş olacaktır.) A.O: 400+1600+800+1300+1900+7800+5600+5300+2700=27400 27400:9=3044
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve grafikle alakasız cevaplar

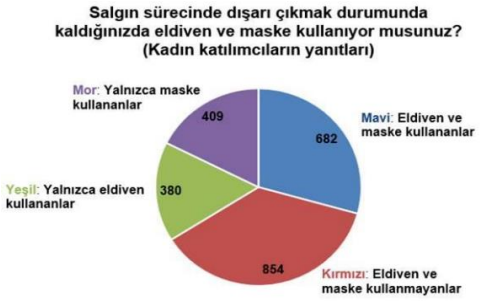
2) Grafik incelendiğinde, sizce bu grafik Aralık ve Ocak ayında nasıl devam ederdi? Nedenini açıklayınız.

Level 4	“Grafikteki verilere bakıldığında, Ağustos-Kasım ayları arası vaka sayısının sürekli bir şekilde düşmesi, ayrıca Ağustos-Eylül ayları arası vaka sayısı (7800-5600=2200 kişi ->0.28 (ya da “yaklaşık olarak çeyreği” ifadesi yeterli)) ve Ekim-Kasım ayları arası vaka sayısında (5300-2700=2600 kişi -> 2600/5300=0.49 (ya da “yaklaşık olarak yarısı” ifadesi yeterli)) büyük oranda düşüş gözlemlenmesi sebebiyle, Aralık ve Ocak ayında da düşerek devam ederdi.” şeklindeki matematiksel nedenselliklerle donatılmış ve doğru öğrenci cevapları
Level 3	“Ağustos ve Kasım ayları arası vaka sayısı düşüşe geçtiği için Aralık ve Ocak ayında da düşerek devam ederdi.” şeklindeki sözel ama doğru öğrenci cevapları
Level 2	“Ekim -Kasım arası düştüğü için düşerek devam ederdi.” şeklindeki öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve grafikle alakasız cevaplar

Ülkemizde ilk vakanın görülmesiyle virüsten korunmak amacıyla maske, eldiven ve dezenfektan gibi hijyen sağlayacak materyaller kullanılmaya başlandı. Grafik 2 ve 3 salgının ilk ayında kadın ve erkeklerin eldiven ve maske kullanımını gösteren daire grafiklerini göstermektedir.



Grafik 2. Salgının ilk ayında erkeklerin eldiven ve maske kullanımı



Grafik 3. Salgının ilk ayında kadınların eldiven ve maske kullanımı

3) Grafik 2 ve 3'e bakarak salgının ilk ayında kadın ve erkeklerin eldiven ve maske kullanım sayıları hakkında neler söyleyebilirsiniz? Bu grafiklere bakarak kadınlar mı erkekler mi daha hijyeniktir?

Level 4	**Cevap 1:** "Kadınlar daha hijyeniktir çünkü grafiklerdeki örneklem sayılarına bakıldığında iki grafikteki katılımcı sayısı eşit olmamasına rağmen (erkekler=1556, kadınlar=2305), "yalnızca maske kullananlar", "yalnızca eldiven kullananlar" ve "maske ve eldiven kullananlar" dilimlerinin oranları kadınlarda erkeklerden daha fazladır (yalnızca maske kullananlar: kadınlar→409/2305=0.18 %18 > erkekler →215/1556=0.14 %14, yalnızca eldiven kullananlar: kadınlar→380/2305=0.17 %17 > erkekler →173/1556=0.11 %11, maske ve eldiven kullananlar: kadınlar→682/2305=0.30 %30> erkekler →266/1556=0.17 %17)." şeklindeki matematiksel nedenselliklerle donatılmış ve doğru öğrenci cevapları **Cevap 2:** "Grafiğin "maske ve eldiven kullanmayanlar" dilimine bakılması sonuç için yeterlidir çünkü diğer daire dilimlerinin hepsi hijyenik olma ile ilişkilendirilir. Tek bir dilime bağlı olan hijyenik olmama durumu işimizi kolaylaştırır. Grafiklerdeki örneklem sayılarına bakıldığında iki grafikteki katılımcı sayısı eşit olmamasına rağmen (erkekler=1556, kadınlar=2305), daire grafiklerinde

	bakıldığında oransal bakımdan "maske ve eldiven kullanmayanların sayısı" erkeklerde (902/1556=0.58 %58) kadınlardan (854/2305=0.37 %37) daha fazladır. Bu durumda kadınlar erkeklerden daha hijyeniktir." şeklindeki matematiksel nedenselliklerle donatılmış ve doğru öğrenci cevapları
Level 3	"Kadınlar daha hijyeniktir çünkü grafiklerdeki örneklem sayılarına bakıldığında iki grafikteki katılımcı sayısı eşit olmamasına rağmen (erkekler=1556, kadınlar=2305), daire grafiklerinde bakıldığında oransal bakımdan "maske ve eldiven kullanmayanların sayısı" erkeklerin yarısından fazla, kadınlarda ise yarısından az görünmektedir. Bu durumda hijyen gerektiren daire grafiği parçaları kadınların grafiğinde yarısından fazla olup erkeklerin grafiğinde az olacaktır." şeklindeki sözel ama doğru öğrenci cevapları
Level 2	"Kadınlar daha hijyeniktir çünkü "yalnızca maske kullananlar", "yalnızca eldiven kullananlar" ve "maske ve eldiven kullananlar" kadınların grafiğinde sayıca daha fazlayken, "maske ve eldiven kullanmayanlar" erkeklerin grafiğinde daha fazladır." şeklindeki öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve alakasız cevaplar

4) Bu grafiklerdeki veriler iki ayrı grafikte gösterilmek yerine ortak bir grafikte gösterilmek istenseydi hangi grafik tercih ederdiniz? Neden?

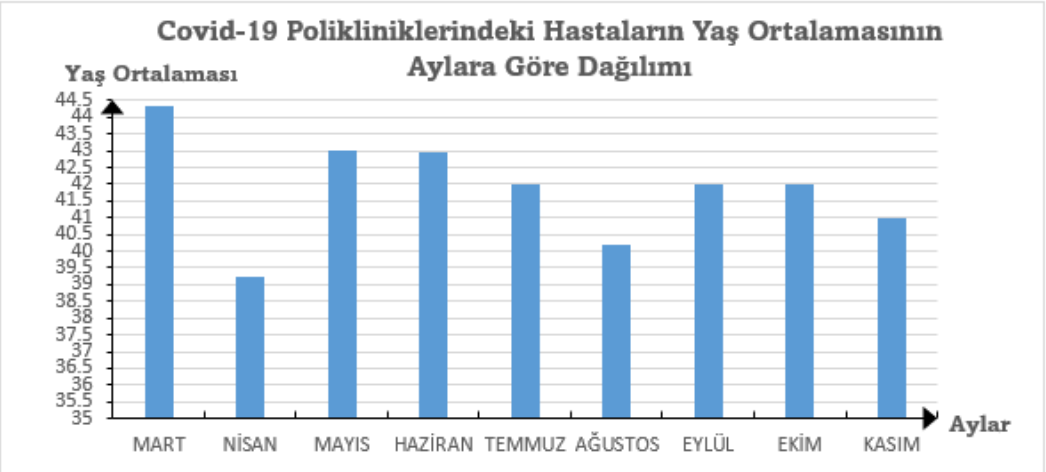
Level 4	**Cevap 1:** "Sütun grafiği çünkü sürekli devam etmeyen veri grupları ve karşılaştırma için en uygun grafik sütun grafiğidir. **Cevap 2:** "Bu grafikte artış-azalış veya değişim (çizgi grafiği) gözlemlenemez, ayrıca parça-bütün ilişkisi (daire grafiği) de yoktur.

	Bu durumda ve karşılaştırma yapılması gerektiği de göz önüne alındığında en uygun grafik sütun grafiği olacaktır.” şeklindeki öğrenci cevapları
Level 3	**Cevap 1:** “Sütun grafiği çünkü karşılaştırma için en uygun grafik sütun grafiğidir.” **Cevap 2:** Cevabı doğru verip yeterli açıklamayı yazarak yapamayan fakat grafiği çizen ve bu şekilde sadece karşılaştırma özelliğine vurgu yapan öğrenci cevapları
Level 2	“Sütun grafiği uygundur çünkü ." şeklindeki öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve alakasız cevaplar (çizgi grafiği, daire grafiği)

Artan vaka sayıları ve ağır semptomlar bazı hastaları evde tedavi olamayacak duruma getirdi. Tablo 1, Covid-19 hastalarının aylara göre polikliniklere başvuru sayılarını gösterirken, Grafik 4 ise Covid-19 polikliniklerinde görülen hastaların yaş ortalamasının aylara göre dağılımını göstermektedir.

Tablo 1. Covid-19 hastalarının aylara göre polikliniklere başvuru sayıları

Aylar	Mart	Nisan	Mayıs	Haziran	Temmuz	Ağustos	Eylül	Ekim	Kasım
Başvuru Sayısı	396	1598	811	1334	1899	7984	6537	6475	3372



Grafik 4. Covid-19 Polikliniklerindeki Hastaların Yaş Ortalamasının Aylara Göre Dağılımı

5) Tablo 1 ve Grafik 4 göz önüne alındığında belirtilen tarihler arasındaki mart, mayıs ve ağustos aylarında Covid-19 polikliniklerde bulunan hastaların yaş ortalaması nedir? Cevabı verirken kullandığınız yöntemi ve nedenini açıklayınız.

Level 4	"Öncelikle hangi otalama çeşidini kullanacağımıza karar vermek için ortalamasını alacağımız veri grubunun elemanlarını incelememiz gerekir. Verilere bakıldığında, Covid-19 polikliniklerde bulunan hastaların yaş ortalaması yaklaşık değerleriyle Mart ayı için 44.5, Mayıs ayı için 43 ve Ağustos ayı için 40 olarak görülmektedir. Değerler birbirine yakın olduğu için aritmetik ortalama uygundur. Tablo 1 gösteriyor ki bu üç aydaki polikliniklere başvuru sayıları eşit değil bu durumda direkt ortalama almamız yanlış sonuç verecektir. Örneklem sayılarına dikkat ederek ortalamayı hesaplamalıyız. Öncelikle her ay için Tablo 1'deki aylara ait kişi sayıları ile grafikteki ortalamayı çarparak her ay için toplam yaş bulunur. Bu toplamlar Tablo 1'deki üç aya karşılık gelen toplam kişi sayısına bölünür ve ayların ortalaması bulunur. Toplam kişi sayısı: 396+811+7984=9191

	Mart → 396x(44.5)=17622 Mayıs →811x43=34873 Ağustos →7984x40=319360 17622+34873+319360= 371855 371855/9191=40.5" şeklindeki matematiksel nedenselliklerle donatılmış ve doğru öğrenci cevapları
Level 3	"Öncelikle hangi otalama çeşidini kullanacağımıza karar vermek için ortalamasını alacağımız veri grubunun elemanlarını incelememiz gerekir. Verilere bakıldığında, Covid-19 polikliniklerde bulunan hastaların yaş ortalaması yaklaşık değerleriyle Mart ayı için 44.5, Mayıs ayı için 43 ve Ağustos ayı için 40 olarak görülmektedir. Değerler birbirine yakın olduğu için aritmetik ortalama uygundur. Tablo 1 gösteriyor ki bu üç aydaki polikliniklere başvuru sayıları eşit değil bu durumda direkt ortalama almamız yanlış sonuç verecektir. Örneklem sayılarına dikkat ederek ortalamayı hesaplamalıyız." yorumunu yapan fakat işlem hatası ya da hiç işlem yapmayan öğrenci cevapları
Level 2	Grafikten Mart, Mayıs ve Ağustos aylarındaki Covid-19 polikliniklerde bulunan hastaların yaş ortalamalarına dikey eksenden karşılık gelen değerleri alıp bu üç aydaki verilerin aritmetik ortalamasını alan öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve alakasız cevaplar

Yalnızca bir grip gibi görülen bu hastalık ciddi semptomlar ve ölüm riskini barındırmaktadır. Fakat aşı hastalığın hafif atlatılmasını sağlamakta ve ölüm riskini azaltmaktadır. Tablo 2 vefat eden kişi sayısının toplam izlenen hasta sayısına oranını göstermektedir.

Tablo 2. Vefat Eden Kişi Sayısının Toplam İzlenen Hasta Sayısına Oranı

	Ölen /toplam izlenen hasta sayısı
Mart	0/111
Nisan	1/216
Mayıs	1/103
Haziran	0/115
Temmuz	0/144
Ağustos	2/265
Eylül	8/185
Ekim	3/123
Kasım	2/49
Toplam	**17/1365 (%1,2)**

6) Tablo 2'ye bakarak aşı uygulamasının etkisinin hangi aylarda daha sık ve hangi aylarda daha az görüldüğü hakkında yorum yapınız.

Level 4	"Soru üzerindeki bilgi paragrafı aşının ölüm riskini azalttığını söylüyor. Bu durumda Tablo 2'deki "Vefat eden kişi sayısının toplam izlenen hasta sayısına oranı" vefat eden kişi sayısı arttıkça oran büyür ve aşının etkisinin azaldığı görülür. Tam tersine bu oran azaldıkça aşının etkisinin arttığı görülür. Bu durumda oranlar incelenirken vefat sayısı az, izlenen hasta sayısının fazla olması bizi düşük orana dolayısıyla aşının etkili olması sonucuna götürecektir. Ayların oranları incelendiğinde; Mart: 0/111=0, Nisan:1/216=0.005, Mayıs:1/103=0.01, Haziran:0/115=0 ,Temmuz:0/144=0 , Ağustos:2/265=0.008 , Eylül:8/185=0.04, Ekim:3/123=0.02, Kasım:2/49=0.04 olduğu görülür. Bu durumda oranı düşük olan ve aşının çok etkilediği aylar: Mart:0**=**Haziran:0**=**Temmuz:0 iken oranı büyük olan ve aşının az etkilediği aylar: Eylül:0.04**=**Kasım:0.04**<**Ekim:0.02**<** Mayıs:0.01**<**Ağustos:0.008**<**Nisan:0.005 olarak gidecektir." şeklindeki matematiksel nedenselliklerle donatılmış ve oranı tamamen inceleyen doğru öğrenci cevapları

Level 3	“Soru üzerindeki bilgi paragrafı aşının ölüm riskini azalttığını söylüyor. Bu durumda Tablo 2’deki “Vefat eden kişi sayısının toplam izlenen hasta sayısına oranı” vefat eden kişi sayısı arttıkça oran büyür ve aşının etkisinin azaldığı görülür. Tam tersine bu oran azaldıkça aşının etkisinin arttığı görülür. Bu durumda oranlar incelenirken vefat sayısı az, izlenen hasta sayısının fazla olması bizi düşük orana dolayısıyla aşının etkili olması sonucuna götürecektir. Bu durumda Mart, Haziran ve Temmuz aylarında aşı etkisi daha fazla görülürken, Eylül, Ekim, Kasım aşı etkisi daha az görülmüştür.” şeklindeki sözel ve aylar arasındaki aşı etkisi sıralamasını vermeyen ama doğru öğrenci cevapları
Level 2	“Soru üzerindeki bilgi paragrafı aşının ölüm riskini azalttığını söylüyor. Bu durumda Tablo 2’deki “Vefat eden kişi sayısının toplam izlenen hasta sayısına oranı” vefat eden kişi sayısı arttıkça oran büyür ve aşının etkisinin azaldığı görülür. Tam tersine bu oran azaldıkça aşının etkisinin arttığı görülür. Bu durumda oranlar incelenirken vefat sayısı az olması bizi düşük orana dolayısıyla aşının etkili olması sonucuna götürecektir. Bu durumda Mart, Haziran ve Temmuz aylarında aşı etkisi daha fazla görülürken, Ağustos, Eylül, Ekim, Kasım aşı etkisi daha az görülmüştür.” şeklindeki sadece vefat sayısına ya da izlenen hasta sayısını inceleyen, oranın tamamına hakkında inceleme yapmayan öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve alakasız cevaplar

E. The Answer Sheet of Daily Diet Task

GÜNLÜK BESLENME BİLGİ KARTI DERECELENDİRME ÖLÇEĞİ

Besinler türlerine göre protein, karbonhidrat, yağ, vitamin, mineraller ve su olarak beşe ayrılır. Protein; et, süt, yumurta gibi besinlerde, karbonhidrat; ekmek, bal, makarna ve yağ; zeytin, kuruyemiş gibi besinlerde bulunur ve vücudumuzda enerji verici olarak kullanılır. Yağ içeren besinler gram başına 9 kcal enerji içerirken, karbonhidrat ve protein için enerji gram başına 4 kcal'dir. Tablo 1 bir öğrencinin kahvaltıda yediği besin türlerini ve porsiyonlarını göstermektedir.

Tablo 1. Öğrencinin kahvaltıda yediği besin türleri ve porsiyonları

Besin Türleri	Porsiyon (gram)	Kazandırdığı Enerji (kcal)
Ekmek (karbonhidrat)	50 g	50x4=200
Yumurta (protein)	50 g	50x4=200
Süt (protein)	200 g	200x4=800
Zeytin (yağ)	10 g	10x9=90
Bal (karbonhidrat)	15 g	15x4=60
Tereyağı (yağ)	10 g	10x9=90

1) Tablo 1'de gösterilen bir öğrencinin kahvaltıda yediği besin türlerine ve porsiyonlarına göre aldığı kalori değerini bulunuz ve kahvaltıyı tamamladığında kaç kcal enerji kazanmıştır hesaplayınız.

Level 2	Tablo 1'deki kırmızı ile gösterilen hesaplamaları ve açıklamaları yapmış ve bulduğu değerleri toplayarak 200+200+800+90+60+90=1440 kcal bulan öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve tablo ile alakasız cevaplar

NOT: Dengeli beslenme (kişilerin metabolizmasına göre farklılık gösterse bile bir günde tüketilen bütün besin türlerinden toplam 2200 kilokalorinin üzerine çıkılmayacak şekilde tüketilmesidir.

2) Birinci soruda bulduğunuz değerlere ve yukarıda bulunan nota göre dengeli beslenen bu öğrencinin günün devamında aldığı enerji miktarı aşağıdakilerden hangisi olabilir?

A) Öğle:720 kcal Akşam:360 kcal **B)** Öğle:1440 kcal Akşam:1440 kcal **C)** Öğle:430 kcal Akşam:520 kcal **D)** Öğle:350 kcal Akşam:350 kcal

Level 4	Soru üzerinde verilen "dengeli beslenme için günlük 2200 kcal enerji ihtiyacının üzerine çıkılmaması" bilgisini kullanarak 1. Soruda hesaplanan 1440 kcal üzerine ne kadar daha kcal alırsa 2200kcal altında kalacağını düşünerek cevabını detaylı açıklayan ve şıkları buna göre analiz eden öğrenci cevapları **Cevap 1:** "Günlük 2200 kcal enerji ihtiyacını aşmamamız gerektiği notta verilmiş buna göre bu öğrenci öğlen ve akşam yemekleri toplamında; 2200-1440=760 kcal daha alabilir. A şıkkında 720+360=1080 kcal, B şıkkında 1440+1440=2880 kcal, C şıkkında

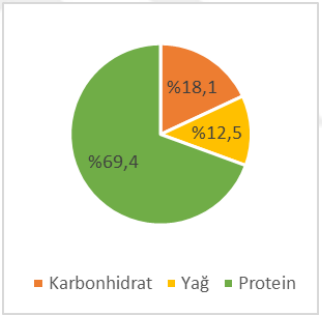
	ise 430+520=950 kcal sınırımızı aşmış ve sağlıksız beslenmeye sebep olmuştur. Fakat D şıkkında bulunan 350+350=700 kcal, 760 kcal limitimizi aşmayıp notta verilen bilgiye göre sağlıklı bir beslenme sağlamıştır." şeklindeki matematiksel nedensellikle etkinlik kağıdında verilen bilgileri birlikte veren öğrenci cevapları
Level 3	Soru üzerinde verilen "dengeli beslenme için günlük 2200 kcal enerji ihtiyacının üzerine çıkılmaması" bilgisini kullanarak 1. Soruda hesaplanan 1440 kcal üzerine ne kadar daha kcal alırsa 2200kcal altında kalacağını düşünen fakat cevabını detaylı açıklamayan veya şıklardaki analizini yaparken bilgi notundan hiç bahsetmeyen öğrenci cevapları **Cevap 1:** "D şıkkında bulunan 350+350=700 kcal, 700+1440=2140 kcal sağlıklı bir beslenme sağlamıştır." şeklindeki etkinlik kağıdında verilen bilgiden bahsetmeyen öğrenci cevapları
Level 2	"Etkinlik kağıdında alt sınır verilmemiş yalnızca üst sınır kcal verilmiştir. Bu durumda en az kcal bizim cevabımız için doğru olacaktır. D şıkkında bulunan 350+350=700 kcal, diğer şıklardan daha düşük kcal değerindedir. Dolayısıyla cevap D olmalıdır." Şeklindeki bilgi notundaki bilgiye ya da 1. sorudaki sonucu kullanmamış, tek bir noktaya odaklanmış öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve alakasız cevaplar

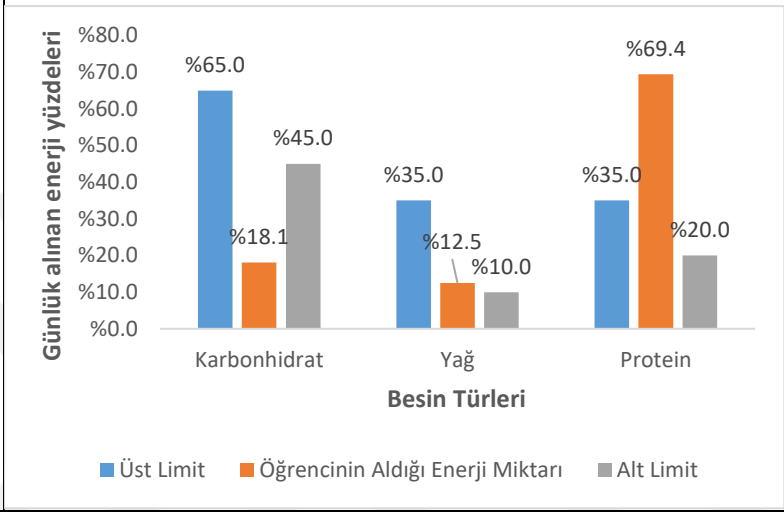
Sağlıklı bir insan için kabul edilebilir makro besin dağıtım aralıkları, bir başka deyişle tavsiye edilen günlük tüketim miktarları besin türlerine şu şekilde dağıtılmıştır:

- Karbonhidrat için tüm enerjinin %45 - %65'i

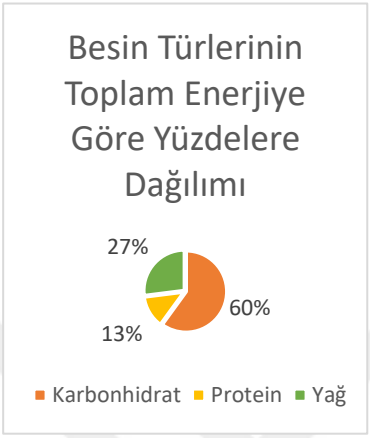
- Protein için tüm enerjinin %10 - %35'i
- Yağ için tüm enerjinin %20 - %35'i uygun aralıktır.

3) Tablo 1'de bir öğünü verilen öğrenci için besin türlerine göre enerji dağılımına uygun grafiği çiziniz. Bu bilgiye bakarak grafiğini çizdiğiniz öğünün kabul edilebilir makro besin dağıtım aralıklarına uygun olup olmadığını yorumlayınız.

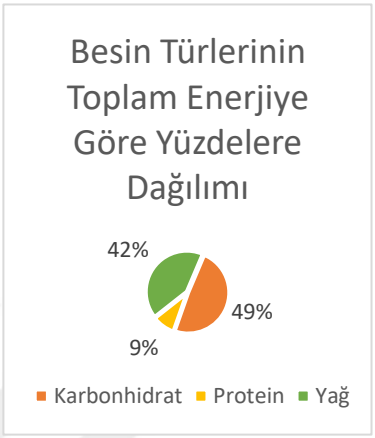
Level 4	**Cevap 1:** "Besin türleri ve günlük alınması gereken enerji ihtiyacı bize parça-bütün ilişkisi gösterdiği için daire grafiğinde gösterilmesi uygundur. Tablo 1'de bulduğum cevaplara göre karbonhidrat (ekmek ve bal) için toplam kcal 200+60=260 kcal. Yağ (zeytin ve tereyağı) için toplam kcal 90+90= 180 kcal. Protein (yumurta ve süt) için ise 200+800=1000 kcal. Yüzdelerini hesaplayacak olursak; Karbonhidrat → $\frac{260}{1440}=\frac{X}{100}$ → x= %18,1 Yağ → $\frac{180}{1440}=\frac{X}{100}$ → x= %12,5 Protein → $\frac{1000}{1440}=\frac{X}{100}$ → x= %69,4  Karbonhidrat (%18,1<%45) aralık dışında alınması gerekenden azdır. Yağ (%10<%12,5<%35) aralıktadır, sağlıklıdır. Protein (%35<%69,4) aralık dışında alınması gerekenden fazladır. Öğrenci az miktarda karbonhidrat ve yüksek miktarda protein aldığı için sağlıksız beslenmiştir." şeklindeki öğrenci cevapları **Cevap 2:** Yüzdeleri hesapladıktan sonra grafik tercihini aralıkları da belirterek sütun grafiğinde (aşağıda örnek olarak gösterilmiştir)

	gösteren ve grafiğin yüzdeler ve soru üstünde verilen aralıklar içinde olup olmamasını detaylı açıklayan öğrenci cevapları **Not:** Veriler sürekli olmadığı için üst sınır ve alt sınır ile tablodaki değerlerden bulduğu yüzdeleri karşılaştırma yapmak için öğrenci sütun grafiğini seçebilir, bu öğrencilerin cevabı da bu seviyede kabul edilebilir. 
Level 3	Level 4'te açıklandığı gibi daire ve sütun grafiğini seçen ve açıklamasını yapmasına rağmen tek bir besin türünü doğru hesaplayarak grafiğin tamamını çizmeyen öğrenci cevapları
Level 2	Grafik tercihini ve açıklamasını doğru yapmış fakat matematiksel yüzde hesabı yapmadan tek bir besine bakarak günlük beslenmenin sağlıksız olduğu cevabını veren öğrenci cevapları **Örneğin;** "Proteinden üretilen enerji miktarı 200+800=1000 kcal bu 1440kcal'nin yarısından fazla fakat aralıkta proteinin üst limiti %35 (%50'den düşük). Bu durumda Protein çok yüksek ve aralığa uymuyor, sağlıksızdır." şeklindeki öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve alakasız cevaplar

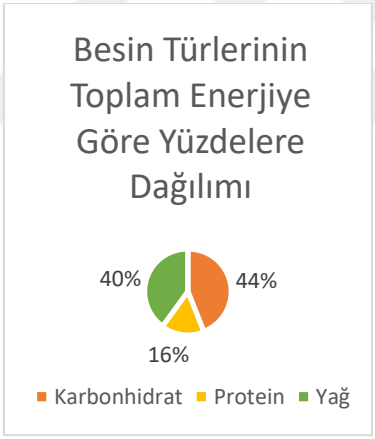
4) Aşağıda üç öğrencinin besin türlerinin toplam enerjiye göre yüzdelere dağılımı grafikleri verilmiştir. Bu üç kişinin grafiklerini beslenmelerine göre tek bir grafikle karşılaştırma yapmak istesek hangi grafiği tercih etmek uygun olurdu? Neden?



2. Öğrenci



1. Öğrenci



3. Öğrenci

Level 4	Sütun grafiğinin uygun olduğunu sebebinin ise hem karşılaştırma yaparken sütun grafiğinin kullanılması hem de veri çeşidinden (verinin değişim göstermeyip sürekli devam eden veri değildir bu sebeple çizgi grafiği uygun göstermeyip sürekli devam eden veri değildir bu sebeple çizgi grafiği uygun olmayacaktır, parça-bütün gösteren bu veri sütun grafiği ile göstermek daha uygundur)

	bahseden ve bunları grafikte göstererek cevabını destekleyen öğrenci cevapları
Level 3	Sütun grafiğinin uygun olduğunu sebebinin ise hem karşılaştırma yaparken sütun grafiğinin kullanılması hem de veri çeşidinden (verinin değişim göstermeyip sürekli devam eden veri değildir bu sebeple çizgi grafiği uygun göstermeyip sürekli devam eden veri değildir bu sebeple çizgi grafiği uygun olmayacaktır, parça-bütün gösteren bu veri sütun grafiği ile göstermek daha uygundur) bahseden sözel öğrenci cevapları
Level 2	"Sütun grafiği çünkü karşılaştırma yaparken sütun grafiği en uygun yöntemdir." şeklindeki sadece karşılaştırmaya odaklanan, veri çeşidinden (verinin değişim göstermeyip sürekli devam eden veri değildir bu sebeple çizgi grafiği uygun olmayacaktır, parça-bütün gösteren bu veri sütun grafiği ile göstermek daha uygundur) hiç bahsetmeyen öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve grafiklerle alakasız cevaplar

5) 4. Soruda grafiği verilen üç öğrencinin besin türlerinin toplam enerjiye göre yüzdelere dağılım grafikleri verilmiştir. Yukarıda verilen bilgilere göre öğrencilerin beslenmelerinin sağlıklı olup olmadığını belirleyiniz ve nedenini açıklayınız.

Level 4	"Yalnızca 1. Öğrencinin beslenmesi sağlıklıdır çünkü aralıklar detaylı incelendiğinde; 1. Öğrencinin besin türlerine göre enerji alımları Karbonhidrat (%60) → %45<%60<%65 aralıktadır, sağlıklıdır Yağ (%27) → %20<%27<%35 aralıktadır, sağlıklıdır

	Protein (%13) → %10<%13<%35 aralıktadır, sağlıklıdır 2. Öğrencinin besin türlerine göre enerji alımları Karbonhidrat (%49) → %45<%49<%65 aralıktadır, sağlıklıdır Yağ (%42) → %35<%42 üst limiti aşmıştır, sağlıklı değildir Protein (%9) → %9<%10 alt limitin altında kalmıştır, sağlıklı değildir Karbonhidrat uygun olmasına rağmen, çok yağlı az proteinli beslenmiştir. 3. Öğrencinin besin türlerine göre enerji alımları Karbonhidrat (%44) → %44<%45 alt limitin altında kalmıştır, sağlıklı değildir Yağ (%40) → %35<%40 üst limiti aşmıştır, sağlıklı değildir Protein (%16) → %10<%16<%35 aralıktadır, sağlıklıdır Protein uygun olmasına rağmen, çok yağlı az karbonhidratlı beslenmiştir." şeklindeki matematiksel nedenselliğe dayanan detaylı açıklanmış öğrenci cevapları
Level 3	"Yalnızca 1. Öğrencinin beslenmesi sağlıklıdır çünkü aralıklar incelendiğinde; 1. Öğrencinin besin türlerine göre enerji alımları Karbonhidrat (%60) → aralıktadır, sağlıklıdır Yağ (%27) → aralıktadır, sağlıklıdır Protein (%13) → aralıktadır, sağlıklıdır 2. Öğrencinin besin türlerine göre enerji alımları Karbonhidrat (%49) → aralıktadır, sağlıklıdır Yağ (%42) → üst limiti aşmıştır, sağlıklı değildir Protein (%9) → alt limitin altında kalmıştır, sağlıklı değildir Karbonhidrat uygun olmasına rağmen, çok yağlı az proteinli beslenmiştir.

	3. Öğrencinin besin türlerine göre enerji alımları Karbonhidrat (%44) → alt limitin altında kalmıştır, sağlıklı değildir Yağ (%40) → üst limiti aşmıştır, sağlıklı değildir Protein (%16) → aralıktadır, sağlıklıdır Protein uygun olmasına rağmen, çok yağlı az karbonhidratlı beslenmiştir." şeklindeki sözel olarak detaylı açıklanmış öğrenci cevapları
Level 2	Sorunun cevabını doğru vermiş ama tek bir öğrenciye odaklanarak detaylı sözel ya da matematiksel açıklama yapmış öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve grafikle alakasız cevaplar

6) Yandaki verilen Tablo 2 on beş kişilik bir grubun bir günde aldıkları kilokalori miktarını göstermektedir. Bu verilere ve günlük alınması gereken enerji miktarına göre gruptaki öğrencilerin dengeli beslenip beslenmediğini yorumlayınız. Sizce bu gruptaki kişilerin aldıkları ortalama enerji miktarı günlük alınması gereken enerji miktarına göre sağlıklı mıdır?

Öğrenciler	Alınan Kcal
1	2639,1
2	2157,4
3	1721,0
4	1803,1
5	2620,2
6	2315,1
7	2046,1
8	2400,0
9	2600,1
10	2250,0
11	1876,4
12	1852,0
13	2548,0
14	2384,0
15	2215,0

Tablo 2. Öğrencilerin bir günde aldıkları kilokalori miktarı

Level 4	Veri grubunda verilerin birbirine yakın olduğunu görüp ortalama hesabı için aritmetik ortalamanın uygun olduğunu düşünen ve bütün verilerin aritmetik ortalamasını doğru bir şekilde açıkladıktan sonra sonucun ilk sayfada bulunan nottaki bilgiye göre 2200 kcal geçtiğini görerek bu gruptaki kişilerin günlük aldıkları enerji miktarı ortalamasının günlük alınması gereken enerji miktarından fazla ve sağlıksız olduğunu açıklayan öğrenci cevapları
Level 3	Veri grubunda verilerin birbirine yakın olduğunu görüp ortalama hesabı için aritmetik ortalamanın uygun olduğunu düşünür. Daha sonra aritmetik ortalamada veri grubunun yarısının ortalamanın altında yarısının üzerinde olması bilgisini kullanarak matematiksel hesaplama yapmadan öğrencilerin yarısından fazlasının 2200 kcal enerji miktarını geçtiğini görerek aritmetik ortalamanın 2200 kcal'den fazla çıkacağını düşünerek grubun sağlıksız olduğunu söyleyen sözel öğrenci cevapları
Level 2	Aritmetik ortalama hesabı yapmayan ve kişi sayısının aritmetik ortalama ile bağlantısını kurmadan çoğunluğun 2200 kcal enerjiyi geçtiğini söyleyerek grubun sağlıksız olduğu yorumunu yapan öğrenci cevapları
Level 1	Tahminen doğru çıkmış veya Soruya dair açıklama olmayan cevaplar
Level 0	Yanlış ve alakasız cevaplar