TECHNOLOGY, INNOVATION AND SPECIAL EDUCATION RESEARCH

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Examining the Data Organization and Display Process for the Data Processing Learning Area in Statistics[1]

Dicle ALTUNSARAY, Ministry of National Education, Turkey, ORCID ID: 0000-0002-6580-8356, diclekizilkaya87@gmail.com
Serdal BALTACI*, Kırşehir Ahi Evran University, Faculty of Education, Mathematics Education Department, Turkey, ORCID ID: 0000-0002-8652-4457, serdalbaltaci@gmail.com

Abstract: The aim of this study is to investigate the data organization and display learning processes of eighth-grade students regarding the data processing learning area, and to present a comprehensive overview of what the students did during this process. The study, which employs a case study method, involves a total of 20 eighth-grade students (8 male and 12 female) attending a public middle school in a district of Kırşehir, Turkey, during the 2022-2023 academic year. Data were collected through interviews, document analysis, and researcher's field notes, and were analyzed using qualitative data analysis methods. Upon examining the tables drawn by the students, it was observed that nearly half of them did not draw tables, more students drew tally tables, but there was a scarcity of students who drew both frequency and tally tables. On the other hand, when the structure of the drawn tables was examined, it was found that none of the students provided titles for their tables. In addition, there were students who did not specify what the rows and columns represented. Furthermore, in the interviews conducted with the students, it was indicated that the primary reason for preferring to draw bar graphs was that they were easier and more familiar compared to other types of graphs.

Keywords: *Statistics, Data Processing, Data Organization and Display, 8th Grade Students*.

1. INTRODUCTION

Today, we can say that there is hardly any field that does not resort to statistics. Statistics can be utilized in various fields such as health, social sciences, natural sciences, agriculture, economy, industry, technology, politics, law, and media. Statistics is a discipline that enables the collection of all kinds of information in our lives, organizing it for comprehensibility, presenting it with appropriate representations, interpreting, analyzing, and predicting the presented information (Romeijn, 2014). Groth (2015) has defined statistics as a distinct discipline that extensively employs mathematics, rather than being a sub-branch of mathematics. Regardless of the field individuals work in, they need to have statistical knowledge to understand, evaluate, organize, execute, and appropriately analyze the collected and observed information (Arıcı, 1998). The necessity of producing or extracting meaningful information from collected and observed data in industrial and commercial activities, as well

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*** Corresponding Author**
Corresponding Author's Institutional Address: Kırşehir Ahi EvranUniverstiy, Faculty of Education

as governmental decision-making processes, demonstrates that the use of statistical methods is indispensable. Consequently, it becomes necessary for individuals to possess statistical knowledge. For this reason, statistics has been included in mathematics curricula in many countries (Shaughnessy, 2007).

In 2005, the American Statistical Association (ASA) emphasized the development of statistical thinking and statistical literacy in the "Guidelines for Assessment and Instruction in Statistics Education" (GAISE) report, due to the importance of teaching statistics. The report also contains six fundamental recommendations: using real data, emphasizing conceptual understanding rather than procedural knowledge, employing active learning methods in the classroom, utilizing technology to improve data analysis and conceptual understanding, and incorporating assessments that measure and enhance student learning. On the other hand, the Program for the International Assessment of Adult Competencies (PIAAC) includes statistical skills such as "applying two or more stages or processes in interpreting simple data and statistics, interpreting data and statistics in texts, tables, and graphs, and analyzing data, statistics and probabilities, spatial relationships and changes, ratios, and formulas through more complex reasoning processes" among the proficiency levels of numeracy skills. Similarly, the National Council of Teachers of Mathematics (NCTM) (2000) lists skills such as creating problem situations related to data, collecting data, organizing and appropriately expressing data among basic skills. Additionally, NCTM's five learning areas are listed as numbers and operations, algebra, geometry, measurement, and data analysis and probability. With societal developments, an innovative approach has been adopted in mathematics education, and a reform process has begun in statistics education as well (NCTM, 2000). In Turkey, various reforms have been implemented in educational curricula, and a data processing teaching area has been added to every grade level (Republic of Türkiye Ministry of National Education, 2018). In the mathematics curriculum updated in 2013, the probability and statistics learning area has been divided into two separate headings: probability learning area and data processing learning area. With this program, the data processing learning area is included in all grade levels.

In the mathematics curriculum revisions made in 2018, the data processing learning area has been organized according to the data processing cycle found in the "Guidelines for Assessment and Instruction in Statistics Education" (GAISE) report prepared by ASA (2005). This cycle or statistical process consists of four stages, as shown below: formulating a researchable question, collecting data for the research question, analyzing the collected data, and interpreting the results.

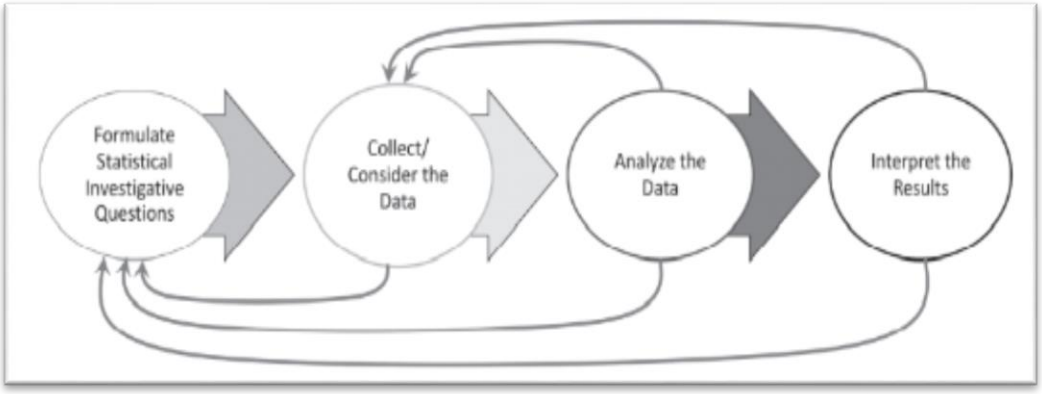


Figure 1. *GAISE Statistical Problem-Solving Process*

Republic of Türkiye Ministry of National Education (2018) has determined the learning outcomes for the data processing learning area in the mathematics curriculum from 5th to 8th grades as shown in the table below.

Table 1. *Distribution of Middle School Learning Gains in the Data Processing Learning Area by Grade*

	SUB-LEARNINGS AREAS	
GRADE	Data Collection and Evaluation	Data Analysis
5	1. Prepares research questions that require data collection 2. Collects data related to research questions, displays with frequency tables and bar graphs. 3. Solves problems aimed at interpreting data displayed with frequency tables or bar graphs.	
6	1. Creates research questions that require comparing two data groups and obtains appropriate data. 2. Displays data of two groups with paired frequency and bar graphs.	1. Calculates and interprets the range of a data group. 2. Calculates and interprets the arithmetic mean of a data group. 3.Uses arithmetic mean and range in comparing and interpreting data from two groups
7		1. Creates and interprets line graphs related to data. 2. Finds and interprets the mean, median, and mode of a data group. 3. Creates and interprets a pie chart for a data group. 4. Displays data using bar, pie, or line graphs and makes appropriate transformations between these representations.
8		1. Interprets line and bar graphs for up to three data groups. 2. Displays data using bar, pie, or line graphs and makes appropriate transformations between these representations.

As seen in the objectives, we can say that the foundation of the majority of statistical knowledge is established in primary and middle schools. As seen in the Table 1, when looking at all grade levels; producing research questions or collecting data, organizing the given data descriptively, analyzing and interpreting the data are the main targeted objectives within the scope of the data processing learning area (MoNE, 2018). When the content of the objectives in the curriculum is examined, it is seen that it includes higher-level skills and reasoning processes such as data analysis, drawing conclusions from data, making predictions based on data, and interpreting, in addition to displaying the data of a data group with tables or graphs.

Since students are expected to use the knowledge they acquire in every area of their daily lives, they need to take an active role in the entire process from formulating questions to interpreting results (Aktumen, Baltaci & Yildiz, 2011; Baki, Yildiz, & Baltaci, 2012; Yildiz, Baltaci, & Aktümen, 2012; Baltaci & Yildiz, 2015; Yildiz & Baltaci, 2016a). However, in our country, students are only presented with problems that require numerical solutions, and the aim is to reach the answer in the quickest possible way. This leads to the emergence of individuals who cannot perform statistical reasoning. Therefore, it is important for students to learn statistical concepts conceptually rather than operationally and to be able to think about them (Cai, 2000). Moreover, when looking at studies conducted with students; it is observed that the majority of students have difficulties and misconceptions related to statistical topics (Cai, 1998; Mokros & Russell, 1995; Uçar & Akdoğan, 2009; Yildiz & Baltaci, 2015; Yildiz & Baltaci, 2016b). Garfield and Ben-Zvi (2008) also revealed that students had difficulties in conceptual understanding despite being able to perform operations related to statistical concepts. Statistical education should enable understanding, evaluating, reasoning, and making decisions about statistical results in daily life. To achieve this, it is important for students to take an active role in learning activities.

Statistics havea meaning beyond just analyzing given graphs and data. To know the meaning of the data at hand, one must be in control of the process from the beginning. In other words, the person who asks questions and conducts research to answer them will be able to move beyond operational learning and reach statistical reasoning power. In this context, students should be provided with experiences of statistical processes through activities focusing on daily life situations. For the development of students' conceptual learning, they need to be involved in all stages of the statistical process (formulating questions, collecting data, analyzing data, and interpreting results) (Van De Walle, Karp & Bay-Williams, 2009). Aktaş (2009) emphasized that this would contribute to students' skills in expressing themselves both verbally and in writing, as well as their statistical thinking skills. When the literature is reviewed, it is observed that there are a limited number of studies specifically focusing on the data processing learning area, and most of them indirectly touch upon the related learning area (Yanık, Özdemir & Eryılmaz Çevirgen, 2017). In addition, there are studies highlighting the contribution of understanding statistics and its representation forms to meaningful learning (Van De Walle, Karp & Bay-Williams, 2009) and the importance of these representation forms in terms of the development of problem-solving skills as well as conceptual understanding (Schults & Waters, 2000). However, very few studies have been found examining the statistical process.

The importance of analyzing data, collecting and evaluating data, interpreting data, making inferences, and making predictions is also emphasized in the literature (Koparan & Güven, 2013). Garfield and Ben-Zvi (2008) state that focusing on the nature of data is one of the essential components of statistics course content, emphasizing the importance of understanding where data comes from, how good data is produced and collected, and what types of analysis and decision-making methods are suitable for collected data. Therefore, this research aims to examine the learning processes of eighth-grade students regarding organizing and displaying data in the data processing learning area and to present what students do during this process as a whole. In this way, students will gain experience in this subject, achieve long-lasting learning, and try to find solutions to the difficulties they face during the data organization and display stages of the data processing process based on their experiences. For this purpose, a four-stage statistical process, including formulating research questions, collecting data, organizing and displaying data, and analyzing and interpreting data, has been adopted in the study, with the organizing and displaying data stage being examined in detail. Although objectives related to the learning area are included in other grade levels of middle school, eighth-grade students were chosen as participants because they are expected to have mastered all of these objectivesby the eighth grade, and the conducted studies would offer richer content in terms of objectives. The purpose of this research is to answer the question, "How do the learning processes take place for eighth-grade students in the data organization and display stage within the data processing learning area?"

2. METHODOLOGY

In this section, information about the method of the study, participants of the study, data collection, and data analysis is provided.

2.1. Research Method

In this study, the case study method has been used, as it allows for an in-depth examination of a specific group and enables the analysis of data obtained from the data collection tools without concern for generalization. A case study is described as a method in which one or more events, environments, programs, social groups, or other interconnected systems are examined in-depth (McMillan, 2000).

2.2. Research Participants

The participants of the study consist of a total of 20 students, 8 males and 12 females, who are attending eighth grade in a public middle school located in a district of Kırşehir city in Turkey during the 2022-2023 academic year. The fact that the study was conducted in one of the researcher's own classrooms ensured the participation of all students in the process, and an attempt was made to establish the principle of voluntariness during this period.

2.3. Data Collection Tools

In case studies, multiple data collection methods are used to ensure a rich and diverse set of data that supports each other, and the collection of data using different methods increases reliability and validity. For this reason, data were collected through interviews, document and the researcher's field notes. In the statistical research process, the students were first asked to create a research question. Then, the students collected their data from daily life for these research questions. During the statistical research process, students were first asked to create a table related to the data processing learning area, decide on a suitable graphical representation for the data, display the data in the graphs, and interpret the processes performed. All documents written during this process were used in the analysis of the data. In this study, the data obtained in the organizing and displaying data stage of the given stages were presented. In other words, all types of documents prepared by the students constitute our data. Moreover, throughout these processes, interviews were conducted with the students, and data were enriched with field notes taken by the researcher. The researcher took the role of a guide in the process by taking part in all the processes of the research. For example, within these processes, some of them applied the process of determining research questions similar to the research questions below.

"What is the favorite color of the 8C class students at Akpınar Secondary School?"
"What are the activities that Akpınar Secondary School teachers like to do on Sundays?"

The data analysis and interpretation stage related to the research question has been thoroughly addressed, and the students' experiences in each process have been examined in depth.When we consider that organizing data includes sorting, grouping, and visualizing data using various representations, the most important tools used are tables and graphs. The tools used by primary and middle school students in data representation are frequency, tally tables, bar, line, and pie charts.These tools that students used in data representation were collected through interviews and document analysis during the process and were included in data collection tools.

2.4. Data Analysis

In this study, the organizing and displaying data stage was evaluated by selecting from the stages of formulating research questions, collecting appropriate data for the question, organizing and displaying the collected data, and analyzing and interpreting the data in the statistical research process. This provided an opportunity to gain in-depth knowledge about the students' experiences related to the stages of the statistical process. In this process, deficiencies, erroneous thoughts, and appropriate/inappropriate expressions were detected, and situations overlooked during interviews with students were included in the study. In this way, an effort was made to gain information about what the students thought during the process and how they reflected these thoughts on the process. During the process, while the data were jointly interpreted and evaluated, the organizing and displaying data stage was analyzed using qualitative data analysis methods.

3. FINDINGS

In this study, which aims to examine the organizing and displaying data stage of the statistical research processes of eighth-grade students in detail, the findings are presented as follows. The data analysis and interpretation stage related to the research question has been thoroughly addressed, and the students' experiences in each process have been examined in depth. To view the obtained data as a whole, it is necessary to organize it for easier interpretation and analysis. When we consider that organizing data includes sorting, grouping, and visualizing data using various representations, the most important tools used are tables and graphs. The tools used by primary and middle school students in data representation are frequency, tally tables, bar, line, and pie charts. Therefore, at this stage, students were asked to display the data they collected in various representation formats. During the data collection stage, students simply listed the data they collected. Since they did not categorize and group the data, they first classified the data using tables at this stage and then drew graphs. Information about what the possible representation formats could be was provided, and the choice was left to the students. In this way, it was determined whether the students chose the appropriate representation method for their data or not.

Firstly, when examining the tables drawn by the students, it can be seen in the table below that 8 out of 20 students did not draw any table, 7 students only drew a tally table, 2 students only drew a frequency table, and 3 students drew both frequency and tally tables.

Table 2. *Ways Students Displayed Their Data in Tables*

Table Drawing	Frequency
No Table Drawn	8
Tally Table	7
Frequency Table	2
Both Tally and Frequency Table	3

When the created tables were examined, they were generally drawn in the form of variables and their numerical values. When the drawn tables were structurally examined, it was observed that none of the students gave names to the tables. In addition, there are students who do not specify what the rows and columns represent. It was observed that some students did not even perform framing operations by dividing the groups into equal parts with lines. For example, a snippet from the work of student S17, who presented it in this way, is given below.

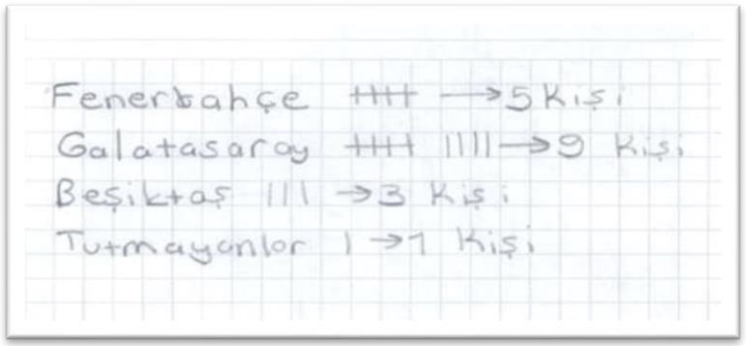
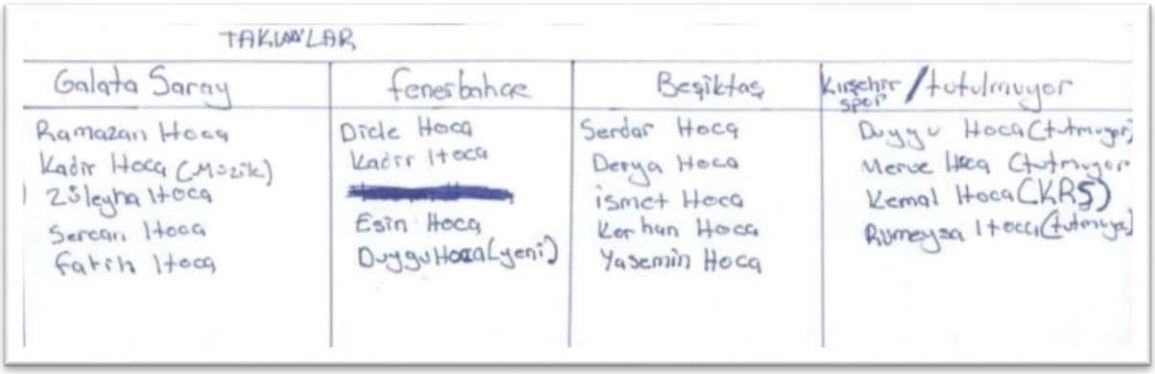
Data representation style of student with code S17 (Turkish)	English translation of the data representation style
	*Fenerbahçe football team-five people* *Galatasaray football team-nine people* *Beşiktaş football team-three people* *Not supporting a football team-one people*

Figure 2. *Data Representation Style of Student with Code S17*

On the other hand, student S15, who only made a tally table, explained this situation as follows and wrote it as in Figure 3 and Figure 4.

S15: I researched the teams my teachers support. I had categorized the answers while conducting my research, so I did not make a table again. When I saw that my friends generally had tally tables, I decided to add one too. That's why I only made a tally table.

Data representation style of student with code S15 (Turkish)



English translation of the data representation style

Football Teams

Galatasaray	*Fenerbahçe*	*Beşiktaş*	*Not supporting a football team*
Teacher Ramazan *TeacherKadir (Music)* *Teacher Züleyha* *Teacher Sercan* *Teacher Fatih*	*Teacher Dicle* *Teacher Kadir* *Teacher Esin* *Teacher Duygu (new)*	*Teacher Serdar* *Teacher Derya* *Teacher İsmet* *Teacher Korhan* *Teacher Yasemin*	*Teacher Duygu (not supporting)* *Teacher Merve (not supporting)* *Teacher Kemal (not supporting)* *Teacher Rumeysa (not supporting)*

Figure 3. *Data Representation Style of Student with Code S15*

Data representation style of student with code S15 (Turkish)

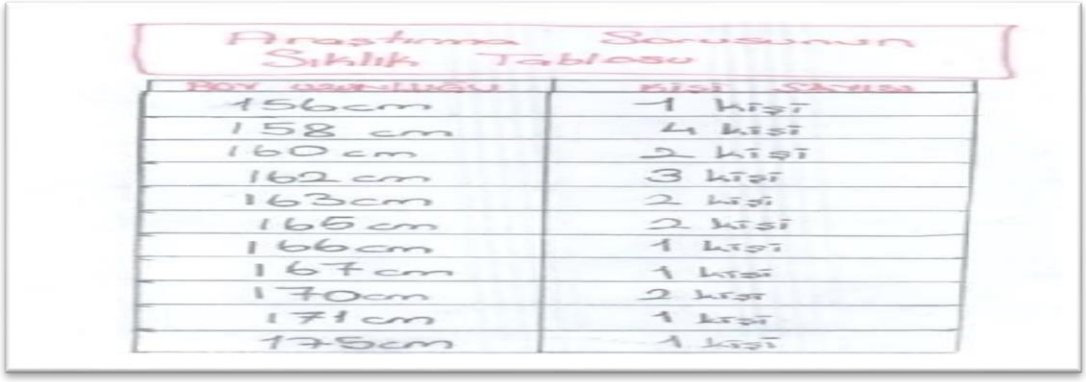
English translation of the data representation style

Football Teams	*Votes*
Beşiktaş football team	*five*
Galatasaray football team	*five*
Fenerbahçe football team	*four*
Not supporting a football team	*three*
Kırşehirspor football team	*one*

Figure 4. *Data Representation Style of Student with Code S15*

As seen from the tally table and the explanation made by the student with code S15, the student did not feel the need to create a separate frequency table or frequency representation, as they took each team selected during the data collection phase as a group and took notes of the selections accordingly. When looking at the tally and frequency tables drawn by the student with code S8, we see that they followed an order from small to large when writing the height length part. We can say that such a writing style would facilitate the analysis and interpretation of the data. In relation to this situation, the frequency table of the student with code S8 and the field notes of the researcher summarize the experiences of the student with code S8 during this process as follows.

Data representation style of student with code S8 (Turkish)



English translation of the data representation style

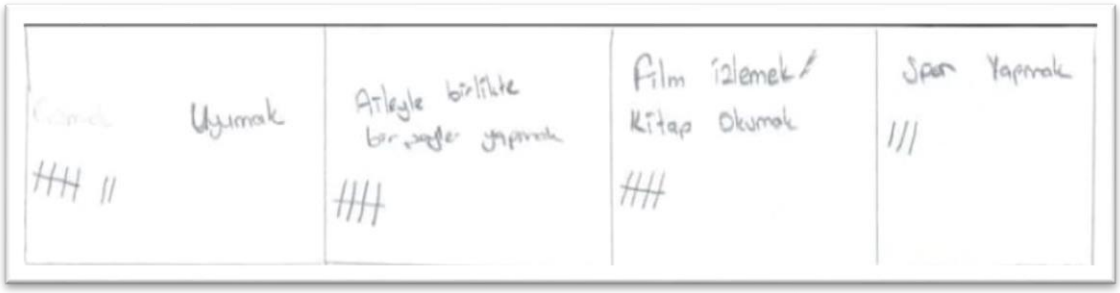
Frequency Table of Research Question	
Heights	*Number of People*
156 cm	*One people*
158 cm	*Four people*
160 cm	*Two people*
162 cm	*Three people*
163 cm	*Two people*
165 cm	*Two people*
166 cm	*One people*
167 cm	*One people*
170 cm	*Two people*
171 cm	*One people*
175 cm	*One people*

Figure 5. *Data Representation Style of Student with Code S8*

"*When I went to the student with code S8, I saw that he/she was trying to draw a tally and frequency table. While creating this table, I saw that he/she followed an order from small to large, especially when writing the height lengths. Actually, this was a good idea. Because in this way, it would provide conveniences for my student in the analysis and interpretation he/she would do later. In situations where there are too many data, it is more appropriate to classify and specify the frequency over data groups while creating frequency tables. However, since the student with code S8 collected their data from 20 people, the table he/she created was also suitable and did not cause confusion.*"

On the other hand, the student with code S6, who researched the activities teachers did on Sundays, gathered different answers under four categories to show them more easily in graphs. For example, they collected answers such as walking, running, and going to sports under the title of doing sports. The tally table that the student with code S6 tried to draw regarding the grouping they made is given below.

Data representation style of student with code S6 (Turkish)



English translation of the data representation style

Sleep *Seven*	*Doing something with the family* *Five*	*Watching movie / Reading books* *Five*	*To do sports* *Three*

Figure 6. *Data Representation Style of Student with Code S6*

After the tables, the graphs drawn by the students were examined in terms of structure, suitability to their data, and placing the data correctly. When examined structurally, it was seen that 2 out of 20 students gave names to the graphs. In addition, some students are seen to write graph types such as "bar graph, pie chart" as the graph name. It was seen that there were 10 students who drew bar and line graphs without naming the axes, and 9 students who named them. The table below shows which students named the axes. Student with code S10 was not examined in this part as they only drew a pie chart.

Table 3. *Students' Axis Naming Status*

Student Code	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18	19	20
Axis Name	X		X		X			X		X	X				X	X			X

On the other hand, the types of graphs chosen by the students are shown in the table below.

Table 4. *Graph Types Chosen by Students to Display Their Data*

Student Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Column Chart	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Line Chart							X								X					X
Circle Chart	X			X		X	X		X	X	X	X	X	X	X	X	X	X	X	X
Data Fit	X	X	X	X	X	X					X	X	X	X		X	X	X	X	

When the above table is examined, it is seen that all students, except the student with code S10, drew bar graphs. Bar graphs are generally used to display categorical data. Since the students' data is mainly categorical, this choice has been predominantly correct. For example, the student with code S11 explains the reason for choosing this graph as follows:

S11: It was easier for me to show the quantity of my data in a bar graph; it also made it easier to compare. The bar lengths immediately indicate the most and least preferred.

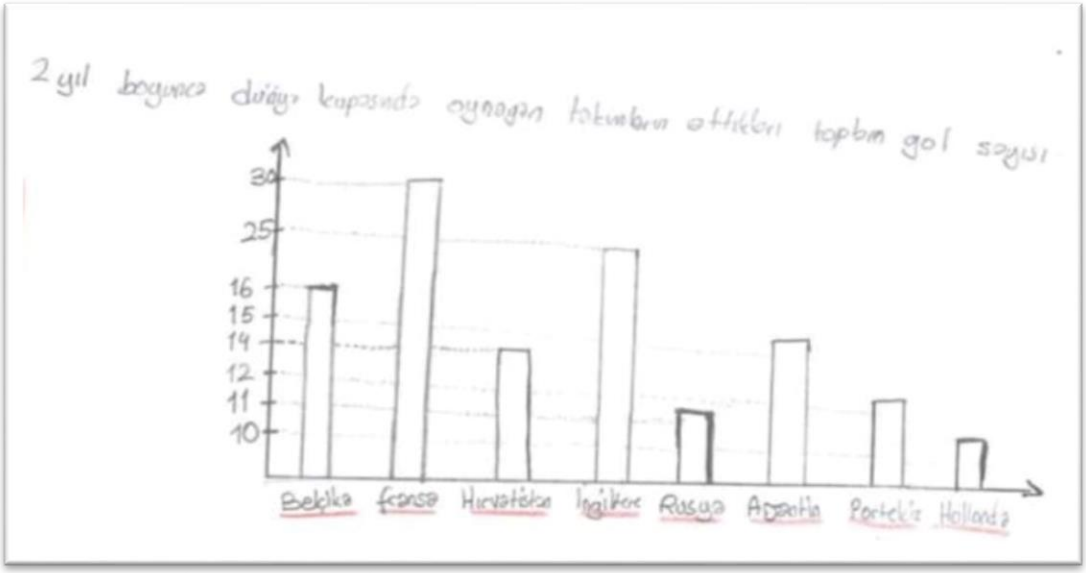
The student with code S2, who only drew a bar graph, explained this situation as follows:

S2: I didn't want to deal with angle measurements and had some difficulty, so I didn't choose the pie chart. Comparing the goals scored in columns was more suitable and easier, so I only drew columns.

Looking at the statements of students with codes S11 and S2, it can be seen that bar graphs are suitable for displaying data quantities and comparing data. Therefore, students' choosing this graph has been the correct choice. Additionally, as a result of interviews with students, the primary reason for preferring this type of graph is that it is easier and more familiar compared to other graph types. Moreover, the student with code S2 changed the research question, "*The number of goals scored by countries in the 2022 World Cup*," to "*What are the top five goal-scoring countries in the 2022 and 2018 World Cups?*" during the data collection phase, aiming to compare the two years. However, during the graph drawing process, instead of drawing two separate data graphs as expected, they displayed the total number of goals for both years in one graph and deviated from the research question. Thus, they tried to present

their data as a single data group. The graph drawn by the student with code S2 is shown below.

Data representation style of student with code S2 (Turkish)

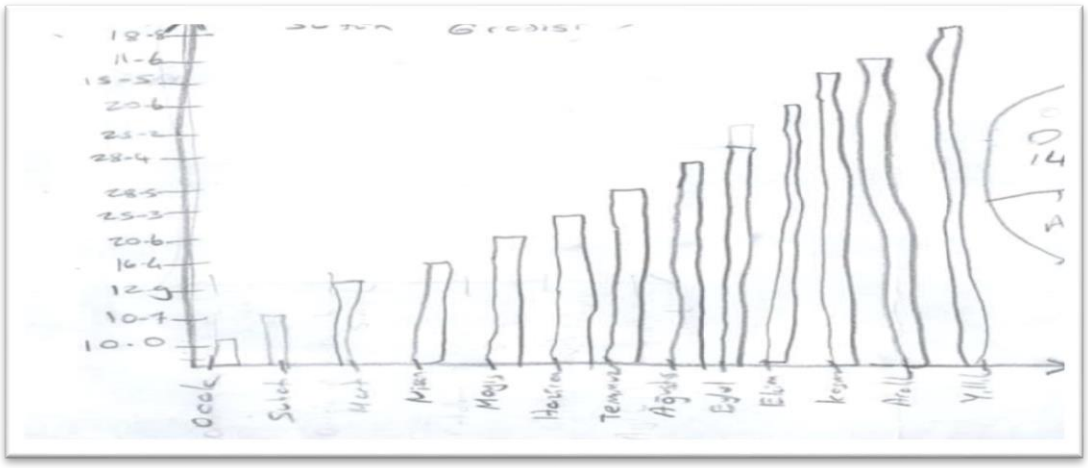


English translation of the data representation style

Total number of goals scored by teams playing in the world cup for two years
Respectively, Belgium, France, Croatia, England, Russia, Argentina, Portugal and Netherlands

Figure 7. *Representation of Data by the Student with Code S2*

Line graphs are used to display changes between data or changes in data over time and are preferred for continuously changing data. The data of the student with code S8 is height measurements, and the data of the student with code S9 is air temperatures, which are continuous data. Therefore, although it was expected that these two students would draw line graphs, they chose bar and pie charts instead. Their graph drawings are incorrect because they did not select graphs suitable for their data. For example, the student with code S9 sequentially placed the months on the x-axis and the corresponding values for the months on the y-axis. They placed the values they would show without any scaling and without following an increasing sequence starting from the origin. The bar graph they drew related to this situation is shown below.

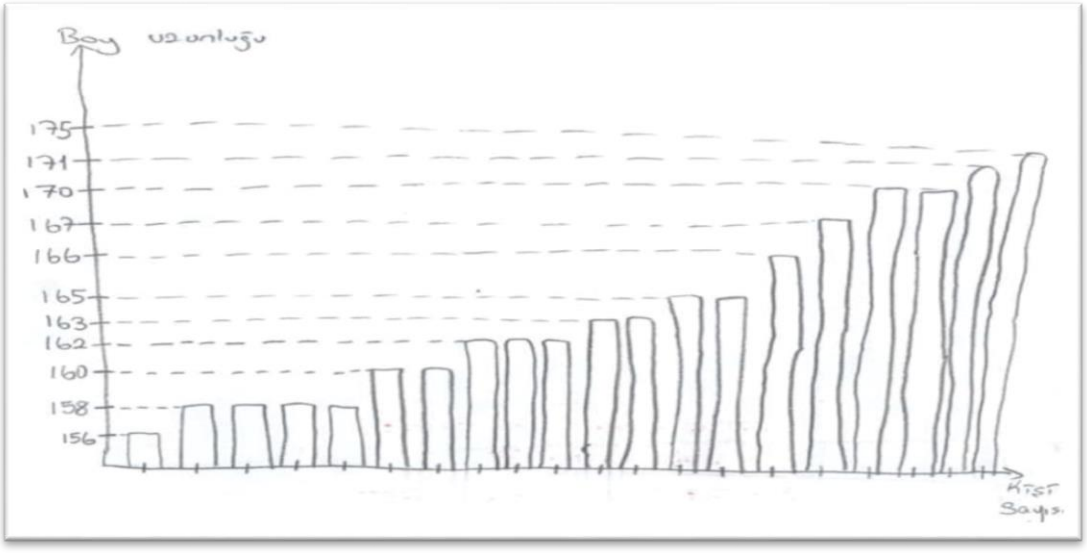


(From left to right the months and the last column show the year)

Figure 8. *Representation of Data by the Student with Code S9*

Similarly, the student with code S8 experienced difficulty in placing the data on appropriate axes. Since the axes were not numbered, a graph with a continuously increasing linear relationship emerged. The student explained this situation as follows. The graph drawn by the student is also provided below.

S8:After writing the heights in the graph, I could not arrange them. I realized there was a problem with the graph I chose, and I know I did not draw it correctly, but I did not know how to arrange it according to which graph type.



(Graphic of heights and number of people)

Figure 9. *Representation of Data by the Student with Code S8*

Students with codes S7, S15, and S20, whose data is not continuous, also drew line graphs. They explained the reason for this as trying to display their data in all the graph types they

knew. It was observed that the students tried to display their data in all the graph types they had seen so far without paying attention to the data type. In this regard, the line graphs drawn by students with codes S15 and S20 are provided below.

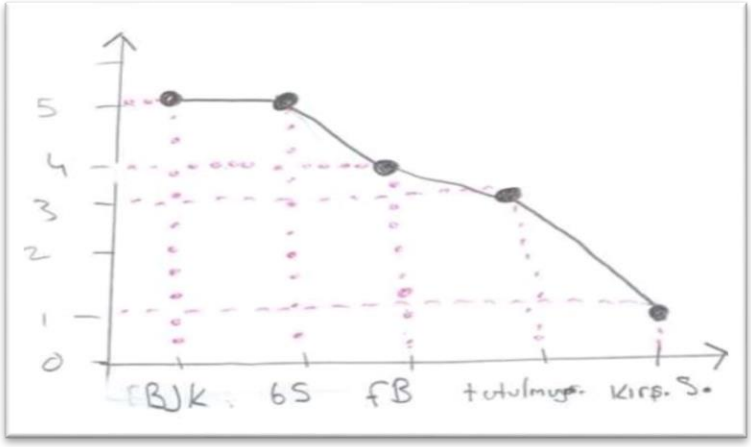
Data representation style of student with code S15 (Turkish)	English translation of the data representation style
	*Respectively; Beşiktaş football team, Galatasaray football team, Fenerbahçe football team, Not supporting a football team, Kırşehirspor football team*

Figure 10. *Representation of Data by the Student with Code S15*

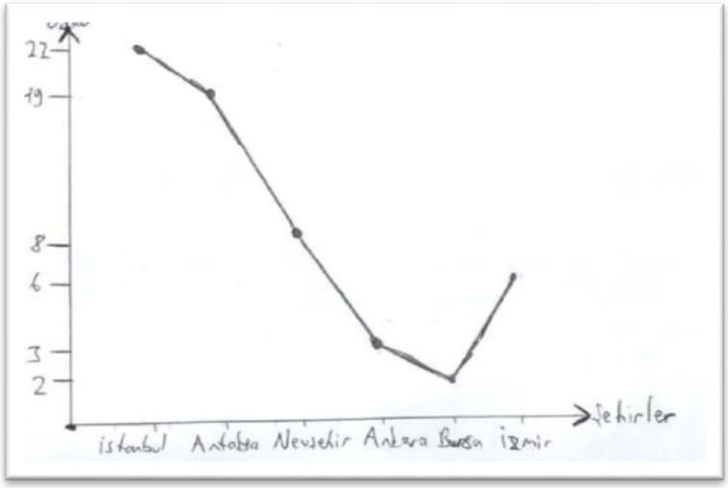
Data representation style of student with code S20 (Turkish)	English translation of the data representation style
	*Respectively Cities; İstanbul, Antalya, Nevşehir, Ankara, Bursa and İzmir*

Figure 11. *Representation of Data by the Student with Code S20*

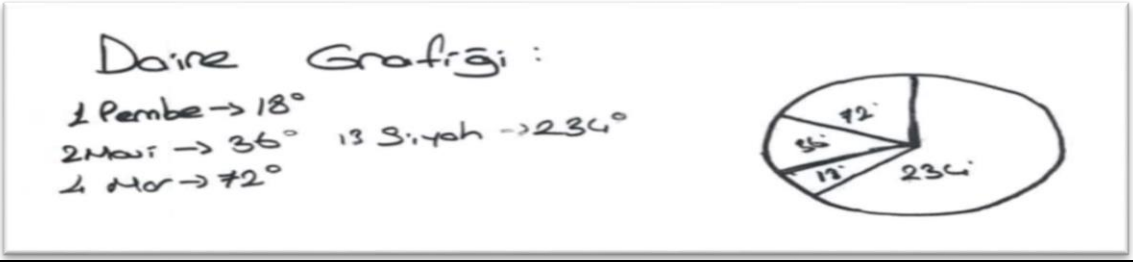
Upon examining the bar and line graphs drawn by the students, it was observed that none of the students applied axis scaling. The students stated that the reason for this was that their teachers also drew graphs in the same way. An interview between the researcher and the student with code S16 about this issue is presented below.

R: How did you place the values on the axes while drawing the bar graph?
S16: I placed them starting from the origin, from my smallest value to my largest value.

R: However, I see that you did not do any scaling, you only placed your own values. Do you think this is a correct representation?
S16: I don't know. In the lessons, our teachers usually did it like this, they only wrote the numbers in the question on the axes. I remember they didn't do scaling.

As seen from the interviews above, the finding that the students' drawings continued in this way, along with the fact that the teachers wrote only the values on the axes without scaling during the lessons, has emerged. On the other hand, it was determined that 16 out of 20 students displayed their data using pie charts. Since pie charts are used to show the parts of a whole, they are more suitable for displaying discrete and categorical data. As our students' data is generally in this form, this choice was correct. From the interviews conducted, we can see that the main reason for the preference of pie charts is that they are generally included in the 8th-grade curriculum. Moreover, we can say that the students' influence on each other was effective in making this choice. As in the choice of tally tables, it was determined that there was an influence from the graphs drawn by each other. When the drawn pie charts were examined, it was observed that 10 students drew correctly, while 6 students drew incorrectly. Students with codes S1 and S4, who found the angle measurements correctly, did not explicitly indicate which pie slice belongs to which variable. The pie chart drawn by the student with code S4 in this situation is presented below.

Data representation style of student with code S4 (Turkish)

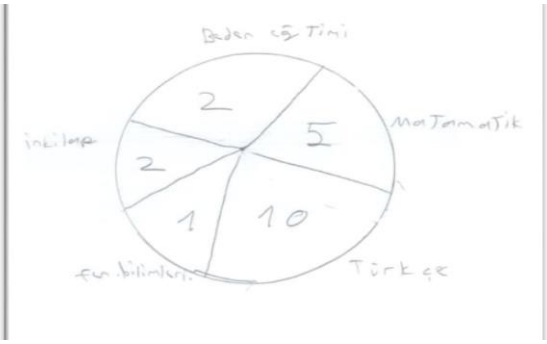


English translation of the data representation style

Cicle Graphic: Pink with 18 degrees, Blue with 36 degrees, Purple with 72 degrees, Black with 234 degrees

Figure 12. *Representation of Data by the Student with Code S4*

Upon examining the pie charts created by the students, it was observed that they placed the frequency values on the pie slices without establishing a proportion between the values in the frequency distribution and the central angles. The pie charts drawn by students with codes S14, S7, S18, and S9, which show this situation, can be exemplified by the pie chart created by the student with code S18, as shown below.



(Lessons; Mathematics (5), Turkish (10), Science (1), English (2), Physical Education (2))

Figure 13. *Representation of Data by the Student with Code S18*

Again, students with codes S10 and S6, who drew incorrectly, tried to find the central angles by proportioning them but found incorrect angle measurements. On the other hand, an interview with student S20, who drew the pie chart correctly, is provided below.

R: What approach did you take while drawing the pie chart?
S20: I had asked my research question to 54 students, and I had difficulty in proportioning it to 360°, so I asked 6 more students and completed it with 60 people. This made it easy for me to proportion, and I found the angle values and wrote them on the pie chart.

As seen from the interviews, we see that most of the students did not have difficulty in proportioning the pie chart because the number of data points was 18 or 20. In data counts that are not multiples of 360°, they struggled, so they adjusted and changed their data to make it a multiple.

4. RESULTS AND DISCUSSION

The findings obtained from this research, which aims to examine in detail the stage of organizing and presenting data from the statistical research processes of 8th-grade students, are discussed as follows. Data processing is a topic covered at all grade levels, and students are expected to display and interpret data collected using tables, frequency tables, tree diagrams, and bar graphs (MoNe, 2018). Information can be recorded on a timeline, a numerical ruler, a coordinate system, a list, or a table containing estimates, results, or both, or even a diagram representing the desired information at different times (Arlington Central School District Poughkeepsie, 1999). The best way to interpret collected data is to convert them into representations such as graphs, tables, charts, and histograms (Martin, 2002). Examining the tables drawn by the students, it is noticeable that nearly half of them did not draw tables, more students drew tally tables, but the scarcity of students drawing both frequency and tally tables is striking. Hacısalihoğlu (2016) emphasized the necessity for students to have adequate knowledge and skills in data, including representation forms such as tally and frequency tables, objects, shapes, bar, line and pie charts, and tree diagrams. Selamet (2014) also found that students were least successful in reading and interpreting

frequency tables in his research. When we look at the Mathematics Curriculum, although there are objectives related to "converting graphs to tally and frequency tables" among the primary school data processing learning area objectives, we see very few activities on this subject in textbooks. Since our teaching is mostly based on converting data in tables to graphs or solving operational problems from tables, it may have led to the lack of development of students' table drawing skills. Having students perform activities that require them to convert from graphs to tables in lessons or conduct activities where they collect and organize their data in a similar way to our research may help to alleviate the problems they experience in this area.

On the other hand, when the created tables are examined, it has been determined that they are generally drawn in the form of variables and their numerical values. When the tables are examined structurally, it is observed that no student has given names to the tables. In addition, there are students who do not indicate what the rows and columns represent. It has also been determined that some students did not even perform framing operations by dividing the groups into equal parts with lines. Güven, Özmen, and Öztürk (2012) found in their research that students focused on examining data in one dimension and most of the table and graph drawings were erroneous. Sezgin-Memnun (2013) also determined that the majority of students had low graph drawing skills in her research. The lack of table naming and framing by students may be due to the lack of emphasis on such issues during teaching. Perhaps this situation has led students to be careless about their drawings. To overcome these problems, it is our responsibility as teachers to emphasize the importance of structural features in table drawing and to have the students draw tables instead of providing them ready-made.

After the tables, the graphics drawn by the students were examined in terms of structural features, suitability for their data, and correct placement of data. When examined structurally, it was determined that 2 out of 20 students gave names to the graphics. Apart from this, it is observed that some students wrote the types of graphics as the graphic name, such as "bar graph, pie chart." Among the students who drew bar and line graphs, 10 students drew without naming the axes, 9 students named the axes, and it was determined that one student only drew a pie chart. Since the data of our students are generally categorical, this choice has been mostly correct. In addition, during interviews with students, the main reason for preferring to draw a bar graph was that it was easier and more familiar compared to other types of graphs. Knowing which type of graph to choose according to the type and characteristics of the collected data and variables is important for the student. For example, it is more appropriate to use circular and bar graphs in the frequency distributions of discrete and categorical variables (Sevimli, 2022). Line graphs are used to show the change between data or the change of data over time and are preferred in continuously changing data. Their graph drawings were also wrong because they could not choose the appropriate graph for their data. As teachers, we can reduce this problem by giving data during teaching and asking students to choose and draw the appropriate graph. Sezgin-Memnun (2013) determined that a significant part of the students had insufficient line graph drawing skills. On the other hand, Selamet (2014) determined in his study that students achieved the most successful results regarding line graphs. In addition to these results, it was concluded that students interested in

mathematics were more successful than those not interested. Again, some students had difficulty placing the data they obtained on the appropriate axes and drew a graph with a continuously increasing linear relationship due to not numbering the axes. On the other hand, it was observed that students with non-continuous data also drew line graphs. They explained this as an attempt to show their data in all the graph types they knew. It has been observed that students have tried to show their data in all the graph types they have seen so far, regardless of the type of data. It should be emphasized during teaching that line graphs show change and should be used in continuous data. In addition, when examining the graphs of students who drew bar and line graphs, it was observed that none of them performed axis scaling. Students have shown that their teachers also made drawings in the same way as the reason for this.

In interviews with students, it was found that student drawings continued in the same way as the teachers wrote only the values on the axes without scaling during the lessons. This situation indicates the necessity for teachers to be adequately equipped in teaching graphics and to continue their teaching processes in a more detailed manner. Having sufficient knowledge, making use of multiple representations and displays, and actively using technology will bring about higher levels of learning. On the other hand, it has been determined that 16 out of 20 students have displayed their data using pie charts. Since pie charts are used to show the parts of a whole, they are more suitable for the display of discrete and categorical data. As our students' data is generally of this type, this choice is correct. From the interviews, it can be seen that the main reason for the predominant preference for pie charts is that they are included in the 8th-grade curriculum. In addition, we can say that students' influence on each other also played a role in making this choice. In this process, when the pie charts created by the students were examined, it was observed that they placed the frequency values into the pie slices without establishing a proportion between the frequency distribution values and the central angles. This is generally due to the problems students have with angle, percentage, and ratio concepts. Also, students' difficulties in proportional reasoning have caused problems in distributing data to pie charts. Improving proportional reasoning can be beneficial for drawing and interpreting pie charts. To achieve this, students should be prevented from memorizing procedures related to proportionality. Studies have shown that students experience significant difficulties in organizing and displaying data in various graphic and other representation formats at various grade levels and in disciplines other than mathematics, such as science and social sciences (Bell & Janvier, 1981; Padilla, McKenzie & Shaw, 1986; Leinhardt, Zaslavsky & Stein, 1990; Brasell & Rowe, 1993; Berg & Philips, 1994; Çelik & Sağlam Arslan, 2012). To overcome these difficulties, as in this study, students should be encouraged to actively participate in the process and to represent the data they organize with the appropriate display format. In addition, both in textbooks and during lesson instruction, emphasis should be placed on multiple representation types, and transitions between them should be made. Furthermore, activities such as converting a given table to a suitable graph and converting a graph to a table can be increased. In order to ensure students' higher-level learning, they should be enabled to compare, interpret, and draw inferences from graphs. Finally, the use of technology will also help both teachers and students in this regard.

5. ABOUT THE AUTHORS

Dicle ALTUNSARAY: She has been working as a primary school mathematics teacher at the Ministry of National Education since 2012 and a graduate student at Kırşehir Ahi Evran University since 2021.

Serdal BALTACI: Dr. Baltaci has been working at Kırşehir Ahi Evran University since 2007. He is currently an associate professor at the Department of Mathematics Education. Her research interest include teaching and learning mathematics, teacher education, problem solving and posing, dynamic mathematics software, contextual teaching and learning.

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