



Determining the Graphical Literacy Levels of the 8th Grade Students*

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ABSTRACT

Purpose: Previous research focused on graphical skills of the students, which remains a gap that exists, and there has not been comprehensive research on students' graphical literacy abilities. The present study aims to picture graphical literacy levels of the 8th grade students concerning the *reading, interpreting, drawing, comparing* and *evaluating* aspects.

Method: Participants in this study consisted of 46 students at 8th-grade from two different middle

school levels. The data were collected by graphical literacy test.

Findings: The findings showed that student's scores of the graphical literacy skill were low. Students had challenge at comparing two graphs, determining suitable context or graph type and realizing errors in the graphs. These results suggest that students are unable to fulfill advanced levels of the graph comprehension as read between and beyond the data.

Implications for Research and Practice: There is need to design the learning environment through these aspects to raise students as graphically literate. To achieve this, of course, graphical literacy level of teachers and quality of instructional activities are important. For future, graphical literacy levels of the teachers should be determined, necessary arrangements should be considered to raise teachers equipped with graphical literacy.

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Introduction

Individuals are expected to be able to make effective decisions, to understand and interpret the information that they encounter in the media or newspapers, and to display a critical stance in daily-professional lives. These expectations are effective in raising the importance of statistics. Therefore, statistical literacy and raising individuals as statistical literate were mostly emphasized in statistics education research (Aliaga et al., 2005; Franklin et al., 2007; Gal, 2002).

Statistical Literacy

As the need for statistics literate individuals increases, statistics education has an increasingly important place in mathematics curriculum (Aliaga et al., 2005). Gal (2002) defined statistical literacy as an ability to discuss the statistical information or interpreting and critically evaluating encountered situations. National Council of Teachers of Mathematics [NCTM] (2000) standards draw attention to experience students about posing research questions, selecting the sample and collecting-organizing-representing-interpreting the data. Friel, Curcio and Bright (2001) underlined that because of the increasing importance of statistics education, graphs become an important part of school mathematics. On the other hand, the information in our lives is generally presented with a numerical form, and data representations help us to summarize this information. Moreover, all individuals are expected to have basic graph comprehension skills to be effective in their lives. These expectations refer to graphical literacy, taking part in statistical literacy.

Graphical Literacy

Graphs are an important part of statistics education (Franklin et al., 2007; NCTM, 2000). Chia (2016) drew attention to the importance of the graphs as a common theme throughout primary and secondary school statistics education. Thus, graphs are important part of our life, and we meet graphs in many fields (González, Espinel, & Ainley, 2011). Galesic and Garcia-Retamero (2011) point out that graphs provide important information for our choices. Thus, it is important to interpret graphs accurately and effectively. Parallel with the importance of skills as reading, interpreting, drawing graphs, raising students as equipped with graphical literacy is being an inevitable need. Galesic and Garcia-Retamero (2011) defined graph literacy as an ability to understand graphical representations, emphasized that graphs are ubiquitous in various data sources.

Parallel with the importance of graphs, many countries give an important place to graphs in the math curriculum. Therefore, increasing attention to data analysis and statistics subjects provided to graphs take a large part in math curriculum. González et al. (2011) stressed that instruction about graphs is an important aspect of the math curriculum in many countries. In these curricula, drawing, interpreting and analyzing graphs are basic skills in which students are expected to be equipped (Ministry of National Education [MoNE], 2009, 2018; NCTM, 2000). In Turkey, with the revisions of the elementary mathematics curriculum, the importance of graphs is increased. Also, MoNE (2009) curriculum, at sixth-grade level it was aimed to represent data with

proper graph and to interpret graphs, to realize possible misinterpretations of bar graphs. For the 7th-grade level, students learn to create and interpret bar and line graphs, to draw pie graphs, to make predictions based on data. For the 8th-grade level, students learn to create and interpret histogram. Through all these grade levels, students are generally expected to have certain aspects, such as drawing, interpreting, being aware of incorrect graphs, determining the appropriate graphs for a given context.

Through the main goal of raising students as statistically or graphically literate have an important role in the importance of the graphs in mathematics lessons or curriculum. Parallel with the importance of graphs in math curricula, research about the competences of students about graphs was carried out (Bragdon, Pandiscio, & Speer, 2019; Curcio, 1987; Kaynar & Halat, 2012; Schield, 2006; Wu, 2004). Similarly, in Turkey, studies were carried out related graphs. These studies revealed that students have not enough literacy or thinking level for graphs (Kaynar & Halat, 2012; Sezgin-Memnun, 2013; Yayla & Ozsevgec, 2015; Yilmaz & Ay, 2016). In these studies, students faced various challenges related to the graphs. Kaynar and Halat (2012) investigated reading, interpreting and drawing skills of 8th-grade students for the frequency table. They draw attention to the low percentage for interpreting and drawing skills. Dunder and Yaman (2015) aimed to examine the interpreting skills of class teacher candidates for tables and graphs according to their mathematical reasoning skills and class levels. They found that there was a statistically significant relationship between the table and graph interpretation skills concerning mathematical reasoning skill levels. Schield (2006) investigated the reading and interpreting skills of graphs. Many studies focused on interpreting the graph skills of students, or pre-service teachers (Bragdon et al., 2019; Curcio, 1987). Bayazit (2011) investigated the preservice teachers' understanding and interpreting graphical representations. Based on research findings, Bayazit noted that pre-service teachers had difficulties in interpreting the relationships between the variables in the graphs. They could be successful in dealing with the graph point-by-point or making calculations based on the graphs. In other words, they could be able to read the graphs in a basic level. As many studies focused on limited aspects (such as reading, interpreting and creating), some of the studies focused on a graph type. Yayla and Ozsevgec (2015) examined the graphical skills of the 6th, 7th and 8th-grade students concerning the interpretation and construction of the line graphs. They noted that students are more successful in interpreting the line graphs rather than drawing the line graphs. Similarly, Sezgin-Memnun (2013) investigated the reading and drawing of the line graph skills of the 7th-grade students and examine the differentiation of these skills according to students' mathematics course grades. Her findings showed that drawings of the line graphs by students were inadequate. They were more successful in reading the line graphs. In their studies, Yilmaz and Ay (2016) aimed to examine 8th-grade students' knowledge and skills about histograms. They found that students had difficulty drawing and interpreting histograms. They also stated that students are unaware of the differences between histogram and bar graph. In addition to these studies, Curcio (1987) defined three graphic comprehension levels: read the data, read between the data, read beyond the data.

- Reading the data, requires a literal reading of the graph and the information is explicitly stated or directly found in the graph (URL-1, 2019). Curcio (1987) underlined that it is very low-level cognitive task. There is no need to make interpretation at this level. González et al. (2011) stated that this level focuses on extracting data from the graph directly.
- Reading between the data, includes interpretation and integration of data (URL-1, 2019). Friel, Curcio, and Bright (2001) drew attention to find relationships as integrating and interpreting data. It is necessary to find and realize relationships expressed in graphs (González et al., 2011).
- Reading beyond the data, requires predicting about unknown data and inferring from data which is not explicitly stated in graph (URL-1, 2019). This is called as advanced level and requires moving beyond the data (Friel et al., 2001). González et al. (2011) stated that it requires realizing extrapolation of relationships, making predictions about unknown.

In this way, Curcio's (1987) framework is an essential structure for graph comprehension. Besides, Friel et al. (2001) underlined that research on determining the difficulties regarding three graph comprehension levels for readers is needed. Due to increasing importance of graphs, a need to determine graphical literacy levels of students in different aspects emerges. Although there are many studies about students' graph reading skills, they generally focused on certain aspects of graphical literacy. In general, reading, drawing, interpreting graph aspects are investigated. However, in math curricula not only reading, drawing, interpreting but also comparing graphs, realizing errors within the graph, and evaluating graph aspects were considered.

Research Question

Although previous research focused on graphical skills of students, a gap exists that there has not been conducted comprehensive research on students' graphical literacy abilities. When common core standards and math curricula are reviewed students are expected to interpret, draw, read, compare, and evaluate graphs. Also, in literature graphical abilities are generally limited with certain aspects. The aim of the study is determining graphical literacy levels of 8th-grade students concerning reading, interpreting, drawing, comparing and evaluating aspects. Graphical literacy aspects were also examined through graph comprehension levels of Curcio (1987). In this regard, the present study aims to fill the gap existing literature with a wider framework. This study aims to address the following research question:

How are the graphical literacy skills of 8th-grade students concerning reading, interpreting, drawing, comparing, evaluating aspects?

Method

Graphical literacy test was used to investigate students' success related graphical literacy aspects and to determine what challenges students had. Categorical scoring

table, open-ended questions were used to obtain in depth understanding of students' success.

Research Sample


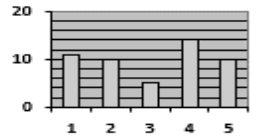
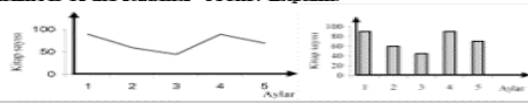
The study group consisted of 46 students attending 8th-grade from two different middle school levels. Due to all subjects and learning outcomes related graphs were taught up to the grade 8 is effective on determining the participants. Two middle schools were determined as one of them has lower, and the other one has higher success to provide variability. While the success of the schools was determined, nationwide exam results were considered. Students participating of this study were coded as S1, S2,, S46.

Data Collection

The data of this study were collected with graphical literacy test. Open-ended questions, including the graphical literacy aspects, were asked to students. After the test was developed, a field expert examined the test. For reliability analysis, Cronbach Alpha coefficient was calculated as 0.82. Then, necessary corrections were made, and final version of the test was given.

There were ten questions with 24 sub-questions in the test. Because four questions belonged to both drawing and evaluating the graphs aspects, students' answers were evaluated based on the 28 sub-questions. When the questions were written, graph comprehension levels of Curcio (1987) were considered. Sample questions are given in Table 1.

Table 1
Questions related the Graphical Literacy Aspects

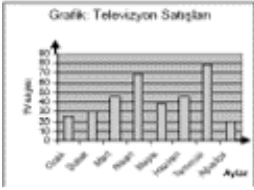
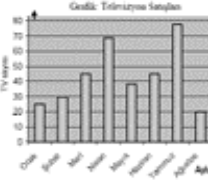
| Aspect | Level | Question | Sample Questions | Explanation | | | | | | | | | | | | | | | | |
|------------------------------|---|---------------------------|--|---|------------------|-------|----|-------|----|-------|----|-------|----|-------|----|-------|----|-------|----|--|
| Reading the Graphs (RG) | Read the data | Q9a-b | <p>Q9) The graph shows the amount (mm) of the rain between 2010 and 2013 in Trabzon city. Using the data on this graph, answer the questions: a) Which year has the most rain amount?</p>  | Students are expected to be able to read data on graphs in a basic form. | | | | | | | | | | | | | | | | |
| Interpreting the Graphs (IG) | Read between the data Read beyond the data | Q2a Q6 Q7a-b Q9c | <p>Q7) The distribution of the mathematics scores of the students were given with the graph at below.</p>  <p>b) If the students have 2 or more scores, they will be evaluated as "successful. Therefore, what percent of the students are successful at mathematics lessons?</p> | Students are expected to be able to make inferences and associate data on the graphs. | | | | | | | | | | | | | | | | |
| Drawing the Graphs (DG) | Read between the data | Q1a-b Q8 | <table border="1" data-bbox="694 630 1052 774"> <thead> <tr> <th>Time</th> <th>Body Temperature</th> </tr> </thead> <tbody> <tr><td>06:00</td><td>36</td></tr> <tr><td>09:00</td><td>37</td></tr> <tr><td>12:00</td><td>40</td></tr> <tr><td>15:00</td><td>38</td></tr> <tr><td>18:00</td><td>39</td></tr> <tr><td>21:00</td><td>37</td></tr> <tr><td>00:00</td><td>38</td></tr> </tbody> </table> <p>Q1a) The body temperature of a patient is measured by 3-hour range time. Data related these temperatures were given at table. Depending on this table, draw a graph displaying the variation of the patient's body temperature in a day.</p> | Time | Body Temperature | 06:00 | 36 | 09:00 | 37 | 12:00 | 40 | 15:00 | 38 | 18:00 | 39 | 21:00 | 37 | 00:00 | 38 | Students should draw the graphs correctly. Besides, they should determine the proper chart type for the given context. |
| Time | Body Temperature | | | | | | | | | | | | | | | | | | | |
| 06:00 | 36 | | | | | | | | | | | | | | | | | | | |
| 09:00 | 37 | | | | | | | | | | | | | | | | | | | |
| 12:00 | 40 | | | | | | | | | | | | | | | | | | | |
| 15:00 | 38 | | | | | | | | | | | | | | | | | | | |
| 18:00 | 39 | | | | | | | | | | | | | | | | | | | |
| 21:00 | 37 | | | | | | | | | | | | | | | | | | | |
| 00:00 | 38 | | | | | | | | | | | | | | | | | | | |
| Comparing the Graphs (CG) | Read beyond the data | Q4 Q5a-b-c | <p>Q4) Number of the books which students read during the 5 months were given with bar and line graphs. Which of the graphs belonging the same data set, present the better understanding about the number of the students' books? Explain.</p>  | Determining that which graph type is meaningful for data. | | | | | | | | | | | | | | | | |
| Evaluating the Graphs (EG) | Read between the data Read beyond the data | Q3 Q8 Q10 Q2b | <p>Q3) There are some context and graph types at below. For all context, determine the proper graph type and write the letter of the context on the box where the graphs do you think the most proper. Explain your reason.</p> <p>A) A graph, displaying the average scores of a student for all lessons <input type="text"/></p> <p>B) A graph, displaying the heartbeat, when a child gets on the stock-car <input type="text"/></p> <p>C) A graph, displaying the daily stock exchange <input type="text"/></p> <p>D) A graph, displaying the Face book usage purposes <input type="text"/></p> <p>E) A graph, displaying the number of the tourists in June <input type="text"/></p> <p>Bar Charts Line Charts Pie Charts</p> | It is aimed to evaluate the appropriateness of graph type or drawings of graphs. | | | | | | | | | | | | | | | | |

Data Analyses

Data were analyzed both quantitatively and qualitatively. Although test scores are obtained as quantitative data, students' answers, justifications, possible errors or misconceptions regarding items are important to evaluate their graphical literacy. In this way, quantitative data were referred to use for descriptive analysis. Because the present study aimed to picture students' graphical literacy abilities in-depth, more emphasis was placed on qualitative analysis. Students' responses to the items were analyzed by the categorical scoring table. This scoring table was created with two steps: all possible answers were determined; categories were established according to the degree of rationality. As an example, the coding procedure is given in Table 2.

Table 2

Sample Answers for the Analyzing Procedure

| Question | Coding Score |
|---|---|
| <p>5) Sales of two companies by months are given with two graphs at below:</p> <div style="display: flex; justify-content: space-around;">   </div> <p><i>Therefore,</i></p> <p>a) Which company has more sales? Why? b) Which company sells cheaper? Why? c) Which company has higher quality? Why?</p> | <p>a) 2: Two companies have the same sales with the reasons 1: Two companies have same sales. 0: No answer or choosing one of the graph.</p> <hr/> <p>b-c) 3: Due not to graph have the data through wanted situations, absolute answer could not be given. 2: They have the same tendency; they could have the same prizes or quality 1: Only answer as "same" or "equal" 0: No answer. Choosing one of the graphs.</p> |

The maximum score that a student could have from the test was 38. After students' answers were scored, distributions of the frequencies and percentages for each question were calculated, total scores were determined.

Result

Results about the Reading the Graphs Aspect

There were two questions related to the RG aspect. Frequencies and percentages of items are shown in Table 3.

Table 3*Distribution of Students' Scores for Reading Graph Aspect*

| Scores | | 1 | | 0* | | 0 | |
|---------------|----------|----|----|----|---|---|---|
| Level | Question | f | % | f | % | f | % |
| Read the data | Q9a | 44 | 96 | 2 | 4 | - | - |
| | Q9b | 40 | 88 | 3 | 6 | 3 | 6 |

0*: No answer 0: Incorrect answer

When the Table 3 was analyzed, it was seen that almost all students answered these questions. In other words, students were successful in reading the data on the graphs and following necessary operations. In other words, students could answer the questions related read the data level. Because this aspect requires only reading data on graphs and basic literacy skills, students could be successful.

Results about Interpreting the Graphs Aspect

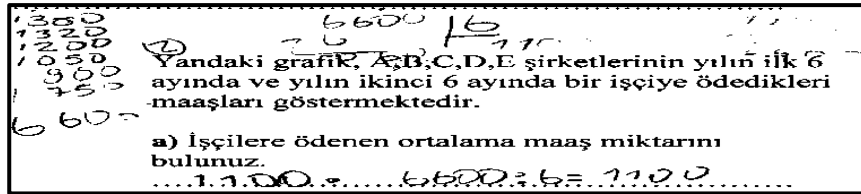
There were five questions related to IG aspect. Frequencies and percentages of the items are given in Table 4.

Table 4*Distribution of Students' Scores for Interpreting the Graph Aspect*

| Scores | | 2 | | 1 | | 0* | | 0 | |
|-----------------------|----------|----|----|---|----|----|----|----|----|
| Level | Question | f | % | f | % | f | % | f | % |
| Read between the data | Q2a | 5 | 11 | 9 | 20 | 12 | 26 | 20 | 43 |
| | Q6 | 32 | 70 | 9 | 20 | 2 | 4 | 3 | 6 |
| | Q7a | 4 | 9 | 4 | 9 | 7 | 15 | 31 | 67 |
| Read beyond the data | Q7b | 8 | 17 | 6 | 13 | 5 | 11 | 27 | 59 |
| | Q9c | 4 | 9 | 5 | 11 | 3 | 6 | 34 | 74 |

0*: No answer 0: Incorrect answer

In this aspect, students generally presented irrelevant or incorrect answers. Students had difficulties in reaching unknown information based on data. While students were more successful in Q6, they had more difficulties in Q7a, Q9c. Because students could not consider all data or frequencies, students calculated average incorrectly. For example, S42 tried to calculate average score only using data on the y-axis.

**Figure 1.** S42's written work for Q7a

S42 added all values on the y-axis and divided this value into 6. At this point, student could not interpret all values on the graphs and presented incorrect solution. In other words, she did not consider frequencies of the values and calculated average salaries without considering the frequencies. For Q7b, students considered the criteria of being successful incorrectly and misinterpreted the graph. Students interpreted the information incorrectly as students getting more than two points were called as successful. These students generally answered the question as 11 or 22%. For example, S15 answered Q7b as follows:

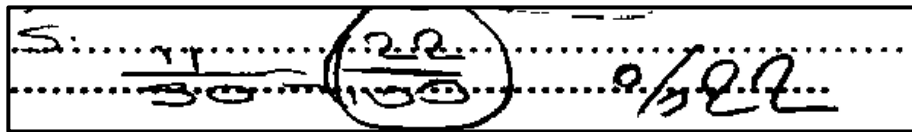


Figure 2. S15's written work for Q7b

S15 thought that students who had one point were unsuccessful. Therefore, he stated that 11 students were unsuccessful. And, he found the failure rate of the students as 22%. Due to misinterpreting the data on the graphs and question, this answer was assigned as 0 point.

Students had lower success on Q9c which required interpreting about an unknown data, following up the data set. Students, answering incorrectly interpreted this question, referred to *pattern based on increase/decrease on graphs, interpreting based on personal thoughts*.

Interpreting based on personal thoughts: Some of the students referred to personal thoughts rather than focusing on tendency of graphs, while they interpreted Q9c. For example, S21 answered "I think, it would be lower, because this year has very little rainfall." and linked to daily life observation in her answer. While students predicted or interpreted the rainfall of next years, they referred to daily life observations rather than considering data and tendency of graph.

Finding a pattern based on increase or decrease on the graphs: Some of the students made predictions based on the patterns on the graphs. For example, S45 "It is 400. Because, there is 100 increase and then 200 decrease. When we subtract 200 from 600, we find 400." S45 answered the question as finding a pattern between years and rainfall amount. Also, it was seen that this pattern was incorrect.

Students asked to answer that how they could more time on studying lesson based on pie graph displaying daily activities and spending times of these activities for one student in Q6. Students generally took 2 points owing to correct interpretations. They increased or decreased these activities in it and reorganized pie graph without any damage to its nature. Although some students realized that pie graph must be a whole, they failed to support their answers with an appropriate or clear justification. For example, S30 answered as: "If he/she increases the duration of the studying, he/she should reduce other data in the pie graph. Because the total value of the pie graph must be equal to 100". He thought that he must reduce other parts in the graphs to increase the duration

of studying and total value must be equal to 100 in graph. Otherwise, in this answer it is not clear that whether total value (100) refers to angle measurements or percentages.

When students' answers related interpreting the graphs aspect was evaluated, it was seen that students had difficulties at determining relationship between given and wanted information on the graphs. On the other hand, while they calculated the average of the data in the graph, they ignored the frequencies of the bars while they were calculating the average value and they calculated average of the values on x or y axis.

Results about Drawing the Graphs Aspect

There were six questions related to DG aspect. Frequencies and percentages of the items related DG are given in Table 5.

Table 5

Distribution of Students' Scores for Drawing the Graph Aspect

| Scores | | 3 | | 2 | | 1 | | 0* | | 0 | |
|-----------------------------|----------|----|----|---|----|----|----|----|----|----|----|
| Level | Question | f | % | f | % | f | % | f | % | f | % |
| Read between the data | Q1a | 21 | 46 | 9 | 20 | 3 | 6 | 2 | 4 | 11 | 24 |
| | Q1b | 16 | 35 | 9 | 20 | 2 | 4 | - | - | 19 | 41 |
| | Q8a | | | | | 12 | 26 | 4 | 9 | 30 | 65 |
| | Q8b | | | | | 27 | 59 | 5 | 11 | 14 | 30 |
| | Q8c | | | | | 25 | 55 | 7 | 15 | 14 | 30 |
| | Q8d | | | | | 2 | 4 | 17 | 37 | 27 | 59 |

0*: No answer 0: Incorrect answer

Although Q1a and Q1b questions were parallel, success of the students differed. Similarly, it was seen that success of the students differed at Q8 by referring the relevant graph types. In this aspect, students made mistakes at *determining the irrelevant graphs, scaling errors, and inability to place the data appropriately.*

Determining the irrelevant graphs or drawing the incorrect graphs: Some of the students preferred to draw with same graphs for Q1a and Q1b. For example, S9 preferred the same graph type without considering the context of the problem.

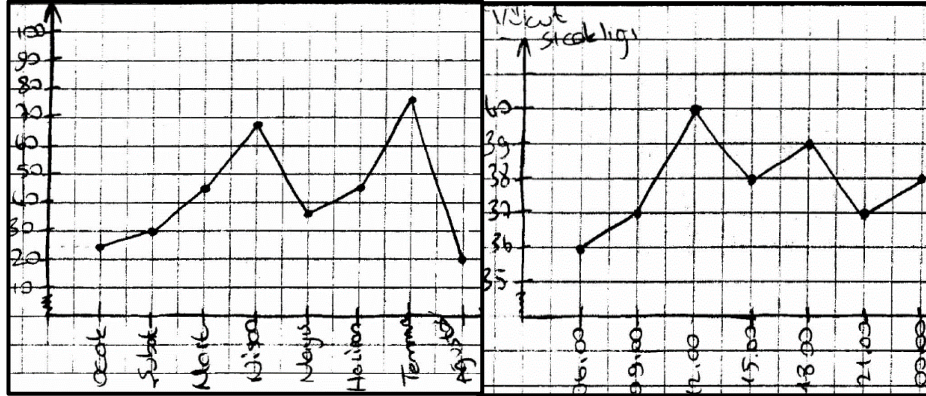


Figure 3. S9's drawn works for Q1a and Q1b

S9 could draw the line graph as a relevant graph type for the Q1b related the body temperature of a patient with a three-hour interval. On the contrary, S9 preferred the line graph for the Q1a which was about TV sales of a company and he preferred irrelevant graph type. On the other hand, some of the students preferred the bar graph both contexts. This finding suggest that students had difficulties in determining the most representative graph type for given context. For Q8, students could determine relevant graph type. However, students generally preferred to use bar graph rather than histogram. Also, students could not consider the total angle measurements of pie graphs that must be equal to 360. For example, drawn works of the S33 and S2 are given at below.

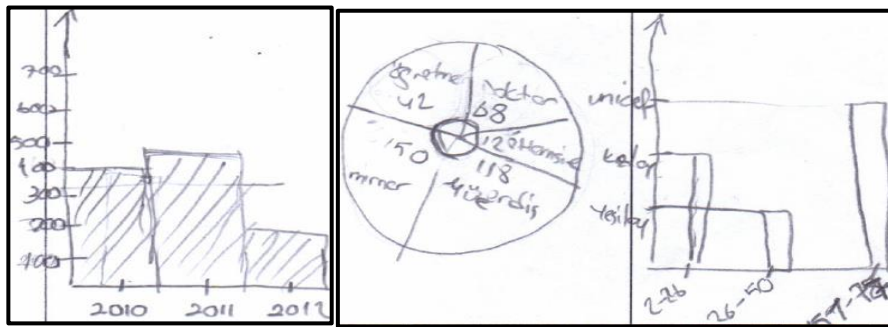


Figure 4. S33's and S2's drawn works for Q8

While S33 represented the PC sales of a company by month with the bar graph, she drew contiguous columns. Therefore, she could not draw appropriately for bar graph. On the other hand, S2 represented the distribution of professional preferences of the students aged 12-18. However, she did not consider the knowledge that the total angle measurement of the pie graph must be equal to 360°. She drew histogram with the non-contiguous columns.

Scaling errors: Some of the students did not consider scaling while they were drawing the graphs. Students failed to determine the units corresponding to the columns in proportion to the numerical values. For example, S4 displayed the distance that athlete ran according to days with the bar graph and made scaling errors in his drawing as below:

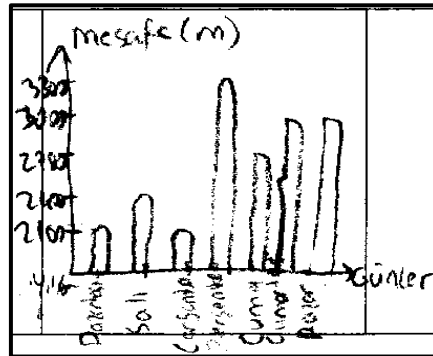


Figure 5. S4's drawn work for Q8

Although 3300 m was equal to the one and half times of 2200 m, she scaled the columns as 3300 m was approximately equal to the three times of the 2200 m and made scaling errors.

Failure to drawing the graph based on the data: Although the origin was not included in between the data, students assumed that the graph passed through the origin point, especially for the line graphs. For example, S22 could give place to data in the graph correctly. However, she assumed that the graph started from the origin point. Drawings of S22 and S15 for Q1b and Q8a are given below:

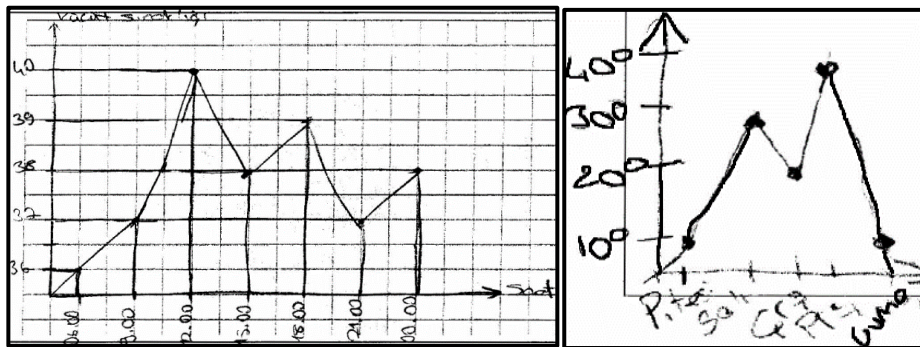


Figure 6. S22's drawn work for Q1b and S15's drawn work for Q8a

S22 could determine the relevant graph type and give place to data in her graph correctly. On the other hand, S15 could prefer the relevant graph as a line graph type for the variation of the temperature according to days. Also, they made mistakes as starting the graph from the origin.

Results about Comparing the Graphs Aspect

There were four questions related to CG aspect. Frequencies and percentages of the items are given in Table 6.

Table 6

Distribution of Students' Scores for Comparing the Graph Aspect

| Scores | | 3 | | 2 | | 1 | | 0* | | 0 | |
|----------------------|-----------|---|----|----|----|----|----|----|---|---|----|
| Level | Questions | f | % | f | % | f | % | f | % | f | % |
| Read beyond the data | Q4 | 1 | 2 | 4 | 9 | 35 | 76 | 2 | 4 | 4 | 9 |
| | Q5a | | | 20 | 43 | 17 | 37 | 1 | 2 | 8 | 17 |
| | Q5b | 6 | 13 | 9 | 20 | 22 | 48 | 1 | 2 | 8 | 17 |
| | Q5c | 8 | 17 | 12 | 27 | 15 | 33 | 3 | 6 | 8 | 17 |

0*: No answer 0: Incorrect answer

Students were unsuccessful in Q4. Although the number of the students who gave an incorrect answer or did not answer was fewer, students generally got 1 point from the Q4. Therefore, most of the students could not have two or more points and they were unsuccessful in this question. Also, students were more successful in Q5a. For example, S2 answered:

The first bar graph is the relevant one. All students could not understand the second graph, and this graph displayed numbers within a wide range. If they give more data and points correspond to data are increased, it could be better.

It was seen that S2 compared the graphs considering the ease of the reading rather than the relevance of the context. Besides, there were few students considering the relevance of the graph for the context. They compared graphs not only explaining why the bar graph is relevant one but also drawing attention to reasons for the irrelevance of line graphs.

Students could realize that TV sales and data were the same for two graphs. However, students generally failed to explain the difference between graphs that arose from different scaling. There were students, answering why two graphs had the same sales. Students answering incorrectly stated that the second company had more sales. Students made mistakes by thinking that the second company had more sales due to having higher columns. While students were successful in Q5a, they could not display similar success in Q5b-Q5c. In these questions, they were asked to compare the companies concerning prize and quality. Students generally answered referring the equality as "equal" or "same". S25 answered:

Due to both graphs are the same, they would have the same prize.

S25 thought that TV prizes must be equal due to having the same TV sales. Students ignored that the information on the graphs was not enough to compare companies concerning prize or quality. It was seen that students' answers were only limited to the appearance of graphs.

Results Evaluating the Graphs Aspect

There were 11 questions related to EG aspect. Frequencies and percentages of the items are given in Table 7.

Table 7

Distribution of Students' Scores for Evaluating the Graph Aspect

| Scores | | 3 | | 2 | | 1 | | 0* | | 0 | |
|-----------------------------|----------|---|----|----|----|----|----|----|----|----|----|
| Level | Question | f | % | f | % | f | % | f | % | f | % |
| Read between the data | Q3a | | | - | - | 28 | 61 | 1 | 2 | 17 | 37 |
| | Q3b | | | 12 | 26 | 26 | 57 | 1 | 2 | 7 | 15 |
| | Q3c | | | 12 | 26 | 23 | 50 | 1 | 2 | 10 | 22 |
| | Q3d | | | 8 | 17 | 26 | 57 | 2 | 4 | 10 | 22 |
| | Q3e | | | 1 | 2 | 26 | 57 | 2 | 4 | 17 | 37 |
| | Q8a | | | | | 21 | 46 | 4 | 9 | 21 | 46 |
| | Q8b | | | | | 35 | 77 | 5 | 11 | 6 | 13 |
| | Q8c | | | | | 34 | 74 | 7 | 15 | 5 | 11 |
| Read beyond the data | Q8d | | | | | 7 | 15 | 17 | 37 | 22 | 48 |
| | Q2b | | | - | - | 2 | 4 | 16 | 35 | 7 | 15 |
| | Q10 | 6 | 13 | 7 | 15 | 5 | 11 | 3 | 6 | 25 | 55 |

0*: No answer 0: Incorrect answer

It was seen that students' scores for this aspect were differed according to the questions. Students were more successful in determining the relevant context for the graph type and assessing the graph type for the given context. On the other hand, they were unsuccessful in evaluating the errors in the graphs and whether the presented graphs had relevant drawings. For Q2b, students were asked to evaluate whether the graph type was relevant or drawn correctly. Students' answers were generally limited with one point due to drawing attention to be clear and understandable. For example, S31 explained why bar graph was relevant:

I think the relevant one is the bar graph to see in detail.

Although S31 realized that the bar graph was the correct choice, he could not explain why it was relevant.

For Q10, the context related to the change of the heat temperature is displayed with the bar graph. In addition, students were asked to evaluate the preference of the graph type. Most of the students failed to evaluate the relevance of the graph type. For example, S39 answered:

It is true. Because we could understand which time it is hot or cold.

S39 could take any point due to this preference. On the other hand, S28 answered:

It is incorrect. They should use a line graph. We could not understand from the graph that how the heat temperature changes. Does it suddenly increase or decrease?

S26 could answer not only drawing is relevant but also it is relevant for context, have 3 points.

Students could determine the relevant graph type for a given context. However, they are failed to explain their justification. It was seen that students preferred to refer their daily life experience or the appearance. Besides, some students could explain in which situation graph types are relevant to use. S11 explained about the preference of pie graph:

Because the percentage rates are calculated and displayed in this form.

S11 was able to explain the preference of the pie chart associating with the percentile. Q8 requires writing the relevant context for graph types. While students are more successful in evaluating the bar and pie graphs, they could have similar performance on the histograms. Students often present contexts related discrete variables. Students ignored that histogram is proper for continuous variables. Students could determine whether the graph type is appropriate for the context. However, they failed to realize the scaling errors. The success of students is changed according to graph type. While students are more successful in pie and bar graphs, they could not display similar success on histogram and line graphs. However, students could determine proper context or graph type. They could not give justification. The average scores of students for graphical literacy aspects and success rates are shown in Table 8.

Table 8

Average Scores of Students for Graphical Literacy Aspects

| Aspect | Maximum score | Average Score | % |
|--------|---------------|---------------|------|
| RG | 2 | 1.85 | 92.4 |
| IG | 10 | 4.74 | 47.4 |
| DG | 10 | 3.02 | 30.2 |
| CG | 11 | 4.83 | 43.9 |
| EG | 20 | 7.80 | 39 |

As Table 8 demonstrates, students have lower success in DG, higher success in RG. Almost all students answer the questions related RG aspect. However, they could not display similar success on other aspects.

Discussion, Conclusions and Recommendations

Students are more successful in reading the graphs aspect. In other words, they could be able to read the data. Reading the graph, by its very nature, requires the basic understanding and analyses of the data on the graph. It could be effective on this result. Studies agreed that students are more successful in reading data (Güven, Özmen, Baki, Uzun, & Arslan, 2018; Özmen, 2015; Sezgin-Memnun, 2013).

For interpreting the graphs, students failed to carry out operational steps. Studies stressed that students have difficulties in interpreting graphs (delMas, Garfield, Ooms, & Chance, 2007; Friel et al., 2001; Kramarski, 2004; Yun, Ko, & Yoo, 2016). Questions involving operational steps as calculating the average or making predictions based on data. Students generally made mistakes in this aspect by carrying out operations. While students calculate the average, they directly add up data on the x-y axis without considering the frequencies. The failure of operational skills is effective for students' misinterpretations. Yun et al. (2016) underlined that students have difficulties while they interpret graphs and make statistical inferences due to lack of understanding of data. Yilmaz and Ay (2016) also found that students failed to interpret the histogram. They point out that students tend to read the graph rather than interpreting the graph. Involving the more complex and interrelated thinking process of this aspect could be effective on this failure. It could be inferred that students generally tend to read the data despite reading between the data if we adopt rich context and use the questions requiring higher thinking level (such as critical, creative thinking, reasoning skills) rather than the familiar context in our classroom practices, we can raise students' graphical interpretation skills.

Students had challenges and lower success in representing data with the graphs. Similarly, Yayla and Ozsevgec (2015) underlined that students have lower success in drawing the graphs rather than interpreting the graph skills. Moreover, Sezgin-Memnun (2013) drew attention to similar results that students were not successful in drawing the line graphs. Maybe, not giving enough place to this kind of in-class practice related to representing the data may lead to these challenges. Although all graph type was centered on math curriculum, students were more successful in representing data with bar and pie graphs. Watson (2006) underlined that students frequently encounter bar and pie graphs in school years and tend to display data with the line, pie or bar graphs. However, Watson (2006) stressed that students have not enough knowledge to display data with graphs and determine relevant graph type. Due to lack of knowledge about in which context histogram, bar graphs are relevant, was effective on this failure. In addition, using columns for both is another factor in incorrect drawings of the histogram. Similarly, Yilmaz and Ay (2016) stressed that students had challenges to distinguish the difference between two graphs.

Thinking that graphs must start from origin, it is not included in the data, and scaling errors are effective on students' failure. Bragdon et al. (2019) also found that college students have difficulties in scaling. They underlined that college students have this difficulty with a similar rate of high school students. Again, Watson (2006) stressed that students have insufficient knowledge about naming and scaling the axis. Yayla and Ozsevgec (2015) also pointed out that students were unable to naming the axes and combining the points on the graphs. Friel et al. (2001) drew attention to the errors related to "read between data" questions. They stated that these errors might be related to insufficient mathematics knowledge, scaling or reading the axes errors. In this study, another difficulty that is effective on students' incorrect drawings is the belief that graphs must start from the origin. Bragdon et al. (2019) also underlined that college students have similar difficulties if graphs passed through the origin. Graphs,

students often met in their life mostly started from origin could be effective on this difficulty. In this way, it was understood that students had difficulties and lower success regardless of the grade level and graph types.

Students compare graphs depending on their personal thoughts or informal criteria rather than focusing on the relevance of graph type for context. They focused on neither context nor prerequisites of graph type. When they compare two graphs, they mostly consider how it looks at. Watson (2006) also stressed that students compare the graphs without suitable justifications. She underlined that students only compare the graphs apparently. In this study, students mostly prefer to bar graphs due to informal reasons, such as better, easier reading and understanding.

Being of students more familiar with the bar graphs rather than line graphs could be effective on these preferences. Students agree that the two graphs are the same. They realized that the difference between graphs is only about scaling. Therefore, students are successful in Q5a (comparing total sales). Although there is not enough knowledge of graphs related to quality or prizes, students think that quality and prize of products must be equal. Therefore, students could not think that comparing two graphs is not possible based on the given data. In this way, students are unsuccessful in determining what kind of information could be available from the graphs. This result suggests that students are unsuccessful in reading beyond the data.

Students are successful in determining the relevance of context or graphical representation. Similarly, Yun et al. (2016) found that students could choose a proper graph representation. Besides, it was seen that students' success changed depending on the graph type. While students perform better at bar or pie graphs, they are unsuccessful in histogram or line graphs. It is thought that this result could stem from the confusion with different graph type each other. Especially histogram and bar graphs were effective on this confusion. Sezgin-Memnun (2013) also stressed that students' confused line and bar graphs in their answers. However, both graphs have quite different nature.

In the present study, we did not meet this kind of result. The grade level of the students could be effective on the differentiation of the results. In her study, Sezgin-Memnun (2013) worked with 7th-grade students. On the other hand, students from 8th-grade level participated in the present study. Although students first met line graph at 7th-grade level, they could confuse these graphs. Koparan (2012) underlined that students have not enough knowledge when they determine the relevant graph type. delMas et al. (2007) stressed that university students had difficulty as determining appropriate graph type. It is understood that students had difficulties in choosing the best graph type regardless of grade level.

Evaluating the graph aspect, students are not able to realize graphical errors or the incorrect graph type. Wu (2004) stated that students had a basic ability to solve graphs, and students are unsuccessful in evaluating the graphs. In our instructions, we usually use a data set and ask students to summarize data with a suitable graph. Otherwise, a graph is given, and students are asked to answer the related questions. These questions are mostly about reading data or basic interpretations. However, students are not

familiar with questions about scaling errors, reading between or beyond data. Moreover, we could neglect to evaluate, compare and draw the graph aspects in our instructions. Thus, making real of the goal as raising students as graphically literate would be a failure. We should arrange the curriculum and design our instructions as serving to raise the graphical literacy of students.

Graphs should be taught, giving place to reading between or beyond data activities. Watson (2006) stressed that when the math curricula or the instructions are planned, practices should be centered upon not only drawing the graph but also determining errors or bias in graphs. Yun et al. (2016) also suggest that students should be taught with more stress on context and scaling. The results of the present study also support this recommendation. Students have a tendency not to consider different scaling of the same graphs. Therefore, they could think that these graphs are different. Similarly, Bragdon et al. (2019) and Watson (2006) recommended on this failure. This result could be stem from not giving enough place in different activities encouraging students to think statistically in-class practices. When we design in-class practices, we should consider both graphical literacy aspects and daily-life contexts.

This paper showed that students were unsuccessful in fulfilling the graphical literacy aspects (especially comparing and evaluating aspects). Their answers generally limited to reading data. They were unsuccessful in reading between and beyond the data. Therefore, students could not display graph comprehension skills defined by Curcio (1987). Similarly, Friel et al. (2001) stated that students are more successful in reading the data, make errors at between data questions. They underlined that questions related “*read beyond the data*” were even more challenging. Because this level requires making inferences and predictions about unknown cases, students may have more challenges. Also, studies in Turkey revealed that students have not enough graphical skills (Kaynar & Halat, 2012; Yayla & Ozsevgec, 2015; Yilmaz & Ay, 2016). The present study has also confirmed that students have difficulties in displaying graphical literacy behavior. Therefore, there is a need to improve the graphical comprehension levels of students. Also, this failure may stem from a lack of instructional activities.

There is a need to design of learning environment through these aspects to raise students as graphically literate. To achieve this, of course, graphical literacy level of teachers and quality of instructional activities are important. Required arrangements to deal with students’ difficulties should be integrated into our statistics teaching. To design better classroom practices, it is also important for teachers to have an opportunity to be a guide for teaching graphs or to cope with the difficulties that students faced. This takes us the idea that the math curriculum in Turkey should also be revised to develop students’ graphical literacy skills. Further studies should also focus on how graphical literacy emerges in the learning environment. Wu (2004) suggests that teachers should assist students in realizing graphical errors, help students to properly use their contextual knowledge of graphs. Friel et al. (2001) stressed that teachers need to increase their knowledge of graphs and be aware of how they would teach graphs providing effective instructions. For the future, graphical literacy levels of teachers should be determined. Necessary arrangements should be

considered to raise teachers as equipped with graphical literacy. Also, in this study, we built graphical literacy aspects and this structure should be considered in further studies.

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8. Sınıf Öğrencilerinin Grafik Okuryazarlığı Düzeylerinin Belirlenmesi

Atıf:

Ozmen, Z. M., Guven, B., & Kurak, Y. (2020). Determining the graphical literacy levels of 8th grade students. *Eurasian Journal of Educational Research*, 86, 269-292, DOI: 10.14689/ejer.2020.86.13

Özet

Problem Durumu: Grafikler konusunun yaşamımızda ve matematik öğretim programlarında önemli bir yere sahip olması, öğrencilerin grafikler konusu ile ilgili zorluklar yaşadıklarının ortaya koyulması öğrencilerin grafiklerle ilgili yeterliklerinin belirlenmesi ihtiyacını ortaya çıkarmaktadır. Araştırmalarda grafiklerle ilgili farklı boyutlar üzerinde odaklanılmaktadır. Genellikle grafik okuma, oluşturma ve yorumlama boyutları ile ilgili araştırmalar yapılmaktadır. Ancak öğretim programı incelendiğinde öğrencilerin sadece grafikleri okuma, oluşturma ve yorumlama becerileri değil aynı zamanda farklı grafikler üzerinde karşılaştırma yapmaları ve grafiklerdeki hatalı durumları fark ederek uygun değerlendirmeler yapmaları da beklenmektedir. Grafikleri doğru kullanabilmek ve grafiklerden uygun şekilde faydalanabilmek için grafiklere tüm yönleriyle hâkim olmak gerekir. Yani grafikleri

okuma, anlama, yorumlama, oluşturma, oluşturulan grafiklerin uygunluğunu değerlendirme ve hatalı oluşturulmuş grafiklerin farkında olma gibi yeterliliklere sahip olmak gerekmektedir. Bu anlamda öğrencilerin grafik okuryazarlığının okuma, oluşturma, yorumlama, karşılaştırma, değerlendirme boyutları açısından resmedilmesi önemli görülmektedir.

Araştırmanın Amacı: Bu çalışmada 8. sınıf öğrencilerinin grafik okuryazarlığının grafikleri okuma, yorumlama, oluşturma, karşılaştırma ve değerlendirme boyutları ve grafik okuma düzeyleri açısından resmedilmesi amaçlanmıştır. Bu amaç doğrultusunda grafik karşılaştırmaya ilişkin geliştirilen yapıda yer alan üç temel düzey (veri okuma, veriler arası okuma, verilerin ötesinde okuma) dikkate alınmıştır.

Araştırmanın Yöntemi: Ortaokul 8. sınıf öğrencilerinin grafik okuryazarlığının grafik okuma, oluşturma, yorumlama, karşılaştırma ve değerlendirme boyutları bakımından incelenmesini amaçlayan bu çalışmada betimsel araştırma yöntemi tercih edilmiştir. Bu çalışmanın örneklemini iki ortaokulun 8. sınıfına devam eden 46 öğrenci oluşturmaktadır. Örneklem olarak 8. sınıf öğrencilerinin seçilmesinde ortaokul matematik öğretim programında grafik konusu ile ilgili kazanımların hepsinin bu sınıf seviyesine kadar görülmesi etkili olmuştur.

Çalışmanın veri toplama aracını grafik okuryazarlığı testi oluşturmaktadır. Bu testte grafik okuryazarlığı boyutlarına yönelik toplam 10 soruya yer verilmiştir. Testte yer alan sorular hazırlandıktan sonra uzman görüşüne başvurulmuştur. Uzman görüşü sonrası sorularda gerekli düzenleme ve değişiklikler yapılarak testin son hali verilmiştir. Öğrencilerin testte yönelik cevapları nitel olarak analiz edilecektir. Her bir soru için olası cevaplar mantıklılık derecesine göre kategorik olarak puanlanmıştır. Öğrencilerin her soru için cevapları kategorik puanlama cetveline göre değerlendirilmiştir.

Araştırmanın Bulguları: Öğrencilerin testte ilişkin başarılarının 22,1 puan ortalama ve 8 standart sapma olduğu görülmüştür. Testten alınabilecek maksimum puan 53 iken en başarılı öğrenci 38, en başarısız öğrenci ise 3 puan alabilmiştir. Öğrencilerin tamamına yakınının grafik okuma boyutuna yönelik soruları doğru cevapladığı görülmektedir. Grafikteki verileri okuyarak doğrudan bu veriler yardımıyla işlem yapmalarını gerektiren veri okuma ile ilgili sorularda öğrenciler başarılı olabilmıştır. Öğrencilerin grafik yorumlama boyutu ile ilgili cevapları değerlendirildiğinde üst düzey cevapların çok az yer aldığı görülmektedir. Öğrenciler grafikte verilen bilgileri, soruda istenilen bilgiler arasında ilişkiyi kurmada zorlanmışlardır. Grafiklerde verilerin ortalamalarını almaları gereken durumlarda frekans sayısını göz ardı ederek doğrudan x veya y ekseninde yazan değerlerin aritmetik ortalamasını almışlardır. Ayrıca öğrenciler grafik yorumlama boyutunda matematiksel işlem gerektiren sorularda daha çok hata yapmışlardır. Öğrencilerin grafikleri oluşturma boyutunda başarılarının grafik türüne göre değiştiği görülmektedir. Grafik oluşturmada öğrenciler uygun grafik türü seçmeme, yanlış ölçeklendirme yapma ve verileri uygun şekilde yerleştirememe şeklinde hatalar yapmışlardır. Grafikleri karşılaştırma ve değerlendirme boyutunda öğrenciler genel olarak başarısız olmuşlardır. Özellikle de verilerin ötesinde okuma düzeyinde cevaplar sunamamaları bu boyutlarda başarısız olmalarında etkili olmuştur. Bu

anlamda öğrenciler grafik okuma ile ilgili tanımlanan düzeylerden veri okumada başarılı iken verilerin ötesinde okuma düzeyinde etkili cevaplar sunamamışlardır.

Araştırma Sonuç ve Önerileri: Bu çalışmada öğrencilerin grafik okuryazarlığına ilişkin başarılarının düşük olduğu görülmektedir. Başka bir deyişle grafik okuryazarlığı ile ilgili beklenen düzeyde bir davranış sergileyememişlerdir. Öğrenciler özellikle grafikleri karşılaştırma, uygun bağlam veya grafik türünü belirleme, grafiklerdeki hataları fark edebilmede başarısız olmuşlardır. Başka bir ifadeyle, veriler arası okuma ve verilerin ötesinde okuma düzeylerine ilişkin zorluk yaşamışlardır. Bu başarısızlıklar grafiklerle ilgili etkinliklere dayalı öğretimlerin yetersiz olmasından da kaynaklanabilir. Bu anlamda öğrencilerin grafik okuyazarı olarak yetiştirilmelerinde grafik okuryazarlığı boyutlarını temel alan öğrenme ortamlarının tasarlanmasına olan ihtiyaç ortaya çıkmaktadır. Bunu başarmada ise kuşkusuz öğretmenlerin grafik okuryazarlığı seviyeleri ve öğretimsel aktivitelerin niteliği de önemli olmaktadır. Öğrenme ortamlarında grafik okuryazarlığının nasıl ortaya çıktığına yönelik çalışmalar yapılabilir. İlerleyen çalışmalarda öğretmenlerin grafik okuryazarlık düzeylerini belirleyen çalışmalar yapılabilir ve öğretmenlerin grafik okuryazarlığı açısından donanımlı olmalarını sağlayacak düzenlemeler dikkate alınabilir.

Öğrencilerin grafik okuryazarlığı boyutlarını başarmada yeterli düzeyde olmadıkları görülmektedir. Bu ise grafik karşılaştırma düzeylerinde de başarısız olduklarına işaret etmektedir. Öğrencilerin cevapları genel olarak veri okuma düzeyi ile sınırlı kalmıştır. Çalışmalarda öğrencilerin veri okuma düzeyinde daha başarılı olduklarını, veriler arası okumada hatalar yaptıklarını belirtmişlerdir. Ayrıca öğrencilerin “verilerin ötesinde okuma” düzeyinde en çok zorluk yaşadıklarına dikkat çekmişlerdir. Bu düzeyin bilinmeyen durumlara yönelik tahminde bulunma ve çıkarım yapmayı gerektirmesinin bu başarısızlıkta etkili olduğu düşünülmektedir. Bu anlamda öğrencilerin grafik okuryazarlığı düzeylerinin geliştirilmesi gerektiği ihtiyacı ortaya çıkmaktadır. Grafikleri öğretirken sadece veri okuma değil aynı zamanda veriler arası ve veri ötesinde okuma gibi farklı düzeylere de odaklanılmalıdır. Grafik okuma düzeyleri ve bu çalışmada ele alınan grafik okuryazarlığı boyutlarına ilişkin yapı grafik okuryazarlığı ile ilgili gelecekteki çalışmalarda kullanılabilir.

Anahtar Kelimeler: Grafikler, grafik okuryazarlığı, grafik okuryazarlığı boyutları, öğrencilerin grafik okuryazarlığı düzeyleri.