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Determining the graphical literacy levels of the middle school mathematics teachers

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ABSTRACT

This study aims to determine the graphical literacy levels of middle school mathematics teachers. The participants of the study consisted of 33 middle school mathematics teachers working in different provinces. The data of the study were collected with the help of the graphical literacy test created by the researchers. The data were analyzed by content analysis method. As a result of the study, it was seen that the teachers were more successful in the questions that required reading the data in the graph. It has been revealed that teachers are unsuccessful in reading beyond data questions that require higher-level thinking. In addition, the teachers had the most difficulty creating the graphs. In other words, it was determined that the graphical literacy levels of the teachers were low. Therefore, it is thought that studies to improve the graphical literacy skills of teachers in in-service training programs will be important.

Keywords: graphs, graphical literacy levels, middle school mathematics teachers, graphical literacy

INTRODUCTION

In our developing world, it is important for individuals to be able to comment on a situation, which they encounter, to make sense of this situation and to display a critical point of view. This importance brings with it the increasing interest of societies in statistical graphs. Statistical graphs that we encounter in many areas of our lives are also an important part of statistical literacy (Bannister et al., 2007; Franklin et al., 2007; Gal, 2002; González et al., 2011). Graphs are important tools in our lives to analyze, understand and visually present the data we encounter (González et al., 2011; Ozmen et al., 2020). In addition, graphs are important tools for us to convey the concepts to be explained in writing to the other party more effectively (Bolch & Jacobbe, 2019; Guler & Didis-Kabar, 2021). Graphs encounter in areas that we often use in our daily lives such as TV, the Internet, newspaper, and magazine (Matuk et al., 2019). Graphs appear not only in mathematics lessons but also in science and social studies lessons in education (Åberg-Bengtsson, 1999; Zucker et al., 2015). Graphs help students to make sense of daily and scientific data (Shah & Hoeffner, 2002). In addition, increasing importance is given in mathematics curriculum in our country (Ministry of National Education [MEB], 2009, 2013, 2018; Sezgin-Memnun, 2013). This importance brings to mind the necessity of being a good reader of graphs we frequently encounter in our lives (Bargagliotti et al., 2020; Bolch & Jacobbe, 2019; Ridgway, 2016). This requirement points to the importance of the concept of graphical literacy. The concept of graphical literacy is expressed in various ways (Bursal & Polat, 2020; Delport, 2021; Friel et al., 2001; Fry, 1981; Galesic & Garcia-Retamero, 2011; Gan et al., 2010; Ozmen et al., 2020). Bursal and Polat (2020) define graphical literacy as the ability to determine the type of graph appropriate for the context, to convert between different graphs, and to comment on these changes regarding data in the graph. Gan et al. (2010) consider graphical literacy as being able to read, interpret and create graphs. Friel et al. (2001) emphasize the importance of reading data at different levels, such as read the data, read between the data and read beyond the data. Ozmen et al. (2020) express graphical literacy as the skills of reading, interpreting, comparing, creating and evaluating the graphs we encounter daily. Although students need to have these skills, it is stated that they experience various difficulties (Aoyama, 2007; Capraro et al., 2005; Guven et al., 2015; Hadjidemetriou & Williams, 2002; Hafiyusholeh et al., 2018). Aoyama (2007) stated that students prioritize their thoughts while interpreting the graphs. Hafiyusholeh et al. (2018) pointed out that students had difficulties in creating the graphs. Capraro et al. (2005) and Guven et al. (2015) stated that students could not determine the type of graph suitable for the context and focused on a single variable while drawing the graph; Hadjidemetriou and Williams (2002) stated that students think that every graph should

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pass through the origin. For students to overcome these difficulties, they must perform effective graph teaching (Monteiro & Ainley, 2007; Ulusoy & Cakiroglu, 2013). The importance role of teachers is emphasized in terms of how graphs are taught, what kind of classroom practices are carried out during teaching and what kind of learning opportunities are provided to students (Batanero & Diaz, 2010; Ben-Zvi & Makar, 2016; Henriques & Ponte, 2014; Sorto, 2004; Ucar & Akdogan, 2009; Yenicirak, 2020).

Considering the role of teachers in helping students become graphically literate, it is important that teachers also have these skills. When the literature is examined, it is seen that the studies on graphs are generally carried out with students (Arteaga et al., 2021; Bolch & Jacobbe, 2019; Bragdon et al., 2019; Bursal & Polat, 2020; Bursal & Yetis, 2020; Díaz-Levicoy et al., 2019; Galesic & Garcia-Retamero, 2010; Glazer, 2011; Guler, 2019; Hotmanoglu, 2014; Kaynar & Halat, 2012; Ozmen et al., 2020; Selamet, 2014; Sezgin-Memnun, 2013; Wu, 2004). Bolch and Jacobbe (2019) examined the graph comprehension of university students within the scope of the evaluation questions in the levels of conceptual understanding in statistics (LOCUS) project, which was carried out to improve students' statistical understanding. As a result of the study, it was revealed that the students answered the questions that required direct reading of graphs, but they had difficulty in answering the questions about making inferences from the graphs. Díaz-Levicoy et al. (2019) aimed to determine the reading the graph levels of 745 middle school students. The study revealed that the students' reading the graph levels remained at the read between the data level, which requires determining the relationships between graphs. In addition, it is stated that the students mostly have difficulty with the questions that require reading the circle graph. Bursal and Yetis (2020), in their study to determine the graphs skills of seventh and eighth-grade students, revealed that students can reading the graphs, but their interpreting the graphs and drawing skills are insufficient. Wu (2004) evaluated the graph comprehension of 907 students with 13 and 15 years at four levels: reading the graph, interpretation the graph, drawing the graph and evaluating the graph. The results of the study revealed that the students' interpreting the graph and evaluating the graph skills were insufficient. Ozmen et al. (2020) carried out a study on determining the graphical literacy of eighth-grade students. In the study, Curcio (1987) determined students' graphical literacy skills within the scope of read the data, read between the data and read beyond the data levels and reading the graph dimensions. Considering the results of the research, it was seen that the students' reading beyond data and evaluating the graph skills, which require higher level skills, were insufficient. As a result of the studies, it is seen that the students' graphical literacy skills are not at a sufficient level. Emphasis is placed on the importance of teachers' teaching processes and graph literacy skills in the development of these skills of students (Ben-Zvi & Makar, 2016; Henriques & Ponte, 2014; Sorto, 2004). When the literature is examined, there are limited studies on teachers' skills and teaching on graphs (Patahuddin & Lowrie, 2019; Rouan, 2002). Patahuddin and Lowrie (2019) aimed to examine teachers' ability to interpret line graphs in their study. In the results of the study, it was revealed that the teachers could not give high-level answers to the questions about interpreting the line graphs. Rouan (2002) discussed teachers' understanding of graphs under four headings: formal understanding, synthetic understanding, predictive understanding, and visual static understanding. In the results of the study, it was stated that the teachers did not consider the context and could not make inferences. When the studies are examined, it is stated that teachers do not have sufficient graphical literacy skills (Chick & Pierce, 2008; Makar & Fielding-Wells, 2011) and that they have difficulties in their teaching (Ben-Zvi & Makar, 2016). On the other hand, it is seen as important in studies that individuals read, interpret, construct, compare and evaluate graphs. In addition, it is emphasized to perform inter-data and read beyond the datas for the data in the graphs. (Curcio, 1987; Friel et al., 2001). In this context, considering the importance of graphs in our daily life, individuals should have these skills. The education that individuals receive in acquiring these skills has an important place. In this context, teachers are one of the most important elements in school education. In other words, the level of teachers' graphical literacy skills and the development of students are closely related. For teachers to gain graphical literacy skills for students, they must first have these skills. Therefore, it is interesting to see how the graphical literacy of the teachers who direct the education of individuals from an early age. In this context, in this study, it is aimed to answer the following problem situation will be seeked:

What are the graphical literacy skills of middle school mathematics teachers regarding the graph literacy dimensions and graph comprehension levels?

The Aim of the Study

Considering the goal of developing individuals' graphical literacy skills, it is important to what extent middle school mathematics teachers who will teach graphs have these skills (Bargagliotti et al., 2020). In addition, it is emphasized that teachers should have equipped with graphical literacy comprehension levels (read the data, between the data and read beyond the data) and dimensions (reading, interpreting, drawing, comparing and evaluating) to provide effective teaching. In this context, within the scope of the research problem, the study aims to determine the graphical literacy levels of middle school mathematics teachers.

Theoretical Framework

Curcio (1987), emphasizing the importance of graphs, determined a three-stage level of graph comprehension. Studies emphasize the importance of using these levels when determining graphical literacy skills (Guler & Didis-Kabar; 2021; Ozmen et al., 2020). This study was also carried out within the scope of the following levels determined by Curcio (1987) (**Figure 1**).

As seen in **Figure 1**, Curcio (1987) discussed graph comprehension levels at three hierarchical levels: read the data, read between the data, and read beyond the data. Reading data requires direct reading from the graph, reading between data requires establishing relationships between data, and reading beyond data requires making inferences for situations that are not given in the graph. It is also important to evaluate the graph skills of individuals from various dimensions (González et al., 2011). Ozmen et al. (2020), in their study on determining students' graphical literacy, addressed these dimensions as reading the graph, interpreting the graph, drawing the graph, comparing the graph and evaluating the graph. It is thought that it will be important to examine individuals' graphical literacy skills in terms of comprehension levels and dimensions to address them in a wide range.

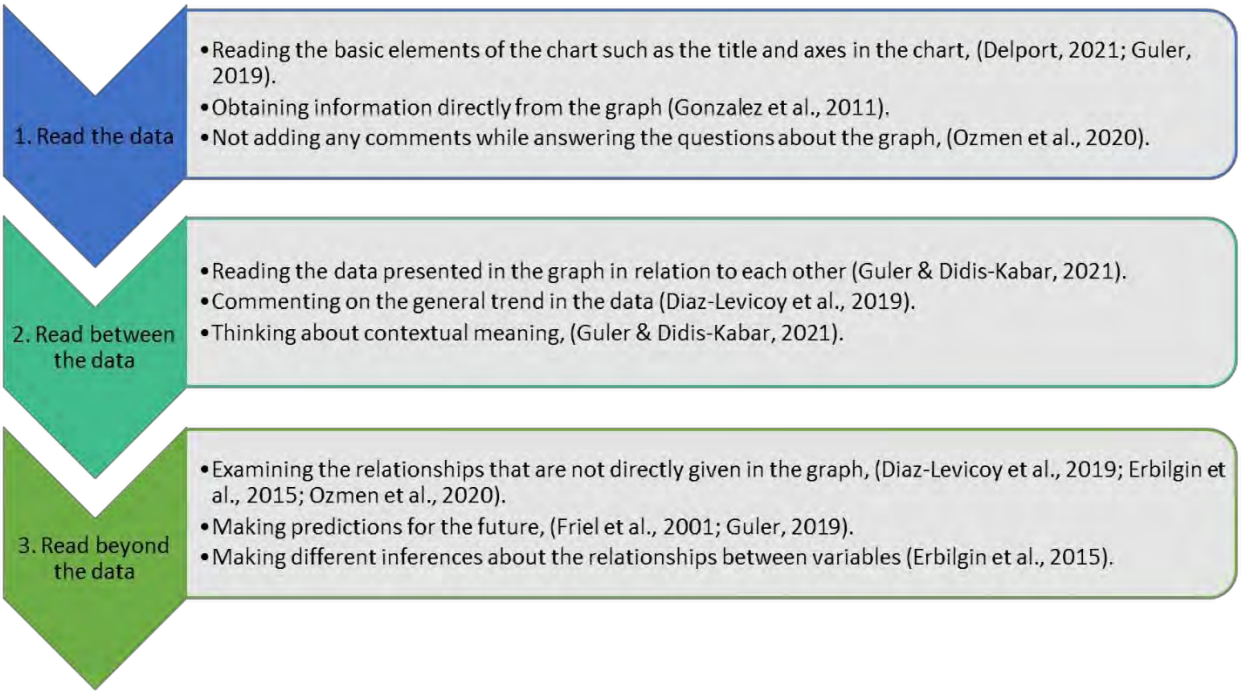


Figure 1. Graph comprehension levels and aspects (Curcio, 1987)

In the present study, while determining the graphical literacy skills of the teachers, the comprehension levels defined by Curcio (1987) were considered. Also, in the present Ozmen et al. (2020), on the other hand, were determined by the fact that they looked at graphical literacy skills from a different perspective. The study we were focused on the graphical literacy dimensions, which were referred by Ozmen et al. (2020). The frequent use of the Curcio (1987) model in studies on this situation (Bolch & Jacobbe, 2019; Delport, 2021; Díaz-Levicoy et al., 2019; González & Pinto, 2008; Ozmen et al., 2020; Patahuddin & Lowrie, 2019) and emphasis on these stages were effective in determining graphical literacy skills. Ozmen et al. (2020), on the other hand, were determinative considering that they looked at graphical literacy skills from a different perspective.

METHOD

The present study, it was aimed to determine the graphical literacy levels of middle school mathematics teachers. In the study, a case study, which is one of the qualitative research methods, was used. A case study is important in that it allows one or more events, environments, and one aspect of problem under investigation to be studied in depth and a short time (Ozmen & Guc, 2013).

Participants

The research group consists of 33 middle school mathematics teachers working in middle schools in Turkey in the spring term of 2021-2022. Volunteering was taken as a basis in the selection of teachers to participate in the study. It has been tried to ensure that the teachers vary in terms of years of experience, teaching at different levels, and educational status. Each teacher was coded as T1, T2, …, T33.

Data Collection

It is aimed to collect the data of this study with a graphical literacy test. After the test was developed, the test was examined by an expert in the field. Then, necessary corrections were made, and the final version of the test was given. A pilot study was carried out in order to examine the clarity of the test and the scientificity of the questions. The pilot study was carried out with 11 teachers. Teachers were asked 10 open-ended questions including graphical literacy skills.

Graphical Literacy Test

There are 10 open-ended questions consisting of 15 sub-questions in the test. While preparing the questions, the levels of graph comprehension put forward by Curcio (1987) and Ozmen et al. (2020) have been considered. The questions were coded as Q1, Q2, …, Q10, and the sub-questions were coded as Q2a, Q4b. The graphical literacy levels of the prepared questions are shown in **Table 1**. When **Table 1** is examined, it is seen that there are two questions for reading the data level, 10 questions for reading between the data level, and nine questions for reading beyond the data level. In addition, when **Table 1** is examined, it is stated that two questions related to the reading the graph aspect, 10 questions related to the interpreting the graphs aspect, five questions related to the evaluating the graphs aspect, two questions related to the comparing the graphs aspect, and two questions related to the evaluating the graph were prepared.

Table 1. Information on the questions prepared for graphical literacy levels and aspects

Graphical literacy aspects	Graphical literacy levels	Questions
Reading the graphs	Read the data	Q1 & Q6a
Interpreting the graphs	Read between the data	Q3, Q2a, Q2b, Q2c, Q2d, Q2e, Q4a, Q5b, & Q6b
	Read beyond the data	Q4b
Drawing the graphs	Read between the data	Q5a
	Read beyond the data	Q7a, Q7b, Q7c, & Q7d
Comparing the graphs	Read beyond the data	Q8 & Q10
Evaluating the graphs	Read beyond the data	Q9 & Q5a

Sample questions and necessary explanations for each chart understanding level and aspect are shown in **Table 2**.

Table 2. Questions related to graphical literacy aspects and comprehension levels

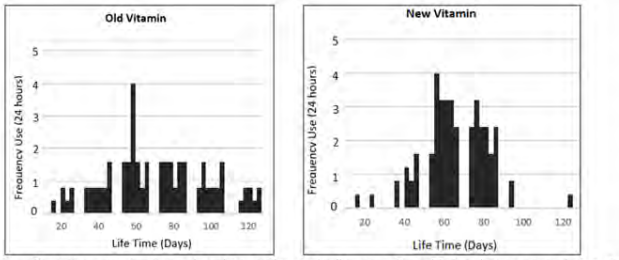
Aspects	Levels	Sample questions	Explanation
Reading the graphs	Read the data	Q3) Zeynep is thinking of investing with the money she has saved. However, she cannot decide how to make this investment. The chart below shows the change in foreign exchange, stock market, housing and land prices over 100,000 TL for the second half of the year. Accordingly, which investment tool should Zeynep choose? Explain your decision with reasons. 	Teachers are expected to present the investment instrument accurately and justify it with the right statistical case.
Interpreting the graphs	Read between the data	Q2)  The chart above shows the ratio of men and women living in some provinces. Put 'yes' no' and 'don't know' statements next to the statements given below according to the graph. a) 35% of women live in Trabzon. Y( ) N ( ) DK [ ] b) Within cities, it is more likely for a woman to live in Edirne than in Ordu. Y( ) N( ) DK[ ] c) Among the cities, people living in Edirne are more likely to be women than men. Y[ ] N[ ] DK[ ] d) The probability of a woman living in Edirne is 3 times the probability of a man living in Edirne. Y[ ] N[ ] DK[ ] e) 15% of men live in Ordu. Y ( ) N( ) DK[ ]	Teachers are expected to mark yes, no and unknown options correctly by reading and interpreting the data on the graph.
Drawing the graphs	Read beyond the data	Q7) The containers given below will be filled with water. For each container, draw the graphs showing the variation of the filling speed of the container with time and make comparisons on the graphs. 	Teachers are expected to draw each stage of the graph correctly.
Comparing the graphs	Read beyond the data	Q8)  The effect of a new vitamin produced for turtles on the life span of an old vitamin is compared. Out of 250 randomly selected turtles, 100 are given new vitamins and 150 are given old vitamins. Compare the old drug and the new drug in terms of its effect on life expectancy with the help of the graphs below.	Teachers should be able to say that the old vitamin is more effective by explaining the data in the graph.

Table 2 (Continued). Questions related to graphical literacy aspects and comprehension levels

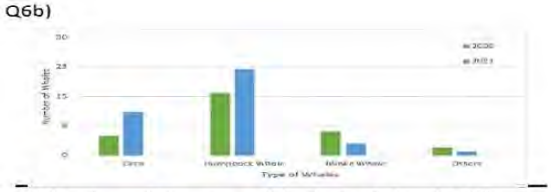
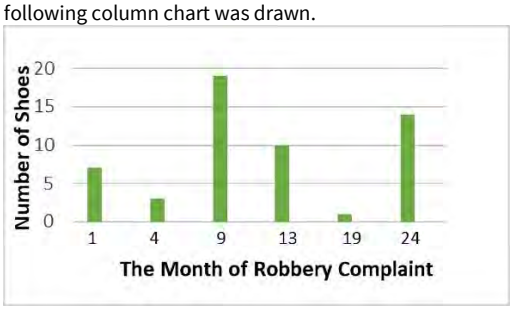
Aspects	Levels	Sample questions	Explanation
Evaluating the graphs	Read between the data	Q6b)  b) An environmentalist is more concerned about the change in the number of killer whales entangling the net from 2020 to 2021 than humpback whales. According to the data, why did the environmentalist express more concern for killer whales? Explain your answer with reasons.	Teachers are expected to justify the change in the question by expressing it with a ratio.

Table 3. Categorical scoring rubric and example answers

Questions	Scoring	Example answers
A store sells products of a company that produces suede shoes. The store manager determined that shoes were brought in with a complaint of peeling how many months after sale. These data were classified, and following column chart was drawn.  a) Using the graph, what can you say about the median and mode values of these data, respectively? b) In the first four months, only 10 shoes were brought back with the complaint of being robbed. If the average usage time of a shoe is considered to be six months, very few shoes came with the complaint of peeling before this period. Therefore, the shoes sold by the store can be considered qualified. What can you say about the accuracy of the inference of a customer who comments about the quality of the shoes? Explain your answer with reasons.	a) 2: Determining median & mode correctly 1: Specify any of median & mode correctly. 0: Both are incorrectly specified. b) 3: Interpreting the customer's inference based on different variables 2: Evaluating the quality of the shoe by considering the customer's inference, the mode value, or by analyzing the graph with some ratios and comparings 1: Indicating that the customer's inference is incorrect and of poor quality, do not explain, just do a general analysis of the graph. 0: Not responding, response based on personal opinion or prejudice	2: Median is 9, mode is 9. 1: Median is 13, mode is 9. 0: Median is 13, mode is 18 3: Looking at the graph, the first nine months came with the highest number of shoe peeling complaints. This makes us doubt its quality, but the graph only gives the distribution of the number of shoes with complaints by months. Without knowing how many shoes have been sold and how many complaints have been made, nothing can be said for sure. 2: The highest value in the graph, namely the mode, is in the 3rd month, so we can say that the quality of the shoes is not good. 1: It is of poor quality. In the first four months, 10 shoes came with the complaint of peeling. 0: Nike sales increase, Adidas decrease.

Data Analysis

The data were analyzed both quantitatively and qualitatively. Even though test scores are obtained as quantitative data, teachers' answers, justifications, and possible mistakes or misconceptions about the items are important to evaluate their graphical literacy. Therefore, quantitative data were used for descriptive analysis. The answers given by the students to the items were analyzed with a categorical scoring table. This scoring table was created in two steps. First, all possible answers were determined, and the categories were handled according to the degree of logic. The example coding procedure and answers were given at **Table 3**.

The maximum score that can be obtained from this test is 37. After the answers of the teachers were scored, the frequency and percentage distributions were calculated for each question, and the total scores were determined.

RESULTS

The questions prepared for the graphical literacy dimensions, the sum of the scores of the teachers from these questions, and the frequencies and percentages are shown in tables under each sub-title.

Results About the Reading Graphs Aspect

The analysis of the questions prepared for the reading of the graphs aspect is shown in **Table 4**.

Table 4. Distribution of teachers' scores for reading the data

Scoring		1		0	
Level	**Questions**	**Frequency**	**%**	**Frequency**	**%**
Reading the data	Q1	30	91	3	9
	Q6a	32	97	1	3

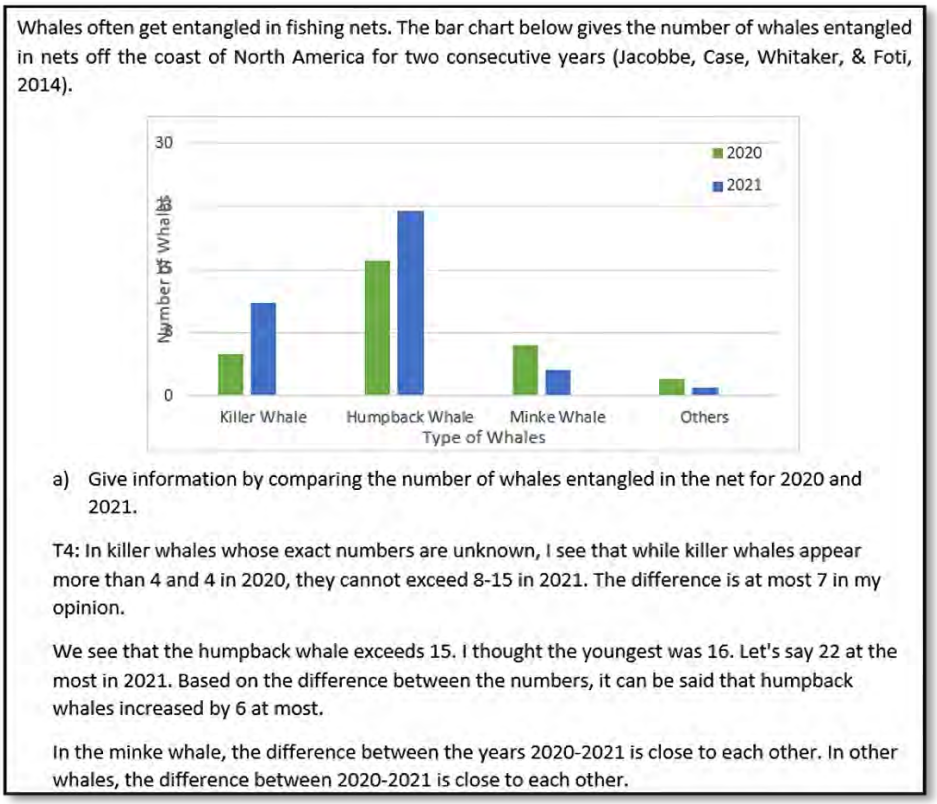


Figure 2. The answer is given by teacher T4 to question Q6a (Jacobbe et al., 2014)

Table 5. Distribution of teachers' interpreting the graphs scores

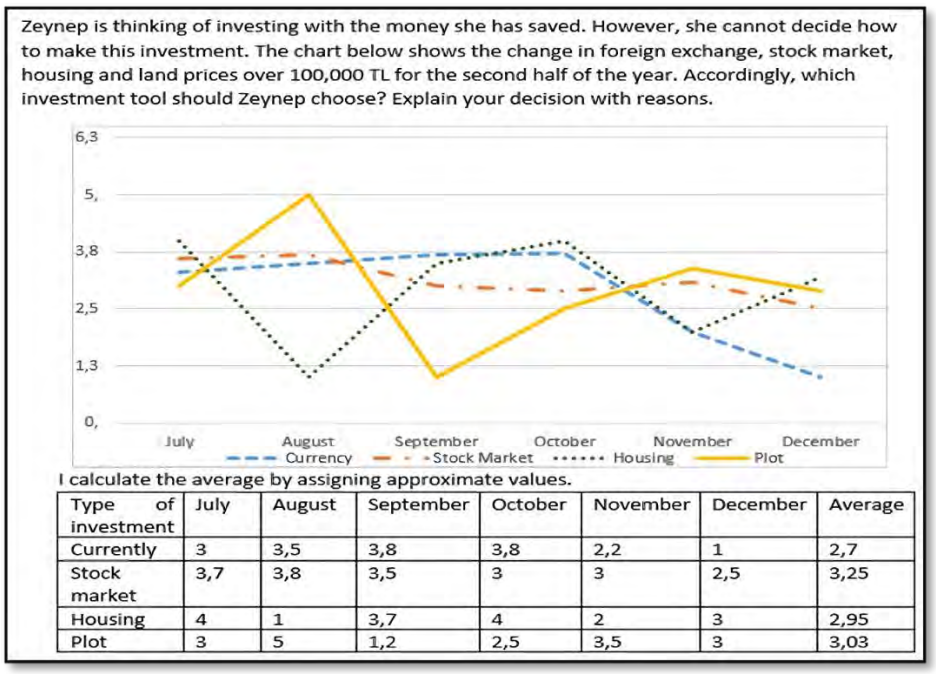
Scoring		3		2		1		0	
Level	**Questions**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Read between the data	Q2a					18	55	15	45
	Q2b					23	69	10	31
	Q2c					17	51	16	49
	Q2d					15	45	18	55
	Q2e					17	51	16	49
	Q3	5	15	17	52	1	3	10	30
	Q4a			20	61	7	21	6	18
	Q5b			10	30	14	42	9	28
	Q6b			18	55	8	24	7	21
Read beyond the data	Q4b	10	30	3	10	5	15	15	45

When **Table 4** is examined, it is seen that the teachers got 91% and 97% full points in questions Q1 and Q6a in the questions related to the reading the graphs aspect. Examined results show that teachers can easily give the correct answer to the questions related to reading the graphs. The answer to question Q6a of the teacher coded with Q4 for these questions is given in **Figure 2**.

Along with **Figure 2**, the answer of teacher O4 to question S6a is given. Since only the whale species were compared according to the data in the column chart in question S6a, this question was considered within the scope of reading the data level and reading the graphs aspect. Teacher T4 got a full point (one) for this question because he compared the whales both by years and among themselves. When examined in general, it is seen that 97% of the teachers got full points from the comparings. It is understood that the teachers reached the desired result by easily reading the data from the numbers in the column chart. The teachers were generally successful in this question, while the teachers who were missing were unsuccessful because they handled the comparings from one side. Since only comparings were made on the column chart, the teachers exhibited behaviour at the read the data level.

Results About Interpreting the Graphs Aspect

The analysis of the questions prepared for interpreting the graphs aspect is shown in **Table 5**.



Type of investment	July	August	September	October	November	December	Average
Currently	3	3,5	3,8	3,8	2,2	1	2,7
Stock market	3,7	3,8	3,5	3	3	2,5	3,25
Housing	4	1	3,7	4	2	3	2,95
Plot	3	5	1,2	2,5	3,5	3	3,03

Figure 3. The answer is given by teacher T7 to question Q3 (Source: Authors' own elaboration)

Table 6. Distribution of teachers' drawing the graphs scores

Scoring		**3**		**2**		**1**		**0**	
Level	**Questions**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Read between the data	Q5a			23	70	3	9	7	21
Read beyond the data	Q7a					6	18	27	82
	Q7b					11	33	22	67
	Q7c					12	36	21	64
	Q7d					7	21	26	79

When **Table 5** is examined, in terms of the highest level of response potential, questions Q2a with 69%, and Q4a with 61% come to the fore. These questions are followed by questions Q2a and Q6b with a rate of 55%. When the frequencies and percentages of the questions Q2a, Q2b, Q2c, Q2d, and Q2e belonging to the level of reading between the data are examined, it is determined that they concentrate on one point. It is seen that the questions Q4a, Q5b, and Q6b at this level concentrate on two points.

The rate of getting full points by the teachers in the questions belonging to the level of reading between the data is higher than the rate of leaving it wrong or blank. On the other hand, 45% of the teachers got low scores from question Q4b, which belongs to the beyond-data level. The answer to question Q3 of the teacher coded with Q7 for these questions is given in **Figure 3**.

When **Figure 3** is examined, it is seen that the teacher first created a table according to the given line chart and made comments on approximate values. Since it is necessary to make interpretations according to the line graph given in the question, this question was evaluated within the scope of the level of reading between the data and interpreting the graph aspect. Teachers were expected to present the investment tool correctly on this question and justify it with the correct statistical situation such as clarity. When the answer of teacher T7 is examined, it is understood that the teacher created a table with approximate values according to the line graph and included the average. In addition, it is understood that in the explanations he made at the bottom of the table, he tended to the one with the least clarity. Therefore, the teacher received full points (three) for including explanations in this question along with his reasons. When the percentages for this question are examined, it is seen that the teachers received two points with a rate of 52%. The majority of the teachers got two points because they made comments on the change in the line graph without mentioning the statistical concepts.

Results About Drawing the Graphs Aspect

The analysis of the questions prepared for the drawing of the graphs aspect is shown in **Table 6**.

When **Table 6** is examined, it is seen that the best-answered question with a rate of 70% in the questions related to the drawing the graphs aspect is Q5a, which belongs to the reader beyond the data level. On the other hand, it is noteworthy that teachers mostly gave wrong answers or left the question blank in questions related to reading between the data. Among these questions, it is seen that 82% of the questions were answered incorrectly or left blank as Q7a. Therefore, it is concluded that the teachers are more successful in the questions related to the reader beyond the data level in the drawing the graphs aspect. The answer to question Q7a of the teacher coded with Q12 for these questions is given in **Figure 4**.

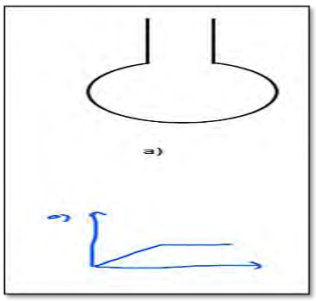


Figure 4. The answer is given by teacher T12 to question Q7a (Source: Authors' own elaboration)

Table 7. Distribution of teachers' comparing the graphs scores

Scoring		3		2		1		0	
Level	**Questions**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Read beyond the data	Q8a			14	42			19	58
	Q10	13	39	13	39	1	3	6	18

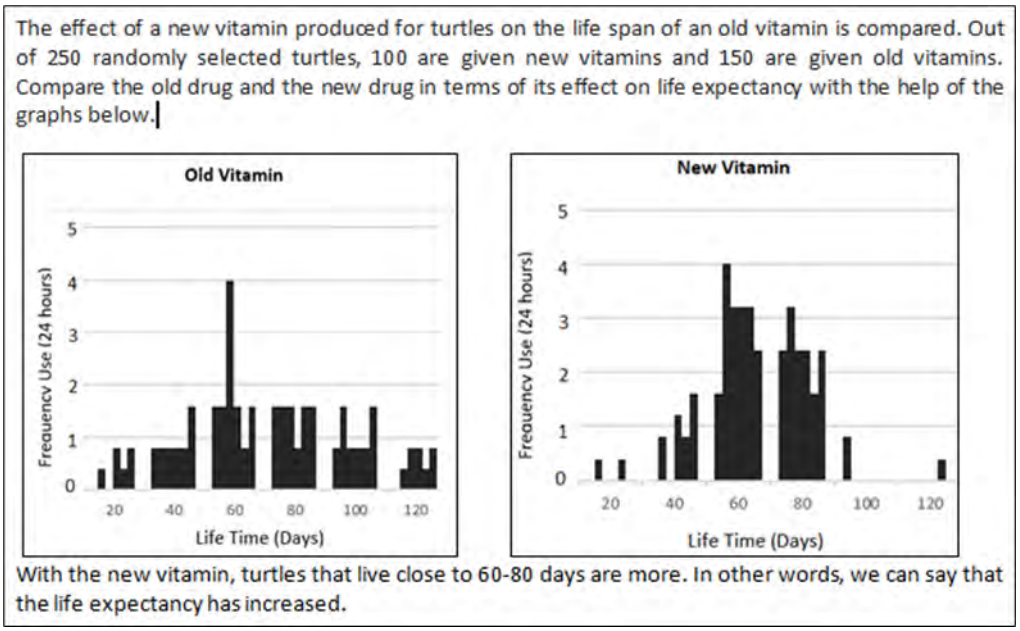


Figure 5. The answer is given by teacher T1 to question Q8 (Topan, 2019)

When **Figure 4** was examined, it was seen that the teacher created the desired graph of the figure in the wrong way. Therefore, the teacher received zero points for this question. When **Table 6** is examined, it is seen that the vast majority of teachers received zero points. Since the shape of the question whose graph is asked to be drawn is not smooth, it will affect how the lines in the graph should be drawn, so this question requires reading skills beyond data. In addition, since this question requires the drawing of a line graph for the given figure, it is considered within the scope of the drawing of the graphs. The fact that the teachers got low scores from the drawing of this graph shows that they have difficulties and therefore they are incomplete at the level of reading beyond the data. On the other hand, it is seen that teacher T12 did not name axes of the graph and did not pay attention to scaling.

Results About Comparing the Graphs Aspect

The analysis of the questions prepared for the comparing graphs aspect is shown in **Table 7**.

When **Table 7** is examined, it is seen that the teachers answered Q8 in correctly with a rate of 58% in the questions related to comparing the graphs aspect. In question Q10, it is seen that the majority of the teachers gave correct or partially correct answers. The answer to the teacher-coded Q1 to question Q8 regarding these questions is given in **Figure 5**.

When the question shown in **Figure 5** is examined, it is necessary to pay attention to how the data in the given graph is distributed and to be able to interpret it. Since interpreting the distribution of data requires higher level thinking, this question has been addressed at the level of reading the beyond data. In addition, since two graphs should be compared in this question, this question was evaluated within the scope of comparing the graph. Considering **Table 7**, it is seen that the majority of the teachers got zero points. When **Figure 5** is examined, it is seen that the teacher stated that the effect of the new vitamin on the lifespan is better than the graph given in the question. However, when the graphs are compared, it should be concluded that the effect of the old vitamin on life span is better. Thus, the teacher got 0 points for this question because he gave an incorrect answer.

Table 8. Distribution of teachers' evaluating the graph scores

Scoring		3		2		1		0	
Level	**Questions**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Read beyond the data	Q9	7	21	8	24	14	42	4	13

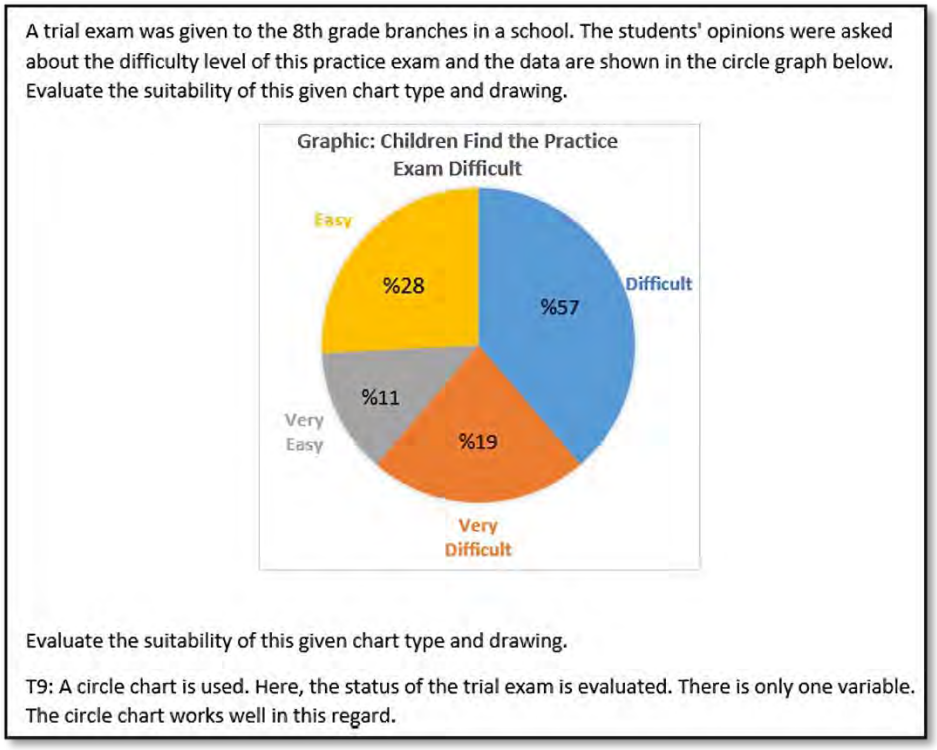


Figure 6. The answer is given by the teacher T1 to question Q9 (Source: Authors' own elaboration)

Table 9. The highest scores and scores obtained for the graphical literacy aspects

Level	Maximum scores	Score from the test	Percentage (%)
Reading the graphs	66	62	93
Interpreting the graphs	561	306	54
Drawing the graphs	198	85	42
Comparing the graphs	165	94	56
Evaluating the graphs	99	51	51

Results About Evaluating the Graphs Aspect

The analysis of the questions prepared for evaluating the graphs aspect is shown in **Table 8**.

When **Table 8** is examined, it is seen that the majority of the teachers got one point with a rate of 42% in question Q9. It can be said that teachers have more difficulties at this level, as the group that reads beyond the data requires more interpretation of the data. The answer to question Q9 of the teacher-coded T1 for this question is given in **Figure 6**.

In question Q9, it is expected that teachers will notice incorrectly given situations such as naming the circle graph and inconsistencies in the percentages specified in the graph. Therefore, teachers need to make evaluating the graph about graphs and read beyond the data in this question. However, when **Table 8** is examined, it is seen that the majority of teachers received one point. The reason for this was determined that the teachers did not adequately examine the information given in the question. When **Figure 6** is examined, the teacher did not pay attention to the erroneous situations of the circle graph in the question and only stated that this type of graph was appropriate according to the given situation. Therefore, the teacher got one point from this question because he only evaluated the graph type.

Comparings were made by calculating the scores and totals of the teachers for each question. First, the highest score that can be obtained from this test was calculated as 37. When the scores obtained were examined, it was seen that the teacher with the lowest score was T19 with 9 points. It was determined that the highest score obtained from the test belonged to T13 with 28 points. The highest score that can be obtained from the questions related to the graphical literacy aspects and the total score obtained from the test are shown in **Table 9**.

When **Table 9** was examined, it was seen that the teachers answered the questions related to *reading the graph aspect* in the best way with a rate of 93%. When the percentages were examined, it was determined that the dimension that the teachers had the most difficulty with was the *drawing of the graphs aspect* with a rate of 42%.

CONCLUSIONS AND DISCUSSION

When the results of the study are examined, it is seen that the teachers are more successful in the questions related to reading the graph dimension. In this case, it can be stated that teachers can directly read the data in the graph. Reading the graph dimension and read the data comprehension levels require a basic understanding of directly reading or expressing the data presented in the graph. The fact that these questions require more basic information may affect teachers' success in reading the graph and read the data comprehension. In similar studies, it is stated that teachers and students are more successful in questions that require reading the graph (Espinel et al., 2008; González & Pinto, 2008; Guler & Didis-Kabar, 2021; Ozmen et al., 2020; Patahuddin & Lowrie, 2019; Sezgin-Memnun, 2013; Wu, 2004).

It is seen that the teachers scored 54% for those categorized as 0 and 1 in the interpreting the graph questions, 55% for those categorized as 0, 1 and 2, and 49% for those categorized as 0, 1, 2, and 3. Therefore, it can be stated that teachers have moderate success with interpreting the graph questions. On the other hand, it is emphasized in studies that students have difficulties in interpreting graphs (Bursal & Yetis, 2020; Boote & Boote, 2017; delMas et al., 2007; Ozmen et al., 2020; Yun et al., 2016). At this point, it can be thought that teachers' deficiencies in interpreting the graph have an important effect on students' difficulties. Interpreting the graph questions asked to the teacher's include making estimations for the situations that are not directly given in the graph, and making calculations such as mode, median, and arithmetic mean. It was revealed that the teachers only made operations on the data in the graph, without considering the situations regarding the different variables in the graph. In other words, it was determined that teachers had difficulties reading between data on graphs. Espinel et al. (2008) emphasized that teachers could not present different interpretations for the information that is not directly given from the graph. In addition, for teachers to be moderately successful in questions about interpreting the graph and reading between data, the data should be read by associating them with each other rather than reading the data directly in such questions, they emphasize limited skills in their lessons, they use standard questions, they generally focus on reading the graph and they do not receive training in this direction. causes may have an effect. On the other hand, Bolche and Jacobbe (2019) stated that 48% of the students were successful in reading between data in questions about graphs. Contrary to these results, there are also studies in which students and teachers were successful in questions about the level of reading between data (Díaz-Levicoy, 2019; Monteiro & Ainley, 2007). As a reason for this situation, it can be shown that there are differences in the content of the questions that researchers apply to students and teachers. Another result that emerged from the findings of the study is that teachers were unsuccessful in interpreting the graph questions that require reading beyond data. It is an expected result that teachers who are moderately successful in reading between the data are unsuccessful in reading beyond data, which requires higher-level skills. Similarly, González and Pinto (2008) stated in their, carried out with prospective mathematics teachers that prospective teachers could not give correct answers to questions on reading beyond data. The failure of prospective mathematics teachers increases the probability of failure of mathematics teachers. In another study conducted for teachers, it is seen that results supporting the findings of this study emerged. Patahuddin and Lowrie (2019) emphasize that teachers' answers to interpreting the graph questions are not at the level of reading beyond data.

It is seen that teachers are unsuccessful drawing the graphs appropriately for the presented context. Similarly, Ozmen et al. (2020) point out that students' drawing the graph skills are insufficient. Bursal and Yetis (2020) also emphasize that students have skills in reading graphs but have more difficulty in drawing graphs dimension. In his study with students, Hotmanoglu (2014) underlines that students have difficulties in determining the starting point and scaling the axes while creating the graph. In this study, it was seen that the teachers did not pay attention to scaling while creating the graphs. Teachers' mistakes in this direction may also be effective in students' experiencing these difficulties. In addition, the absence of a course under the name of direct graphical literacy in the pieces of training teachers receive and the emphasis on reading and interpreting rather than the drawing of graphs in our daily lives can be considered as the reason for this failure in teachers. In the study, it is noteworthy that the teachers preferred the circle graph instead of the column graph when determining the appropriate graph type. Similarly, Rouan (2002) stated that teachers had difficulties in determining the type of graph in data representations. This may be an indication that teachers focus on common ideas (such as creating a circle chart if there is a percentage) without considering the context when choosing the chart type.

When the answers given by the teachers to comparing the graph questions are examined, it is seen that instead of making comparisons related to the context, they stated short answers according to personal thoughts or without providing a reason. When the teachers compared the two graphs, it was revealed that they usually read the data directly in the graph and make comparings based on the physical structure of the graphs without associating the data. Similarly, Watson (2006) emphasizes that students compare the graphs according to their appearance without giving any reason. In addition, it is seen that teachers make comparings for only one situation without considering different situations while comparing the graphs. However, in question S8, teachers are expected to make comments depending on more than one variable such as frequency of use and life expectancy. It is noteworthy that more than half of the teachers did not answer this question at all or gave wrong answers. From this, it can be stated that teachers cannot perform read beyond the datas for these questions.

When the answers of the teachers to the evaluating the graph questions are examined, it is seen that they are unsuccessful in realizing the errors in the graphs and determining the appropriate graph type for the context. Similarly, Wu (2004) emphasizes that while students have any difficulty solving the questions asked about graphs, which require any procedural steps there is a failure in evaluating graphs. Likewise, Ozmen et al. (2020) draw attention to the fact that the students could not identify the incorrect graph types and the errors in the graph. In this study, it was expected that a graph given by the context would be evaluated within the scope of different variables by the teachers. More than half of the teachers presented either incomplete or incorrect evaluations. According to this result, it can be stated that teachers have difficulties in performing read beyond the data levels for

such questions. It is thought that these difficulties are caused by the fact that teachers give less place to evaluating the graph questions in their lessons since they are not included in the curriculum. Arteaga et al. (2015) emphasize that teachers are unsuccessful in reading beyond data because making sense of real-life context requires a conceptual understanding competently. Patahuddin and Lowrie (2019) related that teachers' success in read the data questions compared to inter-data and read beyond the data questions is that read the data questions require less cognitive demand. These studies show parallelism with the results of this study.

The difficulties experienced by both teachers and students are closely related to the graphical literacy skills of individuals living in society. For this reason, it is important to develop the graphical literacy skills of teachers who direct the teaching of students. Rouan (2002) stated that there are inadequacies in teachers' understanding of graphs. According to other studies and the results of this study, it is thought that it will be important to include activities that will improve graphical literacy skills in teachers' in-service or pre-vocational training. Watson (2006) drew attention to the importance of considering not only the errors in the graphs but also the issues such as creating graphs and emphasizing the importance of scaling in the planning process of curricula and instruction. The deficiencies in these skills of teachers also affect their absence during teaching. Emphasis on teachers' shortcomings is also a result of teachers' training in graphs. Friel et al. (2001) emphasize the importance of teachers knowing how to increase their skills in graphs and how to implement effective graphs teaching. For future research, it may be recommended to monitor the change in teachers' graphical literacy skills at the end of training given to teachers in this direction. In addition, only middle school mathematics teachers are included in the research group of this study. In another study, it is thought that the selection of mathematics teachers working in both middle and high schools as a sample, examining the teaching given in undergraduate education, and the studies to be carried out on the classroom graphs teaching practices of the teachers may contribute to the investigation of the reasons for these difficulties experienced by the teachers.

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