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An investigation of preservice physics teachers' use of graphical representations

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Abstract

Graphs are very important types of representations in mathematics and science and they are seen as different kind of communication tools and a source for student learning of science. The purpose of this study is to investigate preservice physics teachers' use of graphs. First, the written test that includes tasks related to graphing skills applied to preservice physics teachers. Then clinical interviews are made with selected students. In written test students are asked to read and interpret graphs, to formulate algebraic equations of the graphs, to construct graphs of algebraic function rules, to comprehend informations depicted in graphs.

Keywords: Graphical representations,preservice physics teachers, science education;

1. Introduction

Graphics, which are a kind of mathematical expression, are used as tools in many different disciplines in visualizing verbal expressions. Graphs are important for two main reasons, they are a useful way of summarizing data and they communicate information in a way easy to interpret (Kali, 2005). Instructional programs emphasize that students should gain graphing skills, especially interpreting and constructing graphical representations. Using graphs in problem solving process for visualising problem solutions, summarizing data, interpreting relationships between variables are the objectives of the secondary physics curriculum.

Students' understanding of graphical representations is related to their mathematical understanding and it is a crucial skill to construct graph of an algebraic function rule or to formulate the functional equation represented in a graph. Studies have indicated that students have limited understanding in graphs and they cannot apply the graph knowledge from mathematics class to physics or other subject areas (McDemott Rosenquit&Van Zee, 1987; Mevarech & Kramarsky, 1997; Leinhardt,Zaslavsky&Stein, 1990). It would be better if students learned how to use graphs during the high school years so as to facilitate their understanding and use at the college level, especially for physics majors (Bektasli, 2006). But it is observed that in classrooms students don't communicate with charts, graphs or schemes and they greatly improve their oral expression (Sánchez et al., 2009). It is widely accepted that the effective use of graphics which is considered as being able to read a graphic; to locate specific information within a graphic; to create graphics to organize information; and to communicate to others through the use of graphics should be taught (Coleman et al., 2010). Lemke (1998, 2003) indicates scientific language does not only comprise the verbal language, the words and terms also scientists use diagrams, pictures, graphs, equations, tables, charts and other forms of visual and mathematical expressions. But it is concluded that in classrooms students don't

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communicate with charts, graphs or schemes and they greatly improve their oral expression (Sánchez et al., 2009). As the physics curriculum emphasizes the importance of graphical representations in summarizing and analyzing data in problem solving process, teachers should create situations for students to give them the opportunity using graphs in classrooms. So the graphing skills of preservice physics teachers are important and there is need for studies investigating preservice teachers' graphing skills, their difficulties with graphs and the source of these difficulties.

The purpose of this study is to investigate preservice physics teachers' use of graphs, their difficulties in interpreting and constructing graphs and the transition from verbal or algebraic descriptions to graphical representations. The study is conducted in two phases. First, the written test that includes tasks related to graphing skills, applied to preservice physics teachers. Then clinical interviews are made with selected students. Researches indicates the need of studies that investigates students' graphing skills and their use of graphs in different contexts and using clinical interviews may provide richer insight into understanding of how they conceive graphs (Mevarech & Kramarsky, 1997). The written answers of students analyzed by the researchers and then individual interviews are conducted with the selected participants. In these interviews students are asked to explain their answers and they are asked additional questions to have an insight into their reasoning process.

2. Method

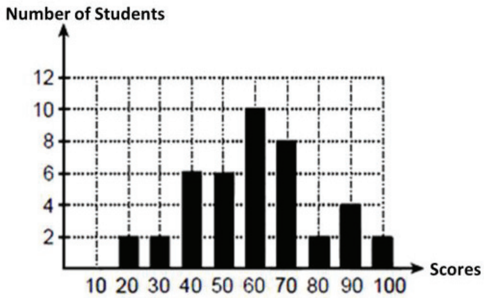
This study is a descriptive one which aims to present the existing graphics drawing, reading and interpretation skills of prospective physics teachers.

2.1. Study Group

The study group consists of 22 freshmen who are enrolled in the Department of Physics Education at a state university in Ankara. These students were selected as the study group since they have recently taken the general mathematics course, and they have recently started their academic life as university students.

2.2. Data Gathering Tool

A "Graphics Skills Determination Test" was developed by the researchers in order to elicit prospective teachers' graphics skills. The test consists of open-ended questions that include the interpretation of graphics and the graphics drawing activities related to the functions in the test. The appropriateness of questions for the students' levels and for the aim, as well as for the scientific correctness of these questions were presented to field experts in order to prove the validity and the reliability of the test. One of the examples of a such-designed open-ended question is as follows:



In the graphic on the left, the distribution of grades taken in the exam of a course according to the number of students is given. Students who get 60 and over are considered successful.

Figure 1: An example of an open-ended question

Prospective teachers were asked to interpret this graphic, and then they were asked two questions related to the information given in the graphic.

2.3. Data Analysis

The answers of prospective teachers were examined very carefully by the researchers. The mistakes in the answers were categorized under two headings, namely, as correctible and uncorrectable answers. In accordance with this categorization, 7 prospective teachers with correctible mistakes were taken into interviews. During the interviews, prospective teachers were re-asked the same questions they have answered incorrectly, and they were also asked to voice their views out loud, where it was deemed necessary by the researchers. By so doing, it was aimed to determine the source of the mistakes.

3. Findings

3.1. Findings Related to the Graphics Drawing Skills of Prospective Teachers

When the tests done by the prospective teachers were examined, it was seen that their knowledge of graphics drawing is insufficient. For example, an incorrect drawing related to the function of y= x – [|x|] and the real graphic of the function are given below:

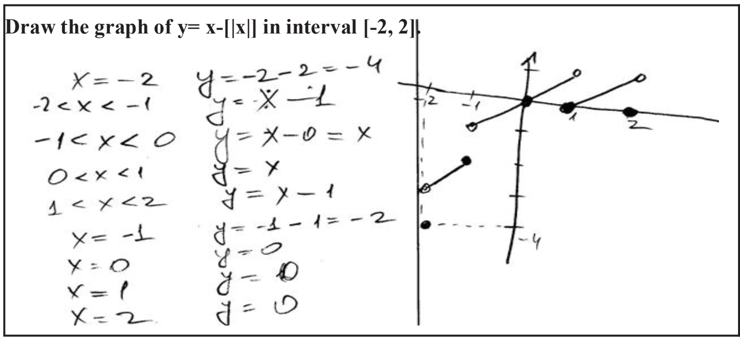


Figure 2: An example of the incorrect graphic drawing of the prospective teachers

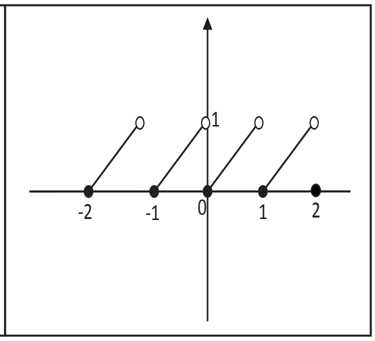


Figure 3: The graphic of the function of y= x – [|x|].

Similar mistakes were found in the graphic reading and interpretation activities. In the example given below, it is noteworthy that a prospective teacher cannot explain the graphic although he/she recognizes the function belonging to that graphic. This case is considered as a problem related to the graphics reading skills.

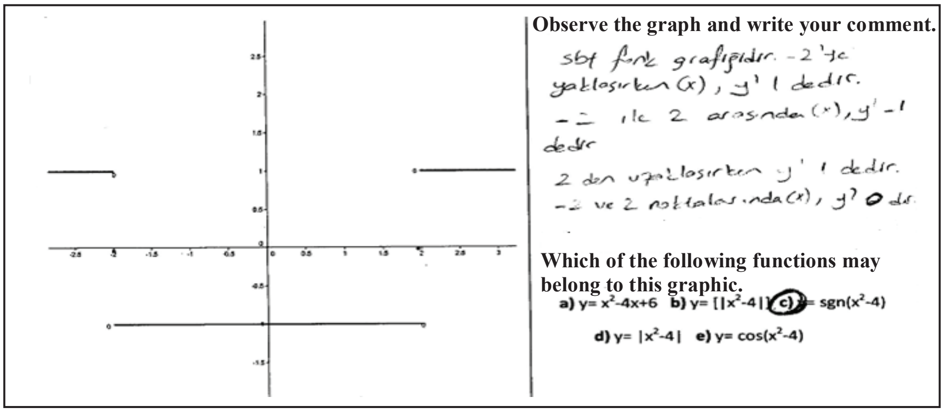


Figure 4: An example of a Misreading of the Graphic

The following can be given as an example to the problematic faced in graphics interpretation skills. In this example, it was observed that only 8 students out of 22 could answer the question related to the graphics given in Figure 4. One of the incorrect answers given to the question "Under the light of the information given in Figure 4, what degree is the central angle of the segment which shows the import value of the year 2003 in the graphic which shows the import of 6 years in a circular region?" is given in Figure 5:

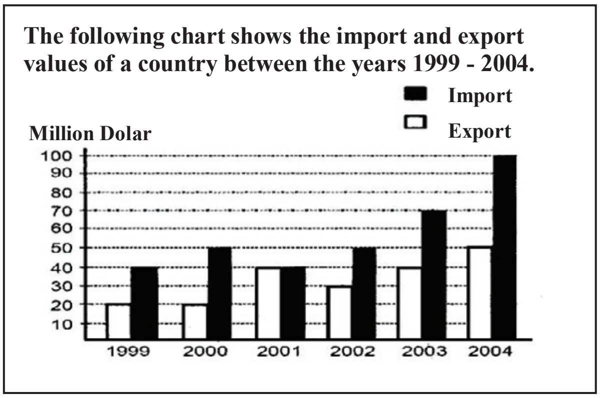


Figure 5: Question Graphic Related to Graphics Interpretation Skills

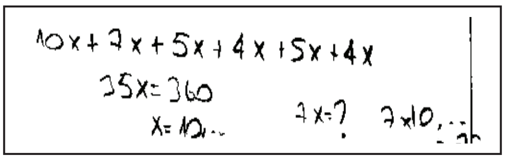


Figure 6: An Incorrect Answer Related to Graphics Interpretation Skills

3.2. Findings Related to the Interviews Done with Prospective Teachers

In line with the answers they have given to the graphics drawing and interpretation questions, 7 prospective teachers who were noted to have distinct problems in graphics drawing and interpretation were taken into interviews. During the interviews, they were asked to draw the graphic of a given function, and they were also asked to comment on a function whose graphic was given, in other words, they were asked to interpret the graphic.

Prospective teachers first tried to draw the graphic of y= x- [|x|]. While doing this, they were asked to think out loud and to check the graphic they have drawn. When they faced with difficulties, the researchers interfered by giving necessary guidelines, and this process was video-taped. After the application, when the visuals and the drawings were examined, the most striking point is that the y=x line, for example, was shown as a point in the analytic plane. Moreover, it was also seen that, in relation to this example, while students knew that the greatest integer function should have been examined on the interval, they also thought that this was true for all variables in the function. For example, in the [-2, -1] interval, thinking that [|x|] = 2, and x=2 for the function of y= x- [|x|] resulted in y=0. Because all the calculations were done accordingly, the value of y in the whole graphic was calculated as 0. Thus, students ended up with an erroneous drawing given below (Figure 7). After the necessary warnings and reminders, students were able to correct their mistake, and revise their calculations. As a result, the graphic of the function became as shown in Figure 8:

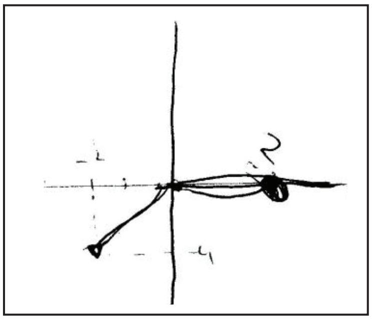


Figure 7: Incorrect Drawing Belonging to the Graphic of the Function

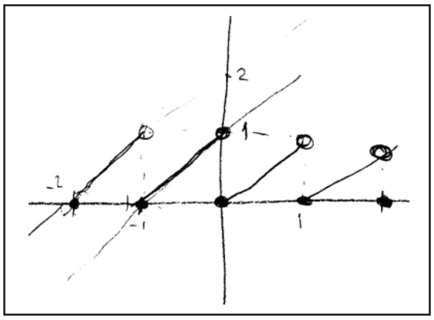


Figure 8: Drawing Made during the Interview Process

In the process given above, prospective teachers were asked to describe their graphic drawing steps in order to determine the reasons of the difficulties prospective teachers have faced. As a result of the statements taken from students, it was revealed that they had difficulty seeing the different movements that a graphic shows at different intervals, and that they worked on a particular part of the line instead of the whole. Another finding from the interviews is that students could not determine the values a function takes at points which are not part of the interval.

Another skill focused on during the interviews is "graphic reading." In this regard, students were asked to interpret the given graphic, and to determine the functions which they think to belong to the graphic. It is noteworthy that students interpreted the range of the function, which they thought to have belonged to the graphic, as a closed interval. On the other hand, the following mistakes were done during the interpretation of the graphic:

- Students thought that the graphic cannot belong to an absolute value function because they thought that the graphic of an absolute value function should be on the x-axis (This case would be invalid for the absolute value function of y= |x|-4 or for the absolute value function of x depending on y).
- They thought that a graphic as such could only belong to a quadratic function (However, curvilinear functions may not always be quadratic)
- There is confusion about the possibility that this function may be a trigonometric function. For example, for the graphic of the y=tanx function, students realized that there should be asymptote values, and they showed this values as x=0 and x= π. In addition to this, prospective teachers indicated that the 30° and 60° angle values make the the function of y=tanx undefined. Likewise, another difficulty in this process was

that sutdents could not predict the new graphic which would be formed after changing the coefficient of the expression (e.g. y=3sinx) or changing the angle value (e.g. y=sin x^2) in a given trigonometric expression (e.g. y=sinx).

4. Conclusion and Suggestions

This study was done in order to examine the graphic skills of prospective physics teachers under different headings. To this end, the graphic skills of prospective teachers were gathered under the headings "drawing, reading, and interpretation" and to what extent they are competent in these skills were determined. When the results of the test of determining the graphic skills was examined, it was seen that graphic skills of prospective teachers are low. This was induced from the fact correct drawings were scarce in questions related to graphic drawing. Due to the detailed examination in the interviews, it can be said that this stems from the insufficiency of their basic graphic skills. The fact that prospective teachers had difficulty in showing the basic elements such as a point and aline on the analytic plae proves that they would face more difficulty in drawing the graphics of more complex functions.

When the graphic reading and interpretation skills of prospective teachers were examined, similar results to graphic drawing were found. It is noteworthy that students cannot identify the general characteristics of the graphic, they act merely upon the points which cut the axis, they cannot guest the movement of the graphic, and they cannot observe the increase or the decrease. One of the reasons for this can be said to be the result of the fact that prospective teachers have a question-oriented focus instead of a solution-oriented one. The most obvious proof for this may be the fact that they concentrate on the functions given in the question instead of observing the graphic given in the question.

The importance of the use of graphics in the field of physics have been noted in many studies (Kohl & Finkelstein, 2006; McDermott et al, 1987; Aydin, 2007). Thus, improving the skills of the use of graphics is of utmost importance for the students in this field. Such an improvement is possible only when necessary pre-knowledge is completed and when basic knowledge is sufficiently provided. Determining the already-existing skills of students through both in-class and extra-curricular activities can be the first step of this process. In addition to providing basic theoretical knowledge, students may find ample application and self-evaluation opportunities with the help of computer-aided graphic drawing programs.

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