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Procedia - Social and Behavioral Sciences 46 (2012) 2937 – 2941

Procedia
Social and Behavioral Sciences

WCES 2012

A study of pre-service science teachers' graphing skills

Didem Kilic [a] *, Nazan Sezen [b], Meltem Sari [b]

[a]Faculty of Education, Aksaray University, Aksaray, 68100, Turkey
[b]Faculty of Education, Hacettepe University, Ankara, 06800, Turkey

Abstract

Teaching students how to read, to interpret and to construct graphs is a substantial educational object and it is also concluded that the students who can read graphs acquire additional capabilities, which will become more useful in science education. In the present study, it is aimed to investigate pre-service science teachers' graphing skills and to determine their difficulties in reading and interpreting graphs. The study was carried out with 128 pre-service science teachers. Multiple-choice test items and open-ended questions were used to evaluate graphing skills of pre-service teachers. As a general result of study graph reading and interpretation skills of pre-service teachers are inadequate and also their graphing performances vary depending on the type of graph.

Keywords: Pre-service teachers, graphing skills, science education.

1. Introduction

Graphs are the most frequently used visual tools while they allow summarizing sets of data and representing complex relationships between variables effectively. According to Shah and Hoeffner (2002) one of the reasons graphs are so pervasive is that they seem to make quantitative information easy to understand. Furthermore graphs can be read and understood more easily and quickly than the same data presented in prose. Reading and interpreting graphical representations requires mathematical thinking and visual perception, therefore graphs are seen as mathematical tools. But graphs are not only used in mathematics they are also widely used in other subject areas such as social sciences (psychology, sociology, etc.), statistics and science (biology, physics and chemistry) to represent and interpret relationships (Özgün-Koca, 2008).

In science education the role of graphic and symbolic representations as essential tool is well established and there is growing consensus on their didactic advantages (Testa et al., 2002). Taşdemir et al. (2005) indicates that graphs serve as concrete materials in science education for enhancing students' understandings of scientific concepts and relationships, constructing conceptual framework and summarizing the subject matter. According to Kali (2005) graphs feature among the science process skills, both in the basic process skills (e.g. communicating could be by means of graphs to explain and relate ideas and information), and in the integrated process skills (e.g. interpreting data could involve organizing data in a graph and drawing conclusions from it).

* Didem Kılıç. Tel.: +90-382-288-2257
E-mail address: didemk@hacettepe.edu.tr

 doi:10.1016/j.sbspro.2012.05.593

Because of the widely use of graphs in science textbooks (Testa et al., 2002; Shah & Hoeffner, 2002) and the emphasis on ability of using graphs as communicational tools in science curriculum, students' graphing skills becomes more important. Graphing skills are required of both teachers and students: science teachers need to be able to manage different kinds of representations and images, while students have to acquire several skills in order to exploit the potential offered by reading such images (Testa et al., 2002). Being able to interpret and construct graphical representations is a crucial skill for students (Özgün-Koca, 2008). Teaching students how to read, to interpret and to construct graphs is a substantial educational object and it is also concluded that the students who can read graphs acquire additional capabilities, which will become more useful in science education (Testa et al., 2002).

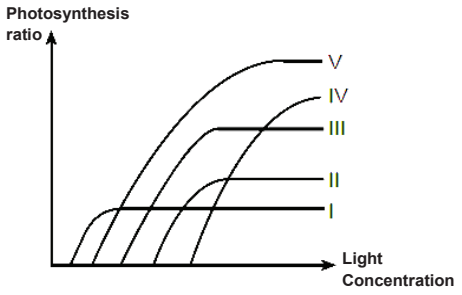
Although graphs have a considerable importance in teaching and learning of different topics, researches show that students have difficulties in reading, interpreting and comprehending information depicted in graphs (McDermott et al., 1987, Leinhardt et al., 1990; Shah & Hoeffner, 2002; Testa et al., 2002; Kali, 2005). McDermott et al. (1987) investigated students' difficulties in connecting graphs and physics. They described the two main categories of student' difficulties as difficulties in connecting graphs to physical concepts and difficulties in connecting graphs to the real world. Similarly Körner (2005) stated that students fail to integrate visual and conceptual information. According to a general result of the researches, students think graphs as pictures or photographs of the objects without considering they are as an abstract representation and they can not distinguish the shape of a graph (Aydın, 2007). Several studies have pointed to students' tendency to see only the marked points on a graph. Also students typically use graphs in much the same way as they use tables –to look up specific pieces of information (Leinhardt et al., 1990).

Teachers' effective use of graphical representations in their lessons can promote students' understandings of graphs by giving them opportunities working with different types of graphs. From this point of view pre-service teachers' graphing skills and their use of graphical representations becomes important. In the present study, it is aimed to investigate the pre-service science teachers' graphing skills. Through the examination of pre-service teachers' graphing skills, their difficulties in reading and interpreting graphs can be determined and consequently possible implications for overcoming these difficulties can be generated.

2. Method

As the study aims to evaluate the graphing skills of the pre-service science teachers, a descriptive study designed to determine the existent state. Employing qualitative and quantitative research data collection tools, the study was carried out with the participation of 128 pre-service science teachers. Of the participants, 41 (32%) are first-year students, 39 (30.5%) are second-year students, 24 (18.8%) third-year students and 24 (18.8%) are fourth-year students. 15 multiple-choice test items were used to evaluate the graphing skills of the pre-service teachers. These test items were selected from among the questions asked in Student Selection Examinations to access higher education that applied between 2000-2010 years, also 2009 and 2010 The Entrance Examinations for Graduate Studies, which were developed and applied by Higher Education Council Student Selection and Placement Center. The selected test items are appropriate for determining the graphing skills of the students and cover the topics from the fields of physics, chemistry and biology and also general ability. Test items include different graph types as line graphs, bar graphs, histograms and pie charts. Moreover, in order to elicit how the pre-service teachers think while reading graphs and how they approach the questions relating to graph reading, the participants were asked to write the data they had read from the graph while responding to each test item and explain the stages of operations in their responses. Some sample items used in the study are presented in Figure 1.

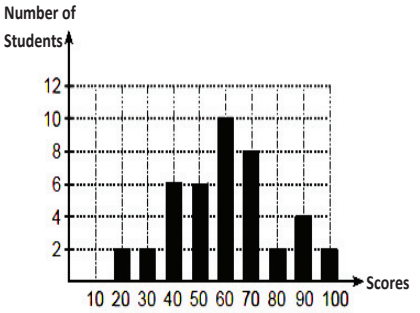
The pre-service teachers' responses were evaluated on two stages. On the first stage, frequencies and percentages were calculated for the responses given to multiple-choice test items. In addition, one-way ANOVA was carried out to determine whether there are significant differences based on grade level among the test mean scores of the pre-service teachers. On the second stage, descriptive analysis of the pre-service teachers' responses to the open-ended questions was carried out and in this way, the graph types in which the pre-service teachers have greater success in reading and interpreting and the difficulties they often encounter while reading graphs were determined.



The curves on the graph show the changing rates of photosynthesis according to the intensity of light regarding five plants.

- Accordingly, the curves numbered I, II, III, IV and V which belongs to the plant that needs more light?

a) I b) II c) III d) IV e) V



The graph shows the distribution of test scores according to the number of students. Students who had a score of 60 and above are considered to be successful.

- How many students have been successful in this course?

a) 18 b) 20 c) 22 d) 24 e) 26

- What is the mean score of students who failed this course?

a) 35 b) 37,5 c) 40 d) 42,5 e) 45

Figure 1. Sample of items

3. Results

The scores that can be taken from the multiple-choice test used in the study ranged from 0 to 15, the lowest score to be obtained from the test was 1 and the highest score was 13. The mean score of the pre-service teachers was found to be 6.02. This mean score showed that the test scores of the most pre-service teachers were low. Frequencies and percentages of the correct responses of the pre-service teachers to 15 multiple-choice items are presented in Table 1.

Table 1. Frequencies and percentages of the correct responses to multiple-choice items

Item	*f*	%	Item	*f*	%
1	44	34.4	9	17	13.3
2	121	94.5	10	4	3.1
3	69	53.9	11	15	11.7
4	102	79.7	12	49	38.3
5	35	27.3	13	58	45.3
6	51	39.8	14	83	64.8
7	57	44.5	15	37	28.9
8	29	22.7			

As can be seen from Table 1, the pre-service teachers' rate of giving correct answers to the test items varies between 3.1% and 94.5%. The pre-service teachers' lowest rates of giving correct answers were obtained for the items 9, 10 and 11, which were general ability questions where a bar graph was used. It was understood that as the pre-service teachers were not able to correctly read the graph given for these items and hence, they could not answer or gave wrong answers to these items. The highest rates of correct answers were obtained for the items 2 and 4, and these items included biology and chemistry questions in which line graphs were presented. When the rate of correct

responses to the items was analyzed according to the type of the graph, it was seen that the highest success was obtained for line graphs and they are followed by histograms, pie charts and bar graphs, respectively.

When the mean scores taken by the pre-service teachers from the test were investigated in relation to their grade level, the mean score of the first-year students was found to be 5.54, the mean score of the second-year students was found to be 5.79, the mean score of the third-year students was found to be 6.38 and the mean score of the fourth-year students was found to be 6.88. From these results, it is seen that with the increasing grade level, the scores taken from the test also increase. One-way ANOVA was conducted to determine whether the difference found among the test scores of the pre-service teachers is significant. As a result of the variance analysis, it was found that the difference stemming from the grade level among the test scores of the pre-service teachers is not significant (F = 2.022; p >.05) (Table 2).

Table 2. Results of one-way ANOVA on test scores of pre-service teachers regarding grade level

	Sum of Squares	*df*	Mean Square	*f*	*p*
Between groups	32.126	3	10.709		
Within groups	656.804	124	5.297	2.022	.114
Total	688.930	127			

When the responses given by the pre-service teachers for the test items requiring them to explain the data presented on the graphs in written form were analyzed, it was understood that the pre-service teachers had difficulties in explaining the data. It was observed that many of the participants did not make any explanations. And the explanations made, on the other hand, include erroneous or deficient interpretations. One of the common mistakes committed by the pre-service teachers while interpreting a graph was the confusion of X axis with Y axis and vice a verse. This leads to interpretation of a graph in the opposite direction. It was also found that the pre-service teachers do not pay much attention to the variables stated on the axes and they rather focus on the figures on a graph. Moreover, some pre-service teachers were confused about the colors and dragged areas on figures and hence, misinterpretations occurred. As another result of the study, it was observed that while the pre-service teachers were responding to the questions, they made various markings on the graphs. It was understood that these markings helped them to solve the graphical data. Also it was indicated that some of the pre-service teachers attempted to explain the data on the graphs by tabulating them. In responding to some items, it was observed that though the data on the graphs were correctly explained in the written form, what they holistically mean could not be interpreted. In the same manner, the pre-service teachers only considered some of the data presented on the graphs rather than all of the data on them, which led to some misinterpretations.

When the responses to the multiple-choice items and open-ended questions were evaluated together, one of the remarkable results found was that though multiple-choice questions were responded correctly, their corresponding expressions in the written form included many erroneous interpretations. This shows that some of the pre-service teachers read the data on the graphs correctly, but they had some difficulties while expressing the data on the graphs in the written form. On the other hand, when a pre-service teacher expressed the data on the graphs accurately and correctly, she/he did not make any mistakes while responding to the corresponding multiple-choice questions.

4. Discussion and recommendation

The findings of the present study investigating the graphing skills of the pre-service teachers revealed that the graph reading and interpretation skills of the pre-service teachers are inadequate. On the other hand, though the difference is not significant, the graphing skills of the pre-service teachers become more improved with the increasing grade level. This may show that the graphing skills of the participants which they have already acquired at secondary level, as a result of the training they are exposed to at university developed. It is of great importance for students and teachers educating them to have graph reading and interpretation skills and to improve them because graph reading and interpretation skills are not only important in the fields of mathematics and science but also for individuals to understand and comprehend graphical representations in the media in relation to social issues. Therefore, it is suggested that more detailed researches should be carried out to investigate the difficulties

encountered by students and pre-service teachers in graph reading and interpretation skills and these researches may focus on the effects of different teaching methods and techniques on graph reading and interpretation skills. Given that there are some studies reporting positive effects of computer-based activities on developing students' skills related to graphical representations (Kwon, 2002), the use of software programs allowing the drawing and interpretation of graphical representations should be encouraged in instructional programs. Also as suggested by (Ozgun-Koca, 2001) instructional programs should enable all students to use representations to model and interpret physical, social and mathematical phenomena.

Another result of the present study was that the pre-service teachers' graphing performance may vary depending on the type of the graph. Hence, it can be suggested that the pre-service teachers should be provided with opportunities to make transitions from one graph type to another in order to improve their graph reading and interpretation skills for all graph types.

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