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Procedia - Social and Behavioral Sciences 46 (2012) 2942 – 2946

Procedia
Social and Behavioral Sciences

WCES 2012

Investigating students' abilities related to graphing skill

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Abstract

Graphs as representational tools are very important in all disciplines especially in mathematics. They are useful for summarizing sets of data, obtaining and interpreting new information from complex data. The purpose of this study is to investigate pre-service mathematics teachers' graphing skills. The participants are 32 pre-service mathematics teachers from a public university. Graphing tasks and questions corresponding to the interpreting, modeling and transforming components of the graphing skill (Kwon, 2002) were used in gathering written data and interviews conducted with selected participants. It is concluded that students have problems in modeling and transforming tasks but they can extract information from graphs so they are better in interpreting tasks.

Keywords: graphing skill, modeling, interpreting, transforming, preservice mathematics teachers.

1. Introduction

Graphs have been considered as fundamental part of mathematics and instructional programs emphasize that graphing skills of students at all levels should be improved. Graphs are useful types of representation for summarizing sets of data, obtaining and interpreting new information from complex data. They are seen as mathematical tools because communicating through graphical representations requires mathematical competencies such as visual perception, logical thinking, plotting points from data or from a function rule, predicting the movement of the line connecting points, deducing the relationship between variables etc. Although graphs are so important in mathematics many studies indicate that students' have problems in using, interpreting, reading and constructing graphical representations (McDermott, Rosenquist&Van Zee, 1987; Leinhardt, Zaslavsky&Stein, 1990; Mevarech&Kramarsky, 1997; Shah&Hoeffner, 2002; Özgün- Koca, 2008). Graphs provide an invaluable aid in solving arithmetic and algebraic problems and representing relationships among variables, display mathematical relationships that often cannot be easily recognized in numerical form (Ersoy, 2004). Because of these advantages graphs should be effectively used in instruction and teachers should design learning environments that supply students' understanding of graphical representations and improve their graphing skills.

Mevarech&Kramarsky (1997) state graphing involves both interpretation and construction. Interpretation usually refers to graph reading and gaining information from it. Construction refers to build a graph and involves labeling of axes, plotting points, predicting the movement of the line connecting the plots. Leinhardt et al. (1990) explained construction requires generating new parts that are not given but interpretation relies on a given piece of data. Kwon

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1877-0428
doi:10.1016/j.sbspro.2012.05.594

(2002) identifies three components in graphing skills: interpreting, modeling and transforming. Interpreting is the ability to translate from graphs to verbal expressions and to extract information from graphs. Modeling is an ability to translate from real-world situations to graphs. Transforming is an ability to see and draw a variety of graphs depicted events and this component integrates both interpreting and modeling (Kwon, 2002). In this study graphing skill is considered as defined by Kwon (2002) and students' graphing skills are investigated related to interpreting, modeling and transforming components.

It is important to investigate pre-service mathematics teachers' graphing skills because teachers have a crucial role in teaching and learning. Teachers' abilities related to graphing skill and their use of graphical representations in their lessons may affect their students' graphing performances. So it is important to investigate pre-service teachers' graphing skills and to determine their difficulties in graphing as the first step of possible recommendations and implications for overcoming these difficulties and enhancing their understanding of graphics.

2. Method

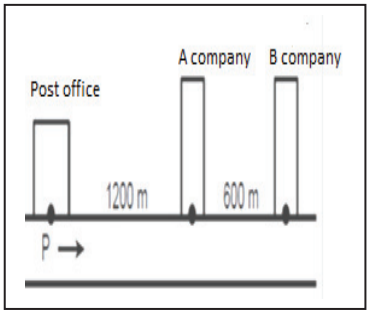
The study aims to investigate pre-service mathematics teachers' graphing skills. Qualitative data collection tools and methods as open-ended questions and interviews were used for this aim. The analysis of the collected data was interpretive and qualitative and the findings were supported by direct quotations from students' written answers.

2.1. Participants

Participants of the study are 32 first grade secondary mathematics education students at a public university. In this study it is aimed to investigate students' abilities related to graphing skills. Participants are decided to be first grade level students because they are just finished their secondary education and began to undergraduate education. It is supposed that they should have gained graphing skills in their secondary education, because they passed the university entrance exam which contains questions from mathematics and science related to graphing skills.

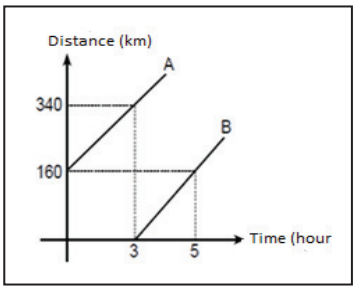
2.2. Data Collection and Analysis

Data was collected by questions which were formed corresponding to the interpreting, modeling and transforming components of graphing skill. These questions were administered to the participants in a classroom hour by one of the authors. Existing literature and graphing questions from national student selection examinations were investigated by the researchers and some questions were revised through the aim of the study. Final version of the questions was formed with experts' opinions. Sample questions that were used in data collection are given in Figure 1, Figure 2 and Figure 3.



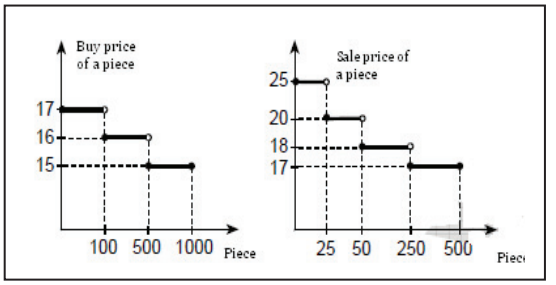
A postman departs from the post office to deliver the letters to the Company A which is 1200m far from the office and Company B which is situated 600m after the Company A on the same way. Postman walks 6km/h. Postman plans to be back at the post office after 45 minutes but he spends much time at the Company A. So he increases his speed on the way to the Company B and he arrives to the post office at the time he planned. Please draw the distance-time graph of the postman's movement.

Figure 1. A question related to modeling component



The graphic shows the change in the distances of the vehicles A and B according to the time. By using this graphic please draw the velocity-time graphs of these vehicles.

Figure 2. A question related to transforming component



A special price list is designed for a salesman for his buying certain pieces of goods. The buy and sale price of the certain pieces of goods are given in the graphs. The salesman bought 600 pieces of goods at once and then sold them in packages which every package includes 100 pieces of goods. What percent profit gained salesman from this sale?

Figure 3. A question related to interpreting component

For modeling and transforming activities velocity-time, distance-time and position-time graphs were used because these graphs are also important for derivation subject in mathematics.

Students written answers were analysed deeply by the researchers and individual interviews were conducted by selected participants. 9 participants whose written answers were mostly not correct and seem to have inadequate graphing skill are selected for interviews. In these interviews students were asked to check their answers and explain their reasoning. The additional data which is collected through interviews were used to explain and support the findings of the written tasks.

3. Findings and results

All students' answers for the first question (Figure 1) which is related to the modeling component was defective. In this task students were asked to construct the distance-time graph of the given real world situation. As it can be seen in the Figure 4 majority of students drawed the back way with decreasing line. In the interviews they said turning back should be drawn in the negative way.

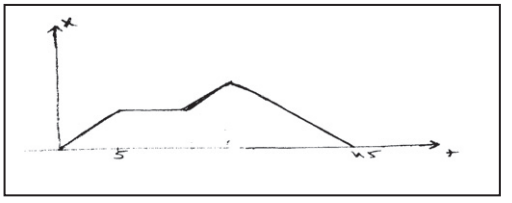


Figure 4. An incorrect answer for the first question related to modeling

Students also have problems with plotting the points and determining the change in the values of time and distance variables on the graph.

In the other modeling task students are asked two interrelated questions. First question was a multiple choice item and they are asked to choose the right graph of the given real world situation. Secondly they are asked to draw the graph of the situation after some changes occured. The written data of students' answers show that most of the students are able to choose the right graph but they have difficulties in constructing a new graph. Leinhardt et al (1990) states constructing requires more competencies than interpreting. Because construction involves generating new parts that are not given, plotting points from data, connecting the points according to the changes in the values of variables, selecting and labeling axes. To choose the right graph of the given situation involves interpreting and predicting and this study shows that students' intrepreting preformances are better than their performances on modeling component.

The majority of the right answers given to the interpreting tasks is the evidence for students high performances on interpreting component. Only a few students answered the questions asked about the given graph (Figure 3) incorrectly. These students' mistakes were not to pay attention to the labels of the axes and they did not notice that the price given on the y-axis is the unit price and some students made computational errors (Figure 5).

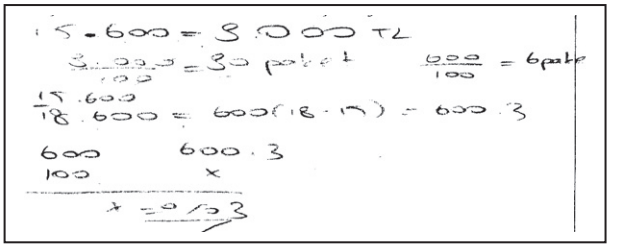


Figure 5. An example of a computational error for the question related to interpreting

In transforming tasks students showed difficulties in drawing the new graph from the given graph when the labels of the axes changed. For example they could not decide how to draw the velocity-time graph of the given distance-time graph. In interviews it is observed that students can answer the questions of the interviewer and explain the shape of the graph for the transforming tasks but they could not draw it correctly or they show avoidance from drawing it. All interviewed students who showed low performance on modeling and transforming tasks said that they are not good at physics so they could not draw the graphs and they could not be confident from their answers. Although graphing tasks in this study do not require physics subject matter knowledge and students should be familiar with velocity-time and distance-time graphs from derivation subject in mathematics, they have difficulties in performing the tasks.

4. Discussion and recommendations

In this study, pre-service mathematics teachers' abilities in interpreting, modeling and transforming components of the graphing skill was investigated. It can be concluded that students' performances on interpreting tasks are higher than the performances on modeling and transforming tasks. This result suggests that students can read graphs and extract information from graphs but they have problems in constructing new graphs. Because modeling and transforming includes building new graph and constructing requires more competencies than interpreting (Leinhardt et al., 1990).

The incorrect answers given to the first question (Figure 1) suggest that students think turning back in a movement should be drawn in the negative way and they confuse the distance and position variables in drawing the graph of the given situation.

Although elementary and secondary schools instructional programs emphasize the importance of graphing, this study shows that students at undergraduate level have difficulties in performing tasks related to graphing skill. It is recommended that teachers should use graphs effectively in learning environments to support the improvement of students' graphing abilities. More opportunities should be given to students to work with graphical representations in different contexts. Especially in mathematics courses teachers should give more importance to the geometrical meaning of the derivation concept and use velocity-time, distance-time, and acceleration-time graphs in instruction.

The improvement in pre-service mathematics teachers' graphing skills will provide the effective use of graphical representations in their future instruction and it is anticipated that this will yield an improvement in their students' graphing skills.

It is suggested that more detailed researches should be carried out to investigate students' and pre-service teachers' graphing skills, to determine their difficulties in graphing tasks and the reasons of these difficulties. The results of these researches can be useful for revising the instructional methods used in teaching and learning of graphics.

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