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Pre-service Science Teachers’ Understanding of One-Dimensional Motion Graphs in the Kinematic Context

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Abstract

The aim of this study is to examine pre-service science teachers’ understanding of graphs in kinematic context. This study focuses on one-dimensional motion graphs. The participants in this study are 115 pre-service science teachers. The data of the study was gathered with an open-ended questionnaire. The case study approach was used in this study. The qualitative data is analysed using thematic content analysis. The results of this study reveal that more than half of the participants cannot adequately understand the one-dimensional motion graphs. These findings suggest that pre-service science teachers’ instructors should be aware of their students’ difficulties in understanding of kinematic graphs. Furthermore, teaching modules which will promote the pre-service science teachers’ understanding of kinematic graphs are designed and implemented.

Keywords: Interpretations of graphs, one-dimensional motion, kinematic, pre-service science teachers

1. Introduction

In the 21st century, individuals frequently are engaged in graphs in their daily life while reading newspapers, magazines, articles, watching TV news, and surfing on the net. Economic developments, election results, the results of public reports in the field of education and health and so on are presented by graphs. Therefore, graphing competence is important and crucial for all the citizens who often need it in their daily life beyond the school achievement. A set of publications and standards such as Benchmarks for science literacy (American Association for the Advancement of Science (AAAS), 1993), Next Generation Science Standards (National Research Council (NRC), 2013) suggest that students should be able to use graphs to analyse and interpret data, mathematics and computational thinking, engage in arguments from evidence and provide communication by the end of the 12th grade.

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If we want the students to understand graphs, the teachers are required to acquire the graph interpretation skills (Jocobbe and Horton, 2010). Kinematic is the branch of mechanics which describes the motion of a body or a system of bodies without consideration given to its mass or the forces acting on it. Graphs are commonly used in the kinematic context. Generally, variables of kinematic-position, velocity and acceleration-are represented in the graphs. However, students have troubles with the kinematic graphs (Hale, 2000). One-dimensional motion is motion along a straight line with constant or changing velocity. The one-dimensional motion is a starting point for kinematic courses. It might be beneficial to search how pre-service science teachers who are going to teach science to the students at primary education level understand one-dimensional motion graphs.

1.1 Aim

The aim of this study is to examine the pre-service science teachers’ understanding of one-dimensional motion graphs in kinematic context. The guiding research questions were:

- What is the understanding of pre-service science teachers about velocity-time graphs of one-dimensional motion in the kinematic context?
- What is the understanding of pre-service science teachers about position-time graphs in one-dimensional motion in the kinematic context?

2. Method

The case study approach, a form of qualitative research method was used in this study (Noor, 2008). The participants in the study were 115 pre-service science teachers. They are in first year in their teacher training program. 70 of the participants were females. The data of the study gathered with an open-ended questionnaire. The questionnaire includes two graphs of one-dimensional motion in kinematic context. One of the graphs is a velocity-time graph and there are four questions relating to this graph. The other graph is a position-time graph and there are five questions relating to this graph. The questionnaire was examined by an expert group which consists of three experts. Except the sampling of the study, the questionnaire was piloted with a group of 36 pre-service science teachers. According to feedback obtained from expert group reviews and piloting, necessary revisions were made. Appendix presents the questionnaire. The qualitative data were analysed using thematic content analysis (Braun and Clarke, 2006). While the data were analysed in the study, firstly the responses of the participants to each question in the questionnaire were coded. Then themes and sub-themes were composed. Frequency and percentages were calculated for each sub-theme. The data were analyzed independently by the author of the paper and a physics instructor. The small differences (less than 5%) between the two coders were agreed via negotiations.

3. Results

3.1 Pre-service Science Teachers’ Understanding of Velocity-Time Graphs of One Dimensional Motion in the Kinematic Context

Table 1 presents the findings obtained from the responses of the pre-service science teachers to the questions in velocity-time graph. Less than a quarter of the pre-service science teachers’ responses fell into sound understanding theme (from 1% to 15%) for velocity-time graph. Most of the pre-service science teachers had partially understanding for velocity-time graphs. More than half of the pre service science teachers could not understand velocity-time graph when the velocity-time graph showed a line with a negative slope.

| Question   | Themes                | Sub themes                      | f  | %  |
|------------|-----------------------|---------------------------------|----|----|
| Question 1 | Sound understanding   | Constant positive acceleration  | 5  | 4  |
|            |                       | Motion in a positive direction  | 18 | 16 |
|            | Partial understanding | Increasing velocity             | 79 | 69 |
Table 2 Pre-service Science Teachers’ Understanding of Position-Time Graph

| Question | Themes | Sub themes | f | % |
|----------|--------|------------|---|---|
| 1        | Sound understanding | Increasing velocity in a positive direction | 13 | 11 |
| 1        | Partially understanding | Motion in a positive direction | 7 | 6 |
| 1        |  | Object changes position | 66 | 57 |
| 1        |  | Constant velocity | 3 | 3 |
| 1        |  | Decreasing velocity | 4 | 3 |
| 1        | No understanding | Object rises | 8 | 7 |
| 1        |  | Increasing acceleration | 2 | 2 |
| 1        |  | I don’t know | 12 | 10 |

Table 2 Pre-service Science Teachers’ Understanding of Position-Time Graph

| Question | Themes | Sub themes | f | % |
|----------|--------|------------|---|---|
| 2        | Sound understanding | Decreasing velocity in a positive direction | 10 | 9 |
| 2        | Partially understanding | Decreasing velocity | 32 | 28 |
| 2        |  | Increasing velocity | 31 | 27 |
| 2        |  | Object rises | 4 | 3 |
| 2        | No understanding | Object falls down | 4 | 3 |
| 2        |  | Increasing velocity in a negative direction | 4 | 3 |
| 2        |  | Constant velocity | 4 | 3 |
4. Discussion and Conclusion

The results of this study reveal that less than half of the participants can adequately understand the one-dimensional motion graphs in kinetic context. Pre-service science teachers usually understand one-dimensional motion graphs partially. They are not able to make explanations about acceleration and position depending on the velocity-time graph. This result might depend on various reasons. One of the reasons is that it is not an easy task to go beyond the direct data on the graph because it requires high level cognitive skills (Aoyama, 2007; Jacobbe and Horton, 2010). Learners need the support of the instructors in order to overcome these tasks. The results of the study suggest that pre-service science teachers compose their unscientific concepts by assembling different concepts in the kinematic context. For example, object slows down at a constant velocity is such a concept. This condition might imply that pre-service science teachers do not understand kinematic concepts in depth. Another reason for the lack of pre-service teachers’ adequately understanding of one-dimensional motion graphs is that they might have weak pre knowledge about the concepts in kinematic context. As it is emphasized in literature, the learners should be familiar with the context of the graph in order to understand the graphs (Roth, 2004; Wemyss and Kampen, 2013). Another result obtained from the study is that pre-service science teachers read one-dimensional motion graphs as if they are pictures. Learners’ reading the graphs as pictures is a common cognitive error (Glazer, 2011). The main reason for this situation might be the learners’ weak view points to the nature of graphs.

5. Suggestions

The importance of graphing competence has been understood very well in educational context. The studies conducted reveal that the students do not acquire graphing competence at an intended level. Graphing competence is not an easy task. Students cannot learn to cope with this task on their own. If we want the students to understand graphs, the teachers are required to acquire the graphing competence. The freshman pre-service teachers do not adequately understand the basic graphs of kinematic context. Pre-service science teachers’ instructors should be aware of their students’ difficulties in understanding of kinematic graphs. Furthermore, they should design and
implement various teaching modules to promote pre-service science teachers’ understanding of kinematic graphs. This study was carried out with only freshman pre-service science teachers. In the future studies, freshman and senior pre-service science teachers’ understanding of kinematic graphs may be compared.

Appendix

1. Explain the motion of the object between the 0th and 1st second.
2. Explain the motion of the object between the 1st and 2nd seconds.
3. Explain the motion of the object between the 2nd and 3rd seconds.
4. Explain the motion of the object between the 3rd and 4th seconds.

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