Role of graphs in the mathematization process in physics education

Gesche POSPIECH

TU Dresden, Chair of Physics Education, Haeckelstr. 3, 01069 Dresden, Germany

Abstract. In this symposium of the GIREP Thematic Group "Mathematics in Physics Education" we elucidate the role of graphs for mathematization. We focus on the interpretation and construction of graphs in the interplay of mathematics and physics. Therewith we describe the difficulties students in secondary school experience and the strategies they employ in different areas of physics. Also problems in the crucial connection between mathematics and physics are being studied. The contributing research groups employ qualitative research methods as well as a quantitative approach.

1 Introduction

The role of mathematics in physics has many appearances. One of the central elements is the use of different graphs displaying functional dependencies between physical quantities [5]. Constructing graphs is fundamental in physics not only in the context of scientific communication but also within the process of gaining knowledge. Seen from the learning perspective they also give access to the "revelation of the complex". However, there are significant difficulties of students in all levels in connecting the appearance of graphs to the physical situation [1, 6, 7] On the other hand there are many attempts of providing students with hands-on experiences in order to enhance the understanding and interpretation of graphs [2, 9] or to teach explicitly about graphs with different success [4]. As often the mathematical abilities of students are doubted some studies tested how mathematical and physics ability are interrelated showing that the connection to physics adds to the observed problems [3]. It was shown that the physics context plays an important role and that the insightful connection of mathematical quantities and physics concepts present a problem in interpreting graphs.[8]. These studies have mostly been done in kinematics. Therefore in this symposium we also look at graphical abilities in other physics topics. In addition often only the competences and knowledge is tested but the strategies actually used are unknown. This symposium wants to contribute to closing this research desideratum with the goal to develop research-based interventions for different age groups.

2 Contributions

In this Symposium we bring together different approaches to understanding how students interpret or construct graphs or how they connect the mathematical concepts to physical concepts.

2.1 Constructing graphs

Students not only have to interpret given graphs but also to construct them, e.g. in evaluating experimental data or in relating different representational forms. Herewith specific difficulties occur resulting from the necessity of choosing an appropriate type of representation. In this symposium different examples are being studied in qualitative research approaches lying open possible strategies and (mis)understandings of students. The contribution "Lower secondary school students construct graphs in physics" analyses in depth the students' ways of thinking and their difficulties during the process of transferring data from a table, a formula or a verbal description into graphs. This is done by means of an exploratory, qualitative laboratory study in which the students constructed graphs in the context of physical-mathematical tasks from thermodynamics. On the other hand the contribution “The Role of graphs in IBL study of optical diffraction by secondary students” starts from experimental data gained with on-line sensors and computer simulations. In a specifically designed educational path high school students should learn the physics concepts of optical diffraction and its mathematical expression from own graphing. Their learning path and the related strategies and difficulties have been analyzed deeply in a qualitative study.

2.2 Interpreting graphs

Graphs in mathematics depict functions which are defined as relations between sets, e.g. real numbers. In the context of school linear functions play an important role. Characteristic quantities are the slope and the y – or x- intercept of line graphs. These have a specific meaning if used in physics. An often studied example are the graphs used in kinematics to describe motion. Some difficulties are well known and have been studied from different perspectives [1,3,6]. In this symposium these researches are framed in the perspective of mathematics. In the contribution “Linking concepts of linear relations in physics and mathematics” a quantitative study analyzes students’ understanding of concepts related to linear functions in physics (kinematics) and mathematics in the 9th grade considering graphs as well as formula. The students’ explanations are being analyzed and common errors with focus on the qualitative side of student strategies and on more formal errors are identified. The contribution “Graphs in Physics; Do They Correctly Depict Reality?” studies the role of realistic vs. idealized graphs in teaching kinematics. The hypothesis is that learning is simplified if more realistic and mathematically correct function graphs are being used.

3 Conclusion

This symposium should give an insight into recent research on the strategies and difficulties of students in secondary school in handling graphs in a meaningful way and thus give hints to further fruitful research questions, to give incitations for developing interventions and evaluating them with the overall goal to enhance teaching physics in its interplay with mathematics.

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