High school students’ interpretation of a graph from mechanics influenced by posed questions and observed by the eye-tracking method

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Abstract. The paper presents results of the qualitative eye-tracking study which aimed at visualization of high school students’ thinking processes when they interpreted a graph from mechanics. A real force (time) graph of a jump on a force plate was presented to students. Firstly, they were asked to watch the graph for 7 s, later they were asked to answer several posed questions. Results indicate stronger involvement in a graph interpretation after posing the questions. Several typical misconceptions were identified as well and the results serve as a base for recommendations for teaching praxis.

1 Introduction

“Graph construction and interpretation are very important because they are an integral part of experimentation, the heart of science“[1]. During physics lessons, we make many measurements by means of real sensors and students are asked to interpret real data plotted into a graph. Then interpretation of the representation is an important skill for students to understand science.

Several misconceptions when students interpret graphs from kinematics have been identified [1]. By means of new research methods included into PER, such as the eye-tracking method (e.g. [3], [4]), we can get deeper insight into students’ thinking processes. Let us think about a model of a teaching event, when a teacher presents and discuss with students a graph gained from a measurement. How do they watch the graph and create interpretation of it? As watching of a picture is highly influenced by a task connected to the picture [2] I was interested in allocation of students’ attention when they watch a graph freely and then after posing different questions.

2 Methods

By means of the eye-tracking method we observed students when they were solving graph interpretation tasks. Firstly, they were asked to watch a graph in Fig. 1 for 7 s.

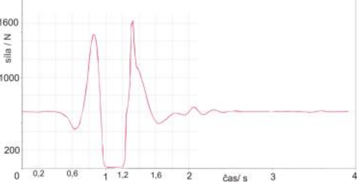

Fig. 1 A force (time) graph presented to students during the test. A squat jump on a force plate [5].

It is a force (time) graph of a person’s squat jump on a force plate [5]. Then students were asked to answer four questions stated in Fig.2. Note: Students could make only an estimation of the Q3 answer. After posing each question, the same graph was presented and students’ eye-movements were recorded during watching the graph. From one student we gained five eye-movements records over the same graph, but when they were thinking about different tasks. See Fig. 2. Additional questionnaire about students’ socio-economic background was administered after the recording. Valid data from altogether 22 high school students were gained during spring 2017. Students’ gaze were recorded by TX300 eye-tracker with sampling frequency 300 Hz and raw data was analysed by TobiiPro 3.2 software. We were interested in both qualitative and quantitative (fixation durations and number of fixations) analysis of students' gaze plots.

2 Results and conclusions

We identified several typical incorrect answers to the posed questions. They are mostly in agreement with a typical misconception, where students perceive a graph as a picture or photograph of the real situation [1]. For example, students could only estimate an answer to the Q3, however the answer should be connected with the first graph maximum rather than with the first graph minimum, what was the typical students' answer.

Based on the gaze plot analysis, we described process of this graph interpretation. Firstly, we identified that glimpse at the graph was not sufficient to provide graph interpretation. During the first 7s, students mostly watched the whole graph area, especially the graph curve. But after posing the first simple question, we observed much more fixations over the whole graph area (Fig. 2). Further, based on the prevalently decreasing number of fixations over the later watched graphs, we identified two typical students' approaches to the graph interpretation. One typical approach is shown in Fig. 2. Usually after two questions, students only looked up a value in the graph, which they considered as the right answer. It suggests their at least roughly created interpretation of the graph.

Furthermore, we identified parts of the graph which attract students' attention but are irrelevant for finding the right solution. Based on the knowledge, we have created a manual for teachers which can help them discuss the questions with students.

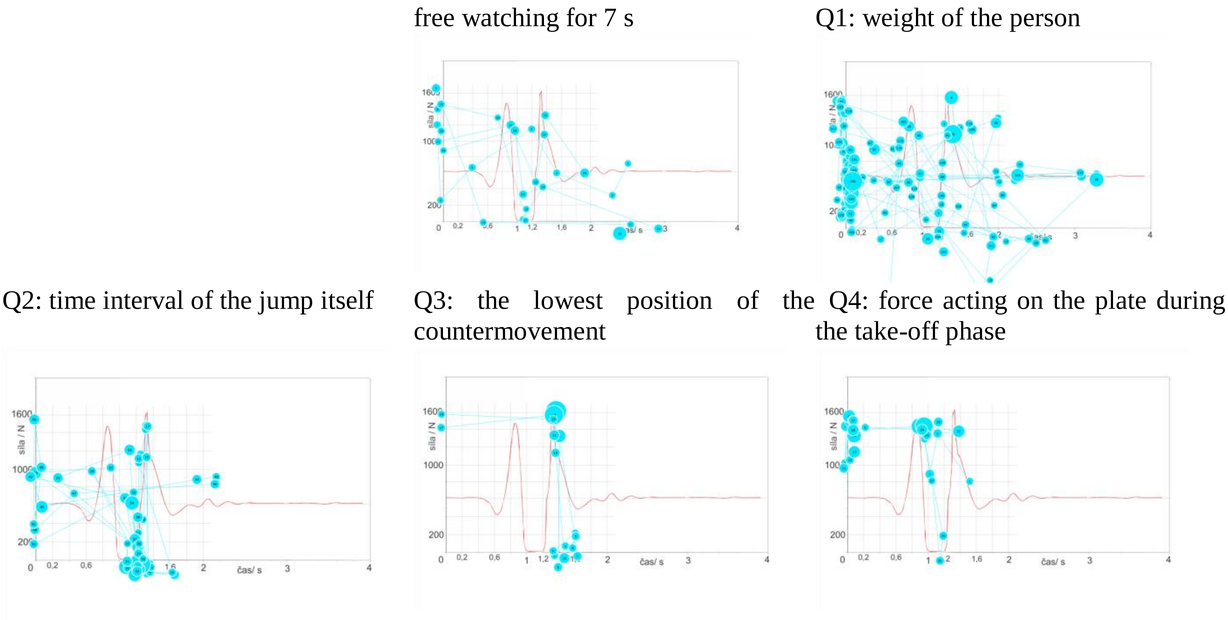

Fig. 2 Examples of all gaze plots for one student

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