Investigating high school students' difficulties with wave optics

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Abstract. Preliminary results of the 27 demonstration interviews about basic wave optics phenomena (polarization, interference, and diffraction of light), held with Croatian high school students in 2018 and 2019 will be presented and discussed using the knowledge-in-pieces perspective.

1 Introduction

Croatian high school students encounter wave optics during their final year of high school education (aged 18-19), where wave optics is typically taught in ten 45-minutes lectures. During the teaching, double slit and optical grating interference, single slit diffraction and polarization of light are covered. To probe Croatian high school students' understanding of basic wave optics phenomena after instruction, we conducted a series of demonstration interviews. The preliminary findings will be presented and discussed within the knowledge-in-pieces theoretical framework.

2 Literature research and theoretical background

The previous research on students' understanding of wave optics phenomena was mostly conducted on university students and showed a lack of students' understanding of wave optics. For example, students failed to differentiate situations where geometrical and wave optics are applicable or when wave model or modern physics concepts (i.e., photons) are applicable [1].

Knowledge-in-pieces framework describes students' knowledge as consisting of various small elements, that are activated depending on the situation. The smallest indivisible elements of knowledge are called *phenomenological primitives* (*p-prims*) [2]; larger cognitive structures are called *conceptual resources* [3]. Activation of cognitive resources can lead to the correct, or incorrect conclusions, depending on the situation.

3 Methodology

Between the springs of 2018 and 2019 demonstration interviews with 27 high school students (aged 18-19) were conducted. Students were shown four typical experiments regarding wave optics (double slit/optical grating interference, single slit diffraction of light, and experiment with two polarizers) and they were asked for their predictions, observations, and explanations of the observed patterns. The interviews were then transcribed and analyzed.

4 Results

The analysis of the interviews showed a variety of students' difficulties regarding polarization of light. For example, students often remembered visual representations of polarization typically shown in schools, but they did not remember (or know) what those visual representations stood for. Some students confused the direction of the electric field oscillation with direction of light propagation or tried to explain polarization using the resources from geometrical optics [5].

When it comes to interference and diffraction of light, students were often unable to predict or explain the patterns obtained on the screen when red laser light was incident on a double slit, single slit, or optical grating. Some student difficulties may have been caused by misapplication of cognitive resources such as e.g. possibly applying the p-prim one cause produces one effect, when they expected one bright spot on the screen for each slit that was illuminated with laser light. For example, some students predicted that there would be 80 bright spots on the screen from optical grating with 80 lines/mm or two spots from the double slit. Other possible misapplications were also identified in student answers,

5 Conclusion

It is important to see what students retain after regular school instruction on wave optics. We identified many problems in student understanding of wave optics and tried to explain them through p-prims or conceptual resources that they activate in the process on the cognitive level.

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