A meaningful introduction to the light postulate for secondary education students

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Abstract. The idea of uniform light speed in relativity theory runs against everyday experience, and proves hard to comprehend for students, even after formal instruction. We propose an alternative teaching approach that builds on students' pre-instructional ideas, rather than starting from a formal definition, which is the practice in most textbooks. In the approach students are made aware of the role reference frames play in their pre-instructional ideas, and they are invited to explore and evaluate those ideas. Preliminary results indicate that this is a fruitful approach to encourage students to reason along the lines of the light postulate. (98, max 100)

1 Introduction

In recent years, special relativity theory (SRT) has gained some popularity as a topic in secondary physics education. A main reason to teach SRT may be to provide a basic conceptual understanding of the 'modern' physics world view. SRT is built on two postulates: the relativity postulate, and the light postulate. For students to advance in SRT, they need a sound understanding of both postulates. Thus far, students understanding of the light postulate has been under researched, but the available research does indicate that conceptual difficulties remain after instruction [1,2]. Our previous research into student pre-instructional reasoning on light propagation showed that students say things that sound like the light postulate, but construct light propagation relative to an absolute space [3].

To find a more effective teaching approach, we decided to do a teaching experiment [4]. In this paper we report on this teaching experiment which aims for a better understanding of the light postulate by having students first explore the limitations of their current understanding, before moving on to the light postulate. We used Event Diagrams (EDs) [5], as an external representation to help students see the consequences of their ideas, and to confront them with content-based reasons to consider new rules for light propagation.

2 Teaching approach

The teaching approach consists of four phases. The aim of the first phase is to make students aware of their intuitive ideas about light propagation. The researcher introduces a thought experiment about an observer seeing two light flashes from different directions arriving simultaneously. The task is to figure out when the light flashes were emitted by two lamps moving relative to the observer. The researcher invites students to use ED A (Fig. 1) to construct the light path. In the second phase, the role of reference frame is problematized. The researcher introduces two options: light speed may either be relative to the lamp (source, like a particle), or relative to the graph paper (medium, like a sound wave). The students explore these propagation models in two situations (ED A and B, Fig. 1). This leads to two different solutions of the thought experiment. We expect students to reach the conclusion that both hypotheses cannot be true at the same time. The aim of the third phase is to evaluate the propagation models. The researcher introduces experimental findings. Neither propagation model holds for both situations. In the last phase the light postulate is introduced. The researcher asks the students to find a new propagation rule that can be applied in both situations. Students are asked to apply this new propagation rule in two new situations (EDs C and D) to test if they stick to their new idea.

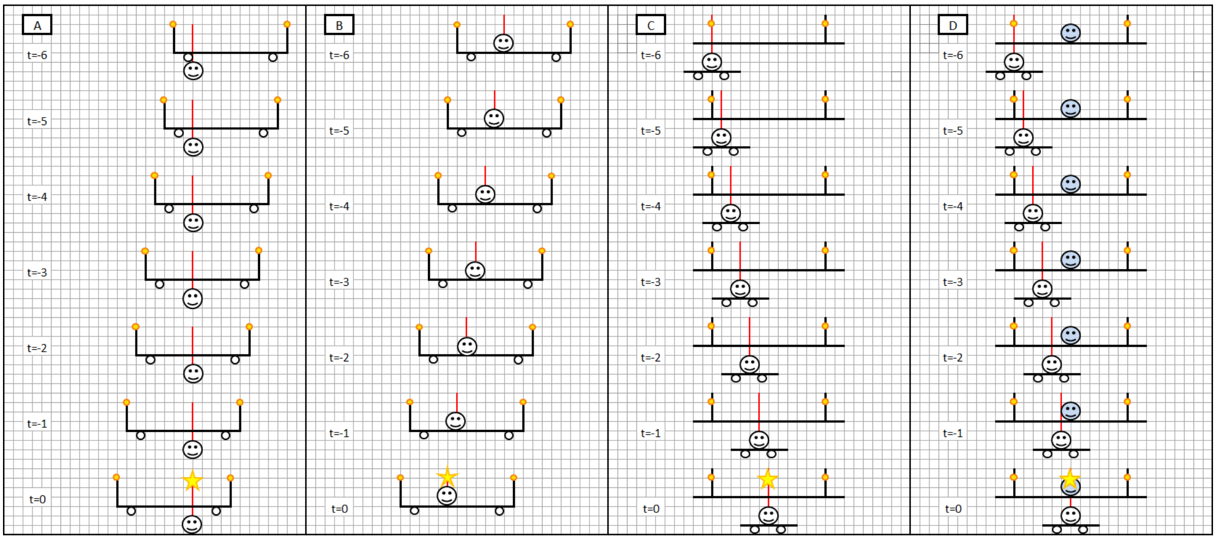

Fig. 1 The four EDs used in the teaching approach. EDs A and B are used in phase 1 and 2, EDs C and D in phase 4.

3 Preliminary results and conclusions

The teaching experiment was performed in seven small groups of 2 to 4 students each. The students all were in 10th grade of pre-university level secondary education in the Netherlands. Initially, students struggled to represent their ideas in the ED's A and B. Over time, students became more fluent in reasoning with light propagation in EDs and applying the two different propagation models. The third phase, evaluating the models with the use of experimental findings was more problematic: the researcher had to lead the students stepwise to the right conclusion. Students identified which of the two propagation models in ED A and B were correct. However, students could not provide an explanation. Surprisingly, the fourth phase went rather smooth. Based on the correct answers students could formulate their own version of the light postulate. Students applied the postulate in the correct way in ED C. Students kept using the light postulate in ED D, although this led to counterintuitive results.

All in all, the teaching experiment was promising for students whose pre-instructional description of light propagation was either relative to the lamp or the graph paper, in accordance with the pre-instructional reasoning we found [3]. However, some students immediately started to describe light propagation relative to the observer. These students were not invited by the tasks to evaluate their own ideas; therefore, the teaching sequence was less fruitful for them and sometimes led to confusion. We conclude that some adaptations are needed, but that the general approach is worth using to introduce the light postulate to secondary education students.

References

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