How challenging is it to extract information from different representations

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Abstract. We investigated the impact of different representations on answering conceptual questions in physics using eye tracking. Students' scores and eye-tracking measures were compared across graphical, pictorial, and verbal representations in isomorphic questions. High school students were rather consistent in their answers across all representations, with no significant score differences. However, eye-tracking data revealed that extracting information was easiest from verbal representations and most challenging from pictorial ones. These findings can inform teachers and researchers about the challenges students face with specific representations and assist them in teaching with diverse representations.

Introduction

Physics education research highlights the prominent role of representations in understanding physical concepts, emphasizing the importance of students using multiple representations for effective problem solving [1]. However, research shows that students often struggle with understanding and employing diverse representations. For example, in one study, researchers found differences in student performance across various representational formats but did not identify a consistently preferred format for all situations [2]. When given the option to choose, students preferred pictures, yet this preference did not lead to increased success in problem-solving. According to cognitive load theory [3], the complexity of different representations might affect students' performance by changing the amount of cognitive effort needed to process the information.

In this study, we used eye tracking to assess individual representation processing and extraction of information from different representations [4]. Our aim was to examine how various representations influence students' responses to conceptual questions and to determine if information extraction is equally challenging across different representations or if one representation has an advantage.

Methods

Participants in this study were 35 high school students (aged 18–19 years) in their final year. We utilized eye tracking to measure their visual attention while they solved six sets of isomorphic questions containing graphical, pictorial, and verbal representations. Dwell time (viewing time), average fixation duration, and the number of revisits were assessed across these different representations.

Results

To evaluate the effect of representations on students' responses, we computed the percentages of correct answers for each representation. The mean scores and standard deviations were (55 ±

22) % for graphical representation, (54 ± 26) % for pictorial representation, and (52 ± 23) % for verbal representation. A one-way ANOVA revealed no statistically significant effect of representation on students' scores ($F(2,68) = 0.46$, $p > 0.05$, $\eta_p^2 = 0.01$).

Figure 1 displays the mean total dwell times, average fixation durations, and numbers of revisits for graphical, pictorial, and verbal representations. The type of representation significantly influenced all three eye-tracking measures. Pairwise comparisons revealed that pictorial representations had longer dwell times than graphical and verbal representations. Additionally, the average fixation duration was the longest for pictorial representation and shortest for verbal representation. Similarly, the number of revisits was smallest for verbal representation.

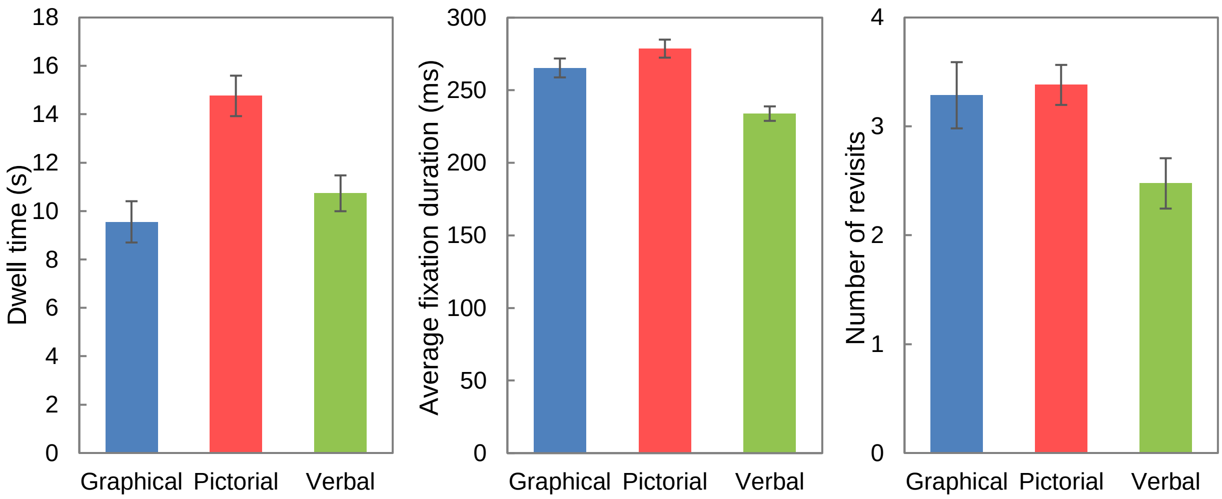

Fig. 1. The mean dwell time, average fixation duration, and number of revisits on AOI representations for graphical, pictorial, and verbal representations. The error bars represent 1 SEM.

Conclusion

The results of this study reveal no advantage in student scores for any representation. Eye-tracking data indicated that extracting information was easiest from verbal representations and most challenging from pictorial ones. This observation about verbal representation may be generalizable, as we likely decode information from graphical and pictorial representations into verbal form for inferences. The difficulty in extracting information from pictorial representations may be linked to specific representations that are challenging for students, such as the motion maps used in this study. Physics teachers should be aware of varying difficulty levels in extracting information from different representations when teaching with multiple representations.

References

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