

Prediction of a Correct Response Based on Eye Tracking and AOI Segmentation

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- Title: Gaze patterns enhance response prediction: More than correct or incorrect
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- Status: Accepted for Publication in Physical Review Physics Education Research

Physics education research aims to understand how students learn and how teaching physics can be improved at all levels. In an attempt to understand how students solve questions based on kinematic graphs, eye-tracking was used to analyze how students interpret visual information to problem solve within the classroom. Kinematic graphs can be used to study how things move without needing to worry about their makeup or the forces on said item. Eye tracking then allows for data to be collected on how students choose to solve visual problems and allows teachers to interpret said data, adjusting for their student's learner-specific difficulties when going through the problem solving process.

This article looks to predict whether a student will be correct or not in solving visual based problems derived from the Test of Understanding Graphs in Kinematics (TUG-K). These predictions are based on total visit duration (TVD) taken from eye-tracking in specific areas of interest and compared to McFadden's pseudo R-squared, which is a measure of prediction quality that is then tested against the corresponding prediction models based on the TVD of AOIs to determine if the two prediction models differed significantly from each other or not [1]. By segmenting the graphs into areas of interest (AOIs), analysis from eye-tracking was able to be taken and provide insight into whether a student would garner a correct response can be predicted or not. This theory was tested under multiple conditions of intra-item and inter-item parameters in order to answer two bigger questions: what sort of segmentation results in the best prediction quality and if response accuracy can improved in a pair of items (inter-item) based on accuracy of the initial item and eye-tracking of the corresponding item.

Data collection taken from problems regarding individual items (intra-item) like displacement, velocity, and acceleration showed that not only can predictions be made from eye-tracking, but exactly which type of segmentation allows for this to be possible. Comparing the two types of AOIs, macro and micro, it makes sense that a clearer prediction whether a student will be correct when answering a visual problem is micro-segmentation. Macro-segmentation focuses more on the visual graph as a whole, the possible answer corrections, and the question text which does not provide the necessary information to problem solve. Micro-segmentation divides the graph into segments based on Gegenfurtner's reduction hypothesis, which states that areas that are relevant to the correct response will have a larger TVD and can then be assumed to yield a correct response [2]. This allows a student to fully understand the question and develop an answer, making it easier to predict a correct response based on their eye movements. Micro-segmentation is then able to be split into two subdivisions, relevant and irrelevant, that allow educators to make even better predictions on their student's responses and behaviors. It makes sense that when students spend a longer TVD in an AOI that is considered to be relevant micro-segmented, educators are able to make a stronger prediction that a student will answer a question correctly. For example, when looking at a time vs. position graph to determine velocity, a relevant area to look at is the where and when the graph's slope starts and ends, while looking anywhere else can be determined as irrelevant.

Correct answer predictions in paired items were also able to be made thanks to eye-tracking. Data shows that the quality of a prediction was able to be made between items increasingly as more information between the initial and corresponding items were given. For all datasets, a poor prediction was made when a student was only told that they got the first initial item correct, but when introducing another micro-AOI on a second item, students were able to put the information together and a clearer prediction was able to be made. When students put this information together, this is where educators are able to make the clearest prediction on whether or not the student will get the question correct.

Being a smaller field of expertise, this study allows one to understand the mission of physics education research: to adapt and improve the learning environment for students with more understanding educators. The discoveries in this paper not only provide insight on tactics that students use in solving kinematic graphs, but also lays the groundwork

for educators to adapt.

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- [1] S. Becker, S. Küchemann, P. Klein, A. Lichtenberger, and J. Kuhn, Gaze patterns enhance response prediction: More than correct or incorrect, *Physical Review Physics Education Research* **18**, 020107 (2022).
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