

Qualitative Analysis of Students' Strategies in Answering Questions Accompanying Textbook Text

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Abstract. Using eye tracking, we observed the strategies of 15 high school students while reading a textbook text accompanied by a question. The question was either answered directly in the text (for Group 1) or related to the text but answered implicitly or only related in theme (for Group 2). We then watched participants' gaze plots and qualitatively compared the different strategies used by both groups while viewing the material. 4 main strategies of working with the material emerged.

Introduction

Eye-tracking is a method of collecting on-line data about overt visual attention from participants, while keeping the distractions caused by the method itself to a minimum. This makes it advantageous for not only educational research, but for direct use in classrooms as well, as demonstrated by other researchers [e.g., *Slykhuis et al.*, 2005]. Another area of learning where eye-tracking has been used previously is in observing student strategies. However, most studies in this area (at least specifically in physics education) focus on problem solving [*Hahn & Klein*, 2022], not on questions accompanying an explanatory text. An example of this could be some previous works of one of this article's authors, *Kekule and Viiri* [2008] or *Hejnová and Kekule* [2018].

In this study, our aim was employing a qualitative, exploratory approach to find out what strategies high-school students use when presented with a textbook text accompanied by a question. The question was either related to the text, or directly answered in it. Another aim was to see if the chosen strategies differ based on the type of question presented. We were also interested in seeing if participants' strategy changes if the type of presented question changes.

This work is a part of one of the authors' dissertation, which aims to create a supporting material for teachers who might want to incorporate eye-tracking into their teaching. The strategies and some of the specific examples of eye-movements from this study will be used. This is also a loose continuation of one of the authors' previous works [*Krejčí*, 2019], in which the strategies of students while reading a textbook text with or without questions were observed. The author found out, that when a text is accompanied by related questions, students spent around twice as long interacting with it.

Methodology

First, participants were introduced to how eye-trackers collect data and asked not to move their heads during the collection process. They were also told that if they see a question in the material, they should think of an answer to it, even though they will not be asked for the answer at any point. Then they were presented with the material (as described below) and data was collected. In the end, participants were asked to fill out a questionnaire with basic demographic information about them (e.g., their age, gender, any specific learning disabilities etc.).

Hardware and software

The data was collected using the eye-tracker Tobii TX300 with a sampling frequency of 300 Hz. No headrest or other method of restraining head movement was used. The material was prepared in its accompanying software, TobiiStudio3.2. in the form of a presentation.

Material

The first slide of the presentation contained a short segment from a book by *Jules Verne* [1981]. The purpose of this slide was to distract participants from the experimental conditions.

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On the second slide, there was an excerpt from one of two consecutive physics textbook [Rauner *et al.*, 2004; Rauner *et al.*, 2005] (Textbook slide), followed by the third slide, which contained the exact same textbook material with a single added question (Question slide). For an example, see Figure 1. For Group 1, this question was directly answered in the text, for Group 2, the question was either vaguely related to the text or implicitly answered in it. This pattern (Textbook slide followed by a Question slide) was repeated for 4 textbook excerpts on the following topics: particle movement, heat appliances, microwave, and lunar eclipse. For the last two slides, similar pattern was repeated, but this time, the original question from the textbook was used for both groups. This question was directly answered in the text. This was done to see whether or not Group 2 participants would change their strategy to accommodate for the change of question type, while Group 1 results would eliminate the possibility of the question being specific enough to change everyone's strategy.

Participants were free to move the presentation forward at their own pace.

Participants

Data was collected from 17 participants, however, one participant's data was of insufficient quality (only 47 % of gaze events collected as calculated by the eye-tracker itself). This participant was excluded, leaving valid data from 16 participants. 15 of those were high-school students (ages 15 and 16), 1 was a teacher. When reviewed, the teacher's data was identical to the students' data, so it was used in the final analysis indiscriminately. They were divided into Groups 1 and 2 randomly, resulting in 9 participants in Group 1 and 7 participants in Group 2 (excluded participant was originally in Group 2; the teacher was also in Group 2).

Data analysis

For identifying strategies, videos of each participant's gaze plots (visualizations of where the participant was looking in real time) were analyzed by one of the authors. Strategies were written down and labelled as they appeared.

The number of times a strategy was used was calculated in MS Excell using the CountIf function. Separate counting was done for Group 1, Group 2 and the total number of times the strategy was used. Then, the same was done for only the question slides (see in Material).

Results

While analysing the gaze plots, 9 distinct strategies of working with a slide were discovered. The strategies are as follows:

S1: reading all text

S2: short, incomplete reading of text; reading the question; incomplete reading of text with skipping

S3: reading of question; incomplete reading of text with skipping

S4: short, incomplete reading of text; reading the question; reading all text

S5: reading of question; reading all text

S6: reading of question (no reading of text)

S7: reading all text; reading of question

S8: short, incomplete reading of text; reading of question; finishing reading of text

S9: short, incomplete reading of text; reading of question

Strategies S2, S4 and S8 all start with incomplete reading and the reading of question, however, they differ in the last reading part. For S2, the participant would never re-read the entire textbook text while on the Question slide. For S4, the participant started, after reading the question, re-reading the entire textbook excerpt, meaning that while on the Question slide, in total they re-read the entire text as a whole and then a part of it. For S8, after reading the question, the participant would finish reading the textbook text, meaning that the textbook text was re-read exactly once while on the Question slide.

For Textbook slides, the only strategy ever used was S1 (96 uses on Textbook slides), making it the most common strategy.

The number of times each strategy was used on Question slides is listed in the table in Figure 2.

Jak je vidět z obrázku, Měsíc nejprve vstoupí do polostínu. Těto situaci říkáme polostínové zatmění Měsíce. Ze Země není tento jev příliš výrazný, protože Měsíc jen trochu ztmavne. Pak část Měsíce vstoupí do stínu Země – nastává **částečné zatmění Měsíce**. Při dalším pohybu se postupně posouvá Měsíc do stínu. Je-li celý Měsíc ve stínu Země, mluvíme o **úplném zatmění Měsíce**. Při některých průchodech se do stínu nedostane Měsíc celý, a proto dochází jen k částečnému zatmění Měsíce, nebo jen k polostínovému zatmění Měsíce. Zatmění Měsíce je pozorovatelné najednou z celé poloviny Země.



konečné fáze úplného zatmění Měsíce

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konečné fáze úplného zatmění Měsíce

Jaký je rozdíl mezi novem a zatměním Měsíce?

Figure 1. Example of consecutive slides in observed material. Left — textbook excerpt without changes. Right — identical excerpt with added question (in blue square).

| Question slides only | | | |
|----------------------|---------|---------|-------|
| Strategy | Group 1 | Group 2 | Total |
| S1 | 1 | 0 | 1 |
| S2 | 9 | 4 | 13 |
| S3 | 18 | 12 | 30 |
| S4 | 6 | 1 | 7 |
| S5 | 1 | 7 | 8 |
| S6 | 4 | 10 | 14 |
| S7 | 3 | 0 | 3 |
| S8 | 2 | 0 | 2 |
| S9 | 1 | 1 | 2 |

Figure 2. The number of times each strategy was used for Question slides only.

As obvious from the table, the most common strategies used besides S1 were S2, S3 and S6, all used more than 10 times. All of these strategies were somewhat common for both Group 1 and Group 2, with S2 and S3 being more common for Group 1 and S6 for Group 2. All of those strategies employed no re-reading (S6) or incomplete re-reading only (S2 and S3). This could imply that students remembered enough of the text to think of an answer to the question, or they remembered the answer was not presented in the text (this would explain S6 with no re-reading being more common for Group 2). This could be due to the fact the text was always very short, or it was not complicated for participants to understand.

In most cases, S1 occurred while participants were reading the Textbook slide. It might not be surprising that they did not read a question, since there was none presented in Textbook slides, however it is an interesting result that no participant decided to skip the Textbook slide, even after finding out that the Question slides contain the same exact text. In one case, S1 was used on a Question slide, meaning the participant decided not to engage with the question in any way and re-read the whole text, even though they did just read it on the Textbook slide.

Only 2 participants decided to use a different strategy on the last Question slide (both groups the same question answered in text) then the strategies they used on Question slides before. Surprisingly, both of those participants were in Group 1, meaning that Group 2 participants didn't see the need to employ a different strategy for a different type of question.

Discussion

Since the sample size for this experiment was rather small (16 participants), it is possible that not all existing strategies were uncovered. However, the most common strategies for this experiment should correspond to the most common strategies in the whole population of high-school students. More research on the topic is certainly needed.

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Even though the research showed no participants skipping Textbook slides to read the text on the Question slide instead, this result might have been a result of the experimental situation. Even though no instruction in this sense was given, participants might have thought they were expected to engage with every slide.

Similarly, even though only participants from Group 1 employed a different strategy when working with the last question, this could be either due to a small sample size, or due to the original textbook question not being similar enough to our questions for Group 1.

The questionnaires revealed that 12 of the students already covered at least one of the Textbook slide topics in school. This could influence the strategies used in answering questions on this topic. For future research, we could either divide the results based on whether or not the participant had previous knowledge of the topics, or we could choose more advanced topics to minimize the possibility of previous knowledge existing in participants.

Conclusion

When students were presented with a textbook excerpt accompanied by a question, 9 different strategies of working with the material were observed. All of the 4 most common strategies for Question slides included only partial re-reading of the textbook text, or no re-reading at all.

All participants decided to read the whole text on all Textbook slides instead of skipping it, however, this could have been due to the experimental situation.

Only 2 participants employed a new strategy (i.e., a strategy not employed by them on any previous slide) when working with a question taken from the original textbook, both of those participants were unexpectedly from Group 1.

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