**BAR-ILAN UNIVERSITY**

# Eye movements' patterns among children with and without reading difficulties in different highlighted modes within an educational e-book

**KARIN BAR-ZVI SHAKED**

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# Abstract

The integration of digital content into schools introduces new opportunities to enhance children's understanding of written text. Highlighted text, for example, contributes to learning, reading, and searching the text. Currently, the assessment of students' educational e-book learning is mostly based on achievement measurement and self-reporting (tests and questionnaires).

This study integrates the analysis of eye movement patterns with these traditional methods, to better understand reading difficulties among children. Multimedia devices that measure eye-movement provide a novel angle from which to examine aspects of learning and reading by providing additional cognitive data.

The main aim of the study was to characterize patterns of eye movements among children with reading difficulties, as compared to children without reading difficulties, while reading informative text in different modes in an e-book (highlighted or static). A secondary aim of this study was to examine the connection between eye movement indices and literacy variables (vocabulary and reading comprehension).

The research sample included 61 children in grades 3-5: 30 children with reading difficulties and 31 children without reading difficulties. They were divided into four groups: Two groups were examined in highlighted reading mode and the other two in static reading mode. They were tested individually in their homes for two sessions, in which they were given a reading task that documented eye movements and assessed reading comprehension and vocabulary achievements.

The e-book used for the research consisted of seven reading screens that included text and pictures. During the study, patterns of eye movements were measured using the following indices: the percentage of fixations in each area of interest (text and picture), the number of transitions between the areas of interest and the dwell time. Also, we examined the relationship between the eye movement indices and the literacy variables in both e-book modes (highlighted or static). The measured literacy variables were: reading comprehension (post) and vocabulary (pre / post).

We hypothesized that among children with reading difficulties, eye movement patterns would reflect more prolonged duration stays, higher fixation percentage and a

higher number of transitions between areas of interest (text/ picture) in comparison to children without reading difficulties. Second, we hypothesized that the highest achievement of reading comprehension after the e-book activity would be found among children who operated in the highlighted mode. We also hypothesized that all subjects would have higher post-activity vocabulary scores than pre-activity vocabulary scores.

Eye- movement analysis yielded a number of findings: First, we found that all of the children focused more on the text area than on the picture area: 95% of the fixations were on the text area while the rest were on the picture area. Second, in the highlighted mode, we found that all the children focused more on the text compared to the static mode. Among children with reading difficulties, the visual focus was significantly higher in the highlighted mode of the e-book. Third, in the highlighted mode, children transitioned more between areas of interest (text and picture) on average compared to the static mode, mainly among children without reading difficulties. In addition, children with reading difficulties had greater total transitions in both e-book modes (highlighted and static) than children without reading difficulties. This provides further support for the benefits of the highlighted mode in relation to children with reading difficulties.

Prior to the activity, the level of vocabulary of all the groups was similar and was found to increase by 19% due to activity. Also, the level of reading comprehension among children with reading difficulties was lower than that of children without reading difficulties.

The last area examined in the study relates to the relationship between the variables in which we found that the higher the reading level of the children, the fewer transitions (between the text and the picture) and the higher the reading comprehension level. Additionally, it was found that the higher the level of vocabulary (pre), the fewer fixations in the text and the higher the reading comprehension level. The difference in reading comprehension between the children was explained by the reading level (19%) and the interaction between the e-book mode (highlighted and static) with the fixations (6%).

The findings of this study may contribute in theory and practice to the understanding of the connection between the various variables involved in the reading

of children's e-books. This, with an emphasis on children with reading difficulties. However, further studies should continue to investigate related questions. What other literacy skills can be promoted by the highlighted feature in e-books? Will greater exposure to the highlighted feature significantly advance the literacy achievements of children with reading difficulties? In addition, we suggest exploring various learning strategies related to the integration of text and picture among children with reading difficulties. The findings of this study can be considered a starting point for further studies that can examine long-term effects of the highlighted mode on reading and comprehension processes in children with reading difficulties. We hope that the findings of this study will contribute to the development, evaluation and adaptation of educational e-books for children with reading difficulties.