# Investigating Eye-Tracking Methods in Educational Environments

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## Introduction

Usability testing is an important detail for designers and engineers wanting to create user-friendly interfaces for different types of technology. This includes websites, which are very popular, as many people find the Internet to be a versatile and helpful resource. Therefore, it is critical for designers to understand how users may view and interact with their websites to ensure satisfaction among their users. Due to the COVID-19 pandemic, online education is increasing for students as young as kindergarten to college graduates. With the use of eye-tracking, there are a few studies that have touched on the fundamental design aspects that are favorable within an online interface, including educational websites. However, these studies often gather young adults for their participants, leaving little to no information for users of other ages (Wang, 2019). Using eye-tracking, we can gain cognitive insight through eye fixations and saccades, and how they relate to students in a stressful environment (Abbott, 2017). This can help us understand students' preferences of certain features in a learning website. If successful, this information can make a great impact on learning applications that are used by millions and ultimately enhance students' online learning environments in the most positive of ways.

Among the previous studies that have examined the use of eye-tracking technologies to improve UIs, Wang (2019) explored the relationships between eye tracking and usability testing by analyzing aspects of an online math learning system. Eye-tracking was a major part of this study due to the eye-mind hypothesis, suggesting that visual attention is representative of mental attention and that visual patterns can often reflect cognitive processes of individuals. He hypothesized that different tasks that required a separate set of cognitive controls would reflect on the users' eye gaze fixations, saccades and the overall time it took to complete each task. Eye movement patterns indicated that more difficult and stressful tasks resulted in higher fixations

and required more visual attention. However, while the results of this study give substantial evidence that visual attention is representative of mental attention and can help improve online learning environments, the results of this study could only be confidently replicated among the age group of the participants– undergraduate college students. This leaves researchers with an absence of information with technology users who may be much older or younger.

On the other hand, Djamasbi (2002) used eye-tracking to investigate and test the visual aspects of websites that users prefer. The author hypothesized that websites are typically communicated through what is known as a "visual hierarchy", stating that location and size was an important factor in attracting a user's attention; people have a tendency to subconsciously focus their eyes on the top center of a stimulus. This theory also suggested that these features at the top of the hierarchy were deemed to be more important, which led to a larger number of eye fixations and saccades to it, as backed up by Wang's study as well. The results indicated to be very useful for website developers, who may have wanted to make their interfaces look as appealing and convenient as possible. However, like Wang's study, there was a limitation of the specific age group the results from study can be valid for. In addition, this article did not cover the eye behavior of users who may attempt to complete a task on the website quickly. This is an important aspect to consider when designing a website, as the speed of accessing information without causing stress or anxiety to their users is a huge factor that can contribute to a successful interface. This knowledge would be very insightful to researchers who may want to develop websites that are user-friendly for a more diverse group of users.

For this reason, this current study seeked to investigate the presence of a timer feature on a website interface among a younger age group of students and how it could affect their testing abilities. This study included the participation of middle school students who used one of two

interfaces of a popular online learning management tool, Canvas. The students were asked to take an English exam on Canvas that involved different cognitive processes such as attention, ease of accessing information, and cognitive load. An eye-tracker was used to record each student's eye movements, along with the accuracy and completion time of each exam.

By comparing the results between the two versions of Canvas's testing interfaces, this study design decoded visual information and provided insight into the aspects of a modern educational UI that can be either helpful or detrimental to a student's learning experience. For example, saccades, fixations and completion times during a task could indicate the cognitive difficulty of a task. Sudden eye movements to unrelated areas of Canvas during a task could demonstrate a break in attention and can help eliminate distracting features within the application as well.

## Method

### Participants

Sixty participants who were new to the Canvas application took part in this study. They were middle school students of ages 11 to 14 and were ensured to have up to an elementary school level of reading proficiency. They were evenly split into two groups who used one of two of the following Canvas interfaces: a UI with the presence of a countdown timer located at the top center of the page, or a UI that simply showed the maximum time that was allowed to take the exam, located at the top center of the page.

### Stimuli

Students of both groups were presented with a 40-minute English exam consisting of twenty multiple choice questions. The exam covered topics of grammar, vocabulary, and reading comprehension. For one condition, students took the exam on an interface where a fixed

countdown timer showcased the remaining time; it was located at the top center of the page. Students of the second condition took the exam on an interface where the total amount of time allowed to complete the entire exam was fixed and located at the top center of the page.

**Apparatus**

Both conditions of the interface were displayed on an external 20-inch flat screen monitor, viewed at a 30-inch distance. An Eyelink 1000 Plus system and its Screen Recorder software were used to simultaneously capture each participant's eye movements and their screen activities while allowing for free head movement. Prior to the beginning of the study, the gaze of each participant was calibrated and validated with a 13-point algorithm. While the participants worked on each task, their eye movements (i.e., fixations and saccades) and on-screen activities were recorded with the eye-tracker and screen recorder. The completion time and accuracy of the exam were recorded as well. Prior to the experiment, every word in each question was categorized to be either "high frequency" or "low frequency". Common words such as "a", "the", and "is" were grouped as to be high frequency, while less common words that are more relevant and specific to the individual question itself were considered to be low frequency.

**Procedure**

Students of both conditions were asked to complete an English exam, given a maximum of forty minutes to complete the exam. After pressing the start button, the time elapsed began to be recorded. Once the students finished each exam, they pressed the submit button located at the bottom of the page to record their answers and the amount of time they took to finish the exam.

**Analysis**

The dependent variables measured by these testing methods included the completion time of individual questions, the total completion time, and accuracy for the exam. This data was

complemented by eye movement data including the number of fixations, average fixation duration, and number of saccades for each task. These average eye measures, along with average accuracy and average time spent for each exam, were analyzed through ANOVA.

**Results**

The ANOVA results indicated significant differences in the duration of completing each question, overall test accuracy, number of fixations and saccades, and average fixation duration between the two groups. The presence of a countdown timer resulted in a larger average number of saccades and fixations to the timer itself, as well as an average longer fixation duration for every question of the exam. Students of this condition, on average, took longer to complete the exam and had an overall lower exam score. In addition, the group who interacted with the timer had a smaller number of average fixations with the high frequency words.

## Discussion

This study was designed to observe how the presence of a countdown timer may affect students' performance on an online exam. Since online learning is becoming increasingly popular, it is important for UI developers of online learning environments to understand their students' cognitive processes; this can help accommodate for their users and ensure the smoothest experiences on their application.

As the results indicated, the significant variability in the dependent variables reflected a difference in cognitive processes when a student was faced with a countdown timer as they tried to complete the exam. In support of the visual hierarchy theory, the increase in attention to the area that contained either a timer or total time for the exam could be explained by the fact that humans have a natural tendency to avert their gaze to the top center of a stimulus.

On average, the group of students with the timer condition took longer to complete each question, resulting in an overall longer completion time for the exam in comparison to the students who were presented with just the allocated time. These results could be explained by the increase in saccades and fixations to the timer and the longer fixations on the timer itself. This was due to the fact that the timer acted as a distractor, and students often found themselves shifting their attention to that. The timer also served as a "threatening" stimulus, invoking a sense of anxiety and urge for the students to complete the test on time. Because of this, the students who were in the presence of the timer often attended to this stimulus at the expense of the less-intimidating stimuli, the exam questions (Abbott, 2017). Additionally, since the students with the timer condition may have felt anxious after knowing how much time they had left, they found themselves skipping over high frequency words in the questions in an attempt to answer each question more quickly. This was shown in the results where the students with this condition had a smaller average number of fixations on short, high frequency words like "is", "the", and "and". However, this behavior could backfire, as students sometimes missed an important part of the question or did not give themselves enough time to think about the question, resulting in answering the question incorrectly. This was reflected by the overall exam score of the students with the timer condition, which was significantly lower than those who only knew the total allocated time for the exam.

These results were consistent with that of the previous studies by Wang and Djamasbi, who stated that different eye patterns can reflect a person's different cognitive processes for different situations. Along with support from previous studies, these results suggested that the presence of a countdown timer during an exam could cause stress and anxiety for students taking the exam. Therefore, in order to eliminate these distractions, reduce anxiety, and keep Canvas a

positive platform, designers of such applications may want to consider these timers to be optional for the students on a test or placing them in a more discrete location of the page.

Unfortunately, there was a limitation of this study in which the participants were students in middle school, making these results only reliable to people of a similar age group of pre-teens. In order to allow these results to be consistent with a larger pool of students, this study can be replicated, but could include participants of a more diverse age group.

From a more general standpoint, these results indicated that it is important for designers of learning platforms to understand that some website features can cause additional pressure to students which they may not perform well under. It is the designer's responsibility to create websites in ways that can eliminate as much anxiety and stress among students as much as possible from their end. The pandemic has made many students turn to online learning and while it may have its pros and cons, it is important to keep this platform a safe and positive environment for all.

## References

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