Modeling Visual Attention of Students Using Pendulum Problem on Physics Playground

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1 Abstract

This study modeled visual attention of students as they solved a problem within an educational game for Physics. Participants(PP) were given time to view a hint before the static image of the game problem was displayed. Upon viewing the static problem, they were instructed to think of a solution using the hint. An eye tracker recorded eye movement data. After viewing the problem, participants played the actual game level. Gold, silver, or no badges were awarded to the participants depending upon their performance. When analyzing the relationship between the eye movement and performance, the findings are the following: 1) There was a significant difference in the total contact time and number of fixations between participants that had good and bad performance in solving the physics problem on the regions labeled essential to solve the problem. 2) Participants who earned gold, silver, and no badges had different orders of fixating on the regions of interest while thinking of a solution to the PP problem. 3) Participants who had better performance fixated earlier on the regions where the solutions are drawn.

2 Research Objectives

The focus of this study is on attention in the context of learning. Mainly, the investigation was done on the relationship between attention and performance among students using Physics Playground (PP), an educational game designed to help secondary students understand Newtonian Physics [14]. The game aims to help augment the understanding of concepts such as balance, mass, conservation and transfer of momentum, gravity and potential kinetic energy [13]. PP has 80 levels and the goal in each level is to bring the green ball to the read balloon by drawing simple machines such as ramps, levers, springboards, and pendulums.Badges are awarded to the players depending upon the number of objects they have drawn in attempt to solve the problem. A gold badge is given when players solve the level using below or at par with the object count limit set per level. Silver badge is given when players solve the problem but exceeds the threshold. Actions of players are recorded on the background and saved in log files[13]. Different studies on PP yielded different results. While in the US, PP has helped students to have an increased understanding on qualitative Physics[13],in the

Philipppines however, PP did not result to learning gains [2][3]. Researchers of this study have there-fore focused on examining the role of attention (or the lack thereof) among Philippine students that played PP by analyzing their eye movements. Eye-tracking is the method that has been used by researchers to quantify attention relative to the current line of sight of a participant on a given stimulus. This method is generally divided into two major metrics, namely saccades and fixations. Although, saccades are sudden changes of eye gazes between the occurrence of fixation points, no fetching of information happens during this phenomenon [11]. Fixation, on the other hand, is sustained eye gaze at a certain position which indicates a person's intention of what to inter-act with [16], what is the current task a person is working on [15], and that it is a proxy indicator of attention[5]. Because of this, fixation metrics have been used in conducting the analysis in this study. The questions that the researchers aimed to answer in this study are the following: *(1) To what extent can quantify attention of students playing PP by using eye gaze? and (2) Is there a relationship between student'seye movement and performance?*

3 Methodology

Participants and Materials

● A total of 30 high school students were recruited from different parts of the Philippines for this experiment. There were 19 male and 11 female participants.

● Two types of stimuli were used in this experiment. The first type (in Figure 1) contained the simple machine hint that was most relevant to the solution. The second type was the preselected image of the game level problem from PP name Cloudy Day. The regions of interest (ROI) of each stimuli were later defined to investigate how the participants fixated in hint, initial location of the green ball, solution space, travel path, target location of red balloon, and other objects.

Instrument

The EyeNTNU-120 eye tracker (Figure 2 below) was used to record eye movement data while students were looking at the preselected PP problem and thinking of a solution. This device has a sampling rate of 120 Hz and an error rate of less than 0.3 degrees. The four vital metric fixation variables provided by the system have been used for data analysis are the following:

1. Total Contact Time (TCT) - total time in milliseconds a participant gazed at an ROI
2. Number of Fixation (NOF) - the count of fixation in an ROI

3. Latency of First Fixation(LFF) - the time of first fixation on an ROI
2. Duration of First Fixation (DFF)- the total time the first fixation on an ROI lasted
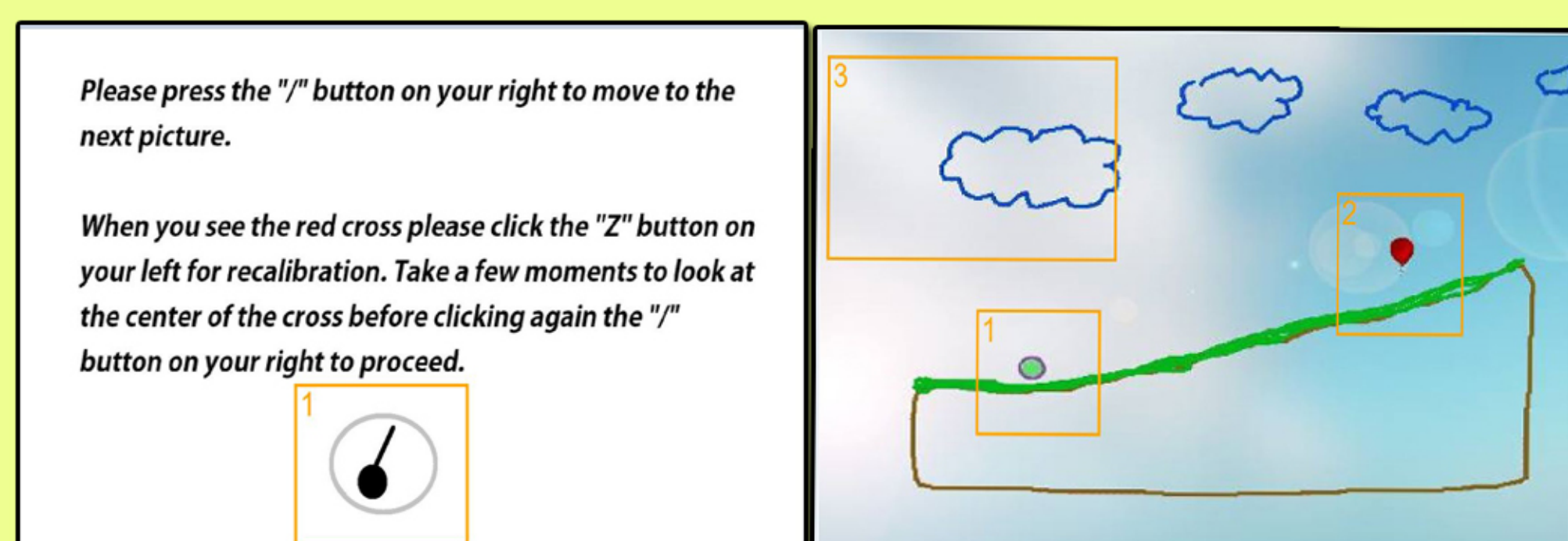

Figure 1. Stimulus 1 on the left picture is the Pendulum Hint for Stimulus 2 on the right picture which is the PP game level named Cloudy Day
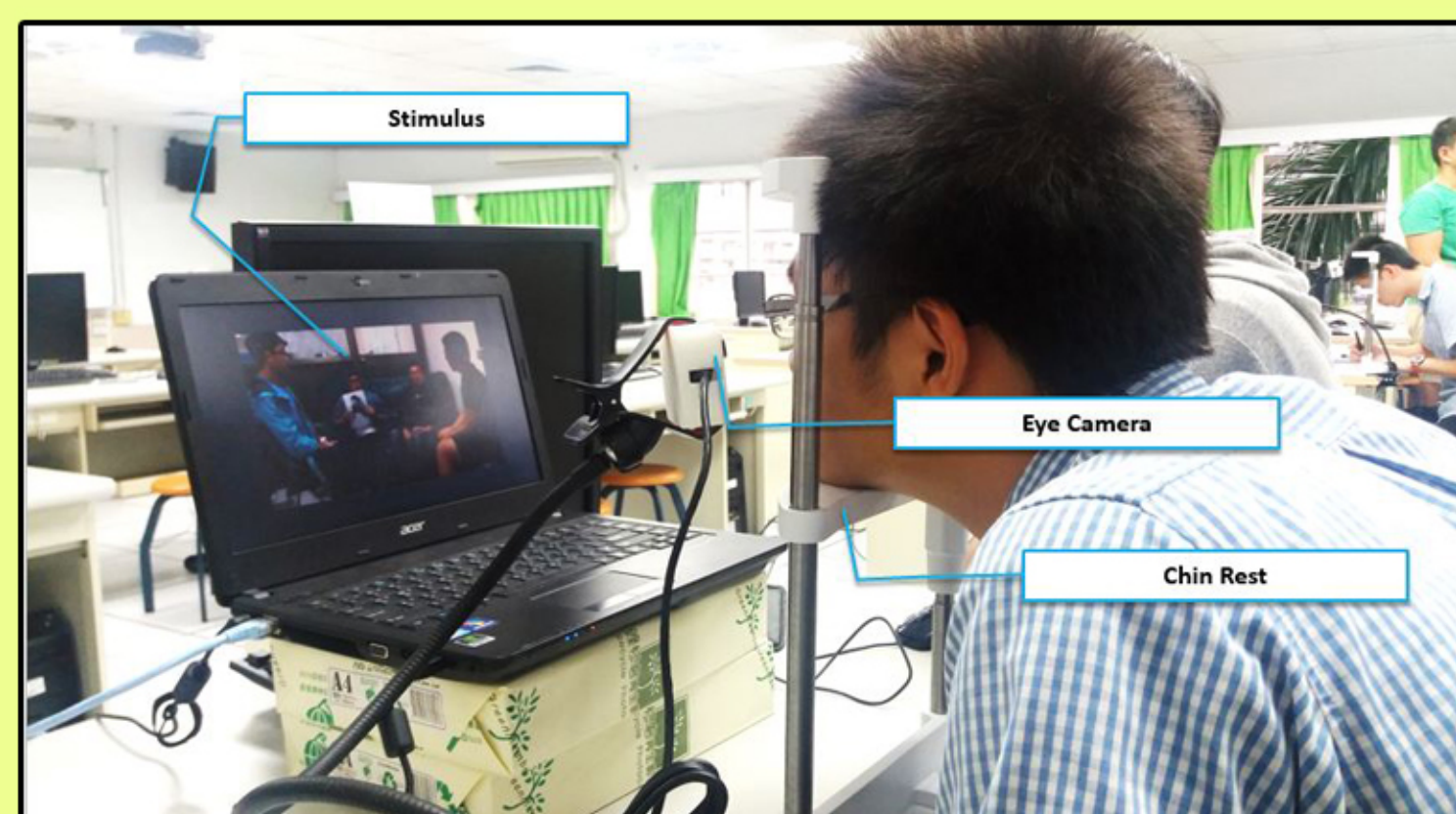

Figure 2: EyeNTNU120 Camera and Chin-rest Set-up

4 Main Results and Conclusion

Out of 30 participants, 20 solved the problem. Six participants earned gold badges and the other 14 received silver badges. Ten participants did not earn any badges. The The significant results for the metric values per ROI and and ROI combinations are the following:

1. TOTAL CONTACT TIME(TCT)

● Gold badge earners had significantly less TCT on Hint than the silver badge earners (t16=2.673 ; two-tailed p=.017). In addition, gold badge earners had significantly less TCT on the Hint than those who did not earn any badge (t10=2.339 ; two-tailed p=.0414).

● Combination of ROIs refer to the average metric values of regions that are essential for solving a level.Gold badge earners had a margin of significantly less TCT on ROI combinations than those who did not earn any badge at all (t14=2.132 ; two-tailed p=.0511).

2. NUMBER OF FIXATIONS(NOF)

● The gold badge earners spent less time gazing at the regions identified to be crucial in accessing information in solving a problem. Gold badge earners had significantly less NOF on ROI combinations than those who did not earn any badge (t14=2.438 ; two-tailed p=.0287).

3. LATENCY OF FIRST FIXATION(LFF) AND DURATION OF FIRST FIXATION(DFF)

● Gold badge earners accessed the solution space earlier but spent the least time on these spaceS themselves. This implies that these participants arrived at the solutions earlier and faster than those who did not earn any badge.

Conclusion

Results show that students that had good performance spent less time looking at the stimuli while thinking of a solution. In addition, participants who solved the problem accessed the solution space almost half the time earlier than those who did not solve the problem. These results are indicative that students that earned badges had thought of solution much more faster and earlier than those who did not solve the problem. These findings depart from Binder and et. al [4] who linked that sustained attention to better learning and better performance. Instead, participants in this study accessed the solution space that might have led them to think of a solution more quickly, hence they did not need to gaze at the material for a prolonged or sustained period of time. The researchers suspect that the difference in finding is due to the material and experiment design used. This difference in result is one interesting point for further examination. Furthermore, it is the goal of the researchers to investigate in the future work wether or not a common trend in attention levels of students can be found in other stimuli in PP.

5 References

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