British Journal of Educational Technology *Vol 38 No 3 2007* 538–542
doi:10.1111/j.1467-8535.2007.00721.x

Colloquium

Studying computer game learning experience through eye tracking

Serkan Alkan and Kursat Cagiltay

Address for correspondence: Kursat Cagiltay, Computer Education and Instructional Technology, Middle East Technical University, Ankara, Turkey. Tel: +90-312-2103683; email: kursat@metu.edu.tr

The use of computer games has been a popular but controversial issue. Dickey (2005) points out that instructional technologists are prepared to borrow techniques from various fields of media such as film, television and comics. Computer games, however, are ignored in terms of advancing new methods for instructional models despite a body of research on computer games and the availability of edutainment material in market. Pagulayan, Keeker, Wixon, Romero and Fuller (2003) suggest that 'the relationship between theories of game design and traditional HCI evaluation methods have yet to be defined but definitely yields an exciting future'. Recently, a few pioneering studies have investigated the use of computer games with eye tracking technology. Sennersten (2004), for example, studied eye movements in an action game tutorial, Kenny, Koesling, Delenay, McLoone and Ward (2005) investigated eye gaze data from a first-person shooter game. Eye tracking studies can be either top-down or bottom-up. Top-down studies are based on cognitive theories whereas bottom-up approaches analyse the data without having any prior theories relating eye movements to cognitive activity (Ramloll, Trepagnier, Sebrechts & Beedasy, 2004).

The aim of this study was to investigate how novices learn to play a computer game. To investigate this question, eye tracking method was integrated with usability study during the computer game learning experience. Specifically, this study tried to answer the following research questions:

- Which strategies are used to learn a new computer game?
- How does attention of participants change during game playing at different levels and different parts of the computer game?
- What are the usability issues of the computer game played by participants?

Method

Participants were 15 undergraduate university students. Eye tracking equipment (Eyegaze, by LC Technologies, McLean, Virginia, USA) was used to record the eye movements of the participants during the playing of the chosen computer game. The demo version of a computer game, *Return of the Incredible Machine: Contraptions* (Copyright by

Sierra On Line Inc, 2000) was chosen, as it does not feature violence, it requires decision making and problem solving constructs which are applicable in educational settings, it is played only with a mouse and it is not a widely known computer game.

Results

The game and eye tracking results

Two of 15 participants were eliminated from subsequent analyses as a result of errors that occurred during the data collection sessions. Eye movement data contained fixations and saccades. The mode of the fixation was 10 Hz which is equal to 167 milliseconds, and the mode of the saccade was 1 Hz, which is equal to 16.7 milliseconds. The mean duration of fixation was $\overline{X} = 20.29$ and $SD = 18.29$, and the mean saccade duration was $\overline{X} = 3.72$ and $SD = 55.41$ based on 60 Hz. Because the camera field rate was 60 Hz, which means 60 different records per second, the average of fixation corresponds to about 330 milliseconds or one-third of a second.

A comparison of individual participants' fixation scores on areas of interest are presented in Figure 1, which shows that the mean of fixation on menu produces smaller values than fixation on contraptions.

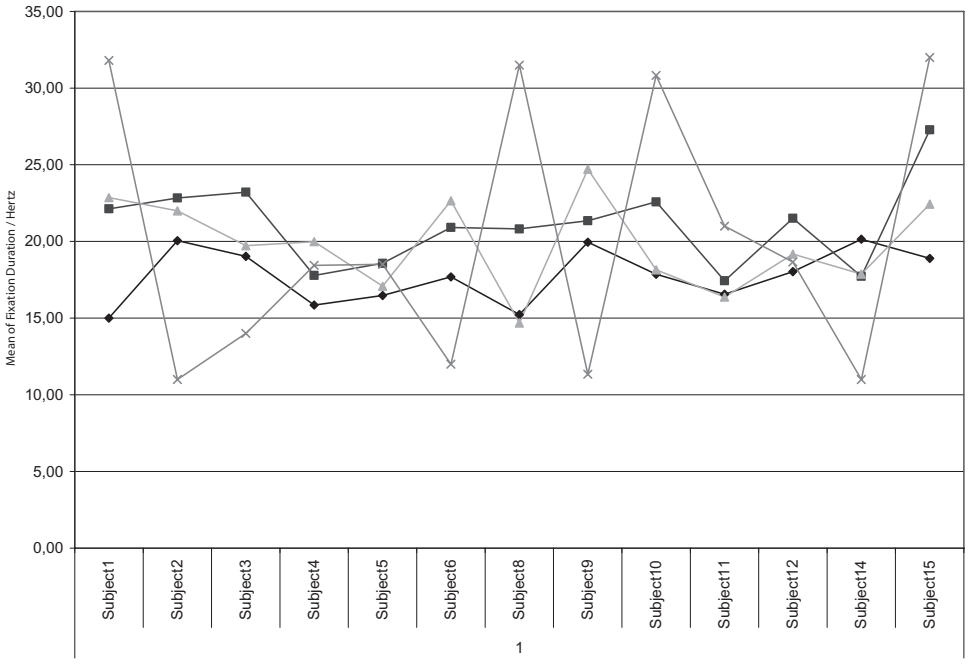

Figure 1: Participant's fixations on areas of interest. —◆—, menu; —■—, contraptions; —▲—, tools; —×—, outrange

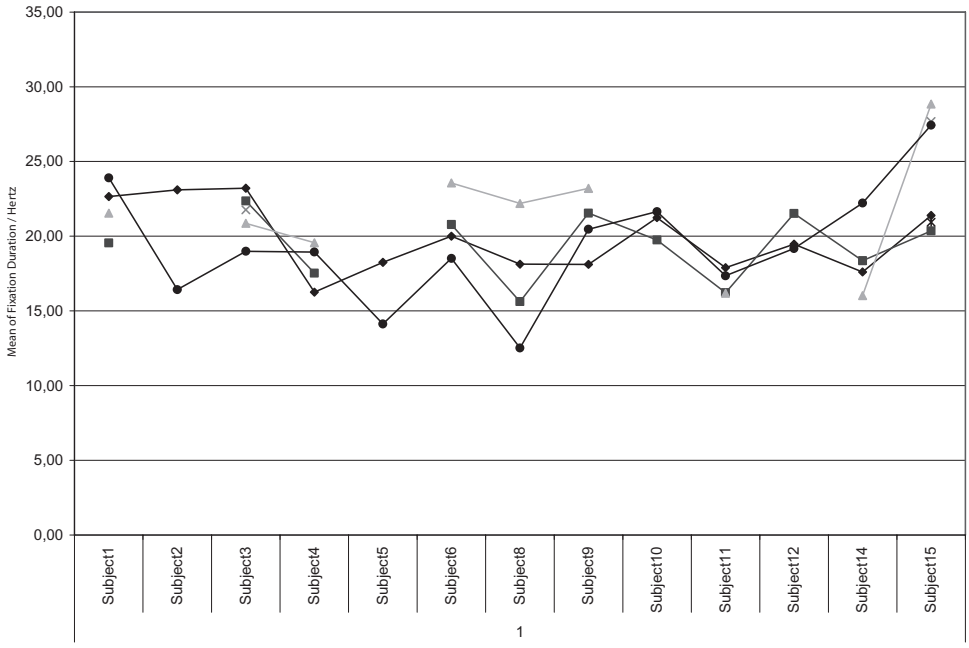

Figure 2: Mean fixations with respect to participant and level. —◆—, Level 1; —■—, Level 2; —▲—, Level 3; —×—, Level 4; —✳—, Level 5; —●—, interlevel

A comparison of means in terms of level and participant is given in Figure 2. To compare fixations with respect to participant and level, fixations on outrange area is omitted. The data shows that the mean of fixations across participants is quite variable. On the other hand, crossing lines between levels showed that the fixation means of levels are changed across participants. But, the variance of means across levels is smaller than the variance between participants. This pattern can be observed from the zigzagged outline of Figure 2.

Interview results

When participants were asked whether it is easy to learn this game, all of them answered that it is an easy game to learn. When they were asked to compare learning strategies of this game and other games that they had played previously, they answered that the learning strategies are different with other games. Video records showed that all of them preferred trial and error strategy. None of them except one reported a systematic strategy to solve the contraptions.

When they were asked how they can classify this game, they replied that this is a game that requires intelligence, reasoning and problem-solving skills. They classified this game as an educational game and one of the participants said that 'it is a game for

children'. When participants were asked to compare the *Incredible Machine* and the other games they had previously played, they mentioned that they prefer more complex action and strategy games.

Conclusions and discussions

The findings of this study revealed the information about how computer gameplayers explore a computer game that they do not know how to play, in a naturalistic manner.

Strategies used to learn a computer game

Participants of the study reported that they use the same strategy to learn all of the games: both trial and error and friends as sources of information about games. The insufficient use of documentation to reach information is worth considering. This result can be supported by another pattern in the game. All of the participants clicked on the hands that contain hints about the game, including exact information such as 'place cat here' or 'place cheese here'. The results showed that none of the participants followed the instructions given in the hints. Therefore, it can be concluded that the use of documentation in a computer game does not guarantee the understanding of information given to the users.

Eye tracking measures of the computer game

The quantitative results of the study are also consistent with the descriptive results, and may be used to investigate the interaction between user and the game. Specifically, the differences between fixation times and patterns of gaze at different areas of interest showed that the types of cognitive processes of participants changed subconsciously. The highest values of fixation times are obtained in the contraptions area, where the participants think about the possibilities of the solution. The menu has the lowest values in terms of fixation times because there is nothing to do in the menu area to solve the contraptions except press the start button.

Usability issues of the computer game

Because the participants explored the game in a free format, their natural experiences can give valuable clues about the usability characteristics of the game. Being a demo, the game provides neither a tutorial nor a help menu, so participants had to explore the game by themselves. However, none of the participants complained about the lack of documentation. The game provides sufficient control and freedom to its players. And the structure of the levels seems to be standard apart from each level becoming harder. All of the objects that will be used for the solution of contraptions are given in one screen. But, this does not mean that all of the hints or the tools are being used in that level, so there is no one-to-one correspondence in levels.

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