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THE EFFECTS OF DIGITAL GAME-BASED LEARNING ON PERFORMANCE AND MOTIVATION FOR HIGH SCHOOL STUDENTS

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Abstract. *The purpose of this study is to investigate the effects of digital game-based learning on the performance and motivation of high school students in computer science education. A simple matching game was designed using the ARCS Model which is well-known in instructional design, and can be implemented to various aspects of game-based learning. The game content was identified by reviewing the exact course content used at national schools. An experiment was conducted to examine the students' achievements through an exam and the learning motivations by The Motivated Strategies for Learning Questionnaire (MSLQ). One hundred and fifty two (152) tenth grade students participated in the users study, and were separated into two groups: one is the experimental group that used game-based learning, and the other is the control group which used the traditional face-to-face approach. The quantitative data was collected and the scores in both learning groups were compared. The results show that students who studied by a game-based learning model performed better than those who studied using traditional teaching sessions. The same users demonstrated positive attitudes toward the use of educational matching games.*

Keywords: Motivation, Game-based learning, Performance, ARCS

1. **Introduction.** Computer games could be effectively applied to education. Ebner and Holzinger [1] indicated that educational games can enhance students' learning interests. It was also shown that games are able to increase motivation towards learning [2].

The computer and mobile devices have become crucial equipment of an adolescent's life. Almost all adolescents experience game playing, searching information and various applications using current technology.

Recent hi-tech games even allow players to immerse themselves in a virtual environment as supporting the game-play experience with interactive feedback. Adolescents, called digital natives, have great access to the digital technology and show natural familiarity to technological progress [3]. Male high school students prefer role-playing, action, strategy, and sports games, while female students most frequently play puzzle games [4].

The implementation of games into education is often more effective than traditional approaches in improving motivation, concentration, and active participation in learning [5]. Games also might strengthen the social skills of students as well as improve their skills in analyzing and solving specific problems [6]. They are flexible and complex enough to provide resources for different learning styles and support cooperation.

Oblinger [7] points the advantages of using games for educational purposes: (i) games can provide multi-sensory, active, experiential, problem-based learning, (ii) players can get feedback immediately, (iii) games are able to provide self-assessment by score, and (iv) players might interact with larger communities in game environments. The primary challenge of integrating game based learning in formal traditional settings is providing an effective connection between the knowledge learned in the game and the knowledge learned in the classroom [8]. Digital games allow the educational paradigm to change from a teacher-centered to a student-centered environment.

Designing an educative game suitable for its specific goals requires more effort and time. It is necessary to be able to combine pedagogical aspects and game design principles for better functionality and outcome of the related systems [9].

The purpose of this study is to examine the effect of digital game based learning in performance and motivation of high school students. A simple matching game was developed by the ARCS (Attention, Relevance, Confidence, Satisfaction) Model [10].

An experiment was conducted with 152 participants and the subjects were divided randomly into experimental and control groups. The learning achievements and motivation outcomes were compared between the groups.

2. **Research Procedure.** The researchers have tried to design digital educational games for various fields such as mathematics, computer science, medicine, and language [11-14].

The research procedure includes the following steps: (1) design and development of a matching game by the ARCS Model; (2) pre-test to collect demographic information and the MSLQ (Motivated Strategies for Learning Questionnaire) data [15]; (3) digital game based learning (DGBL) and traditional learning sessions with high school students within their own context; (4) post-test for collecting data on Learning Achievement Test (LAT) and MSLQ; and (5) analysis of the data (Figure 1).

3. **Game Design: A Matching Game.** Identification of the characteristics of the target users, choice of relevant tools, and designing attractive interfaces are instrumental for encouraging further interaction but avoiding functionality problems.

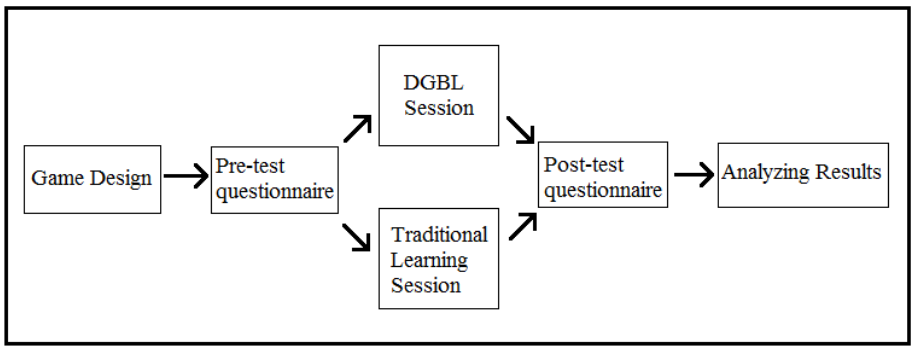

FIGURE 1. Research procedure

FIGURE 2. Matching game

An ordinary matching game was developed as a desktop application using the Java programming language (Figure 2). The content of the game was directly taken from the currently used textbooks and consists of terminology with the corresponding pictographic descriptions. The participants were expected to learn the basic computer programming terminology by playing the game.

The goal of the game was to match all the hidden images and terms used for computer programming. The game rules were very intuitive and simple since they were the same as a common matching game. Users could move to a higher level by matching images with terms randomly positioned in different locations on the screen. The goal was to test whether this simple matching game could stimulate a student's memorization and recalling abilities of new terminologies with corresponding visual representations.

Players were not allowed to pass to the next level without completing the previous round. The difficulty is increased at each level in terms of duration and number of boxes on the screen. A total of ten levels were prepared for the experiment. Students were required to remember the knowledge acquired in the previous levels.

Three lives were given to each player for the experiment. We designed the game to be easy and simple to make the students have a chance to concentrate on the content and learning process.

4. **Methods.** 152 participants (22 females, and 130 males) were randomly selected from a vocational high school located in Istanbul. All participants are 16 years old and they were divided into Group A (75 students) and B (77 students). They were enrolled officially in a *Fundamentals of Programming Language* class and the experiment was conducted for the students.

The game based learning was performed in a laboratory environment for Group A and a traditional teacher's lecture was given for Group B. The same teaching materials and content were used for both groups.

Before starting the sessions, a pre-test was given to collect demographic information and the motivational data. The learning sessions took 45 minutes and were held by the same instructor. PA post-test was given to the participants in order to evaluate the learning achievements and motivational scores once more (Figure 3).

The motivation was measured by the MSLQ. The questions were limited to intrinsic and extrinsic goal orientations. The questionnaire included nine items and a 5-point Likert scale was used. Additionally, an examination was designed to evaluate whether the students totally comprehended the course content or not. It was a multiple-choice written exam which contained ten questions and subjects earned ten points for each

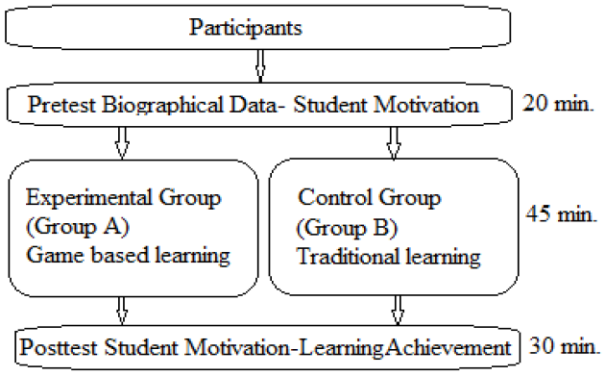

FIGURE 3. Experimental procedure

correct answer. The questions were prepared by two experienced instructors from the school.

5. **Results.** The average exam scores are 84.5 (SD = 13.78) and 74.5 (SD = 17.95) for the experimental and control groups respectively. A significant difference between two groups in learning achievements were observed ($t(150) = 3.84$, $p = .000$). The exam scores have shown that digital game based learning approach increases the students' academic success compared to the traditional method. The accurate balance between fun and education may be the primary reason for this improvement. Some previous research also supports our findings [17,18].

The motivational effect of game based learning on high school students was also investigated. The student motivations associated with the traditional lecture and game based learning environment have been compared by ANCOVA. The data collected for intrinsic and extrinsic motivation was examined separately.

In pre-tests, there was not a significant difference between two groups for both intrinsic ($F_{1,149} = .02$, $p = .882$) and extrinsic motivations ($F_{1,149} = 2.84$, $p = .094$). According to post-test scores, it was found that significant differences occurred between the two groups for both intrinsic ($F_{1,149} = 63.82$, $p = .000$) and extrinsic motivations ($F_{1,149} = 159.52$, $p = .000$).

These findings have shown that digital game based learning approach has a positive impact on students' motivation toward learning compared to the traditional approach. Game based learning attracts students' attention and reinforces their achievements. Recent research also supports this finding, specifically in comparisons of motivation toward learning [5,19].

6. **Conclusion.** High school students often have difficulties in understanding and memorizing the terms of programming languages. This research presents a contribution to the teaching of the main terminology used in programming languages through a game oriented learning approach.

The results show that game-based learning can improve the performance and motivation better than the traditional teaching method. The subjects demonstrated positive attitudes toward the use of an educational matching game for the class.

The matching game boosted the satisfaction, confidence, and attention of the students. The game allowed the participants to discuss their knowledge while competing with themselves and others. Students in the experimental group were observed to be more excited.

The reduced content by only including the programming terminology and the experiment's duration are the primary limitations of this research. Another game with a more interactive environment, including complex tasks and better graphical interfaces should

be developed for a more clear understanding of the students' attitudes and influential factors in the learning process.

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