Interactive Technology and Smart Education

An alternative evaluation: online puzzle as a course-end activity

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Received 17 April 2015
Accepted 20 April 2015

Abstract

Purpose – The purpose of this study is to determine whether the use of online puzzles in the instructional process has an effect on student achievement and learning retention. This study examined students' perception and experiences on use of puzzle as an alternative evaluation tool. To achieve this aim, the following hypotheses were tested: using puzzle activities in lessons increases student achievement, using puzzle activities in lessons increases retention of information learned by the students and students have positive attitudes toward using puzzle activities in lessons. This study uses an online puzzle system (OPS) by which instructors can prepare puzzle activities for students to solve online. The technical and functional properties of the OPS developed and used are beyond the scope of this study.

Design/methodology/approach – A pre- and post-test with control group experimental research design was implemented. Study participants were tenth-grade students in the Information Technologies Department of Gazi Anatolia Technical and Industrial Vocational School in Elazig during the 2011-2012 year. Thirty students each were chosen for the experimental and control groups, totaling 60 students. During the study, a traditional instruction method was used for the control group, while the experimental group received both traditional instruction and performed activities using the OPS. The subject Fundamentals of Networking was chosen, and the implementation period lasted six weeks. Four weeks after completion of the study, the achievement level of students was calculated again to test learning retention.

Findings – The first hypothesis of the study is, "Using puzzle activities in the lessons increases the achievement of the students". In the teaching of the Networking Fundamentals Module of Information Technologies Course for tenth graders, a significant difference in favor of the experimental group was seen, where online puzzle activities were used in terms of student achievement. The second hypothesis of the study is, "Using puzzle activities in the lessons increase the retention of the information learned by the students". Four weeks after completion of the study, the achievement levels of the students were calculated again to test learning retention. The learning retention of the students in the experimental group is higher than that of the students in the control group. In addition, students in the experimental group had positive attitudes toward online puzzle activities. Doing online puzzle activities accelerates learning for students and helps them learn networking terms by creating an enjoyable environment.

Research limitations/implications – The current study was limited to six weeks of implementation during the 2011-2012 school year at Gazi Anatolia Technical and Industrial Vocational High School in Elazig. Similar studies could be conducted in other schools for longer periods and at different levels, so the findings can be compared with those of the current study. This study is further limited to an Information Technologies Course. Studies can be conducted with various courses using appropriate online puzzle activities. Puzzle types other than the crossword used in the OPS of the current study should be developed and added. The system should also be developed by visual multimedia objects, allowing it to be more interactive. Moreover, in the development process of such an

Interactive Technology and Smart Education
Vol. 12 No. 3, 2015
pp. 169-182

1741-5659
DOI 10.1108/ITSE-04-2015-0008

OPS, educators, software designers, psychologists and scholars from other fields should work together. Usability tests should be conducted to improve user-friendliness of the system by adding various features related to functionality and visuality.

Practical implications – From the findings of the study, it can be concluded that online puzzle activities help students understand subjects better and aid in exam preparation. Moreover, these activities are effective for students in terms of increasing understanding and retention of learned terms in and outside class, forming valuable learning experiences. Doing online puzzle activities in class as a course-end activity can be said to be more effective in students' learning than doing them outside of class. Crossword puzzles offer opportunities for students to accelerate learning by quickly mastering new words and phrases and by directing students to more actively interact with computer-related vocabulary and terminology as compared with the rote learning method.

Originality/value – Paper-based puzzles are frequently used, and there are few Web-based puzzles. Despite their frequent use, preparing and evaluating paper-based puzzles can require a significant time investment; another disadvantage is the lack of immediate feedback. Based on the literature review, there is no dynamic OPS used for educational purposes. This study uses an OPS by which instructors can prepare puzzle activities for students to solve online. The originality of this study is OPS features and puzzle generation mechanism. The system presents a user-friendly interface with Turkish character (or any language) support and number-writing properties.

Keywords Computer software, Teaching methods, Assessment, Online applications, Learning methods

Paper type Research paper

1. Introduction

The world of the typical twenty-first-century student has always included Facebook, smartphones and personal computers. Their generation has been raised on interactivity, fueled by the Internet and video games and immersed in all things electronic. The pressure on schools and faculty to reach these students is growing, and appropriate educational strategies and tools encourage them to participate more actively in the teaching and learning process. On the other hand, because today's students have more diverse learning styles, it is important to incorporate multiple teaching techniques into the classroom experience (Hill *et al.*, 2003). The use of games in the classroom, which promotes the active learning process, can be an effective tool, especially at the college level (Davis *et al.*, 2009). Digital games present a form of interactive, relational, experienced-based learning that uses instructional technologies such as simulation and multimedia presentations. They are also fun, particularly for children and young people, and, therefore, highly motivating (Hromek and Roffey, 2009). We need additional high-quality research on game-based learning; there are important reasons for educators to engage with digital games. One literature review (McClarty *et al.*, 2012) has presented an overview of the theoretical and empirical evidence behind five key claims about digital games in education:

(1) they are built on sound learning principles;

(2) they provide more engagement for the learner;

(3) they provide personalized learning opportunities;

(4) they teach twenty-first century skills; and

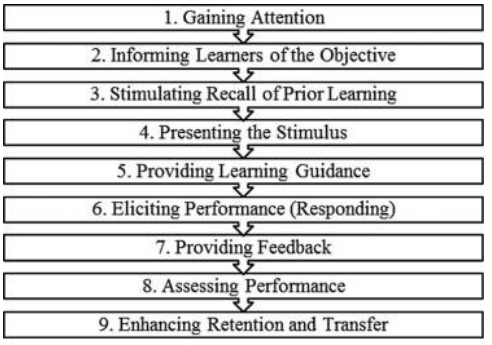
(5) they provide an environment for authentic and relevant assessment.

In another recent study, Takeuchi and Vaala (2014) found that 74 per cent of elementary and middle school teachers use digital games for instruction, especially to motivate and reward students (54 per cent) and for break time activities (43 per cent). Motivation is clearly a primary driver of digital game use in the classroom, and it is essential to determine the aims of the learning-teaching process to implement appropriate motivational strategies and behavioral responses.

In 1960, a pioneer in the behaviorist movement, Robert Gagné, developed the below teaching model (see Figure 1). This model provides a great deal of valuable information to teachers and is an excellent way to ensure an effective and systematic learning program, as it gives structure to lesson plans and a holistic view to teaching (Khadjooi *et al.*, 2011). Evaluating the results of teaching-learning activities and adapting material depending on these results is crucial in terms of retention of acquired behaviors. Behaviors not repeated adequately can be forgotten, so repetition should be made at a degree to promote retention.

During the 1960s, Edgar Dale theorized that learners retain more information by what they do as opposed to what is heard, read or observed. Dale (1969) has stated that retention rates of information learned are closely related to the manner of instruction. According to him, learning occurs 10 per cent by reading, 20 per cent by listening alone, 30 per cent by listening in combination with watching a board or projector and 50 per cent by watching people do something while listening. Moreover, the psychological basics of learning underline the fact that students should be at the center of study and do activities themselves. To relieve monotony in the classroom and arouse interest and encourage participation of students, activities such as puzzles and educational games should be used. These forms of active learning are helpful to review and practice, determine knowledge gaps and develop new relationships among familiar concepts.

A crossword puzzle is a kind of word game in which words, guessed from their definitions, are fitted into a diagram of white and black squares (Wahyuningsih, 2009). To complete a crossword puzzle, the players need to fill in blank squares with the correct letters. These puzzles can be a game for leisure time, but they are also considered a teaching tool that extends students' vocabulary knowledge, develops their attention and concentration and promotes intense searching strategies for solving problems because several skills including spelling, reasoning, evaluating choices and drawing conclusions



Source: Adapted from Gagné (1985)

Figure 1.
Steps in the teaching model

are required. The specific benefits and effectiveness of crossword puzzles can be found in many studies. In a medical study, it was found that crossword puzzle activities help build cognitive reserve and prevent memory loss (Wilson *et al.*, 2010). Gürdal and Arslan (2011) have suggested that using puzzles in lessons increases the attention level of students and retention of concepts. For these reasons, the crossword puzzle has been used in fields of education such as mathematics, science, biology and medicine to improve student learning.

Franklin *et al.* (2003) found that crossword puzzles accelerate learning for first-year biology students and helps them learn terms in an entertaining environment. In a study in the field of pharmacology, it was concluded that a well-planned crossword puzzle is an appropriate method for testing high cognitive levels when compared with other evaluation types (Sivagnanam *et al.*, 2004). In another study where crossword puzzles were used in a medical course, it was observed that using such an exercise stimulated and activated interactive learning among students, reflected by their positive attitude and response (Manzar and Al-Khusaiby, 2004). Weisskireh (2006) stated that a well-designed crossword puzzle activity may offer students an easy and engaging way to review concepts for a test. Songur (2006) stated that puzzles and games in mathematics support retention of the lesson, improve the attitudes of students and increase achievement scores when compared with traditional lessons. In a study where crossword puzzles were used in psychology and anatomy, students expressed that puzzles are attractive, entertaining and helpful in recalling the concepts and present a varied learning experience (Kalyani, 2007). Parsons and Oja (2008) conducted a study in which they used crossword puzzles for teaching computer terms and found a significant effect on increasing students' efforts to learn. In a study where crossword puzzles were used in the instruction of electro-magnetism, it was concluded that crossword puzzles created by a computer have useful effects on learning for engineering students (Olivares *et al.*, 2008). In a study where free software for creating crossword puzzles was used in the field of sports instruction, puzzles lessons increased the interest of the students compared to traditional instruction (Berry and Miller, 2008). Saxena *et al.* (2009) researched the benefits of puzzles in terms of being a fast, productive way of reinforcing the learning of short words and basic terminology. In blood science and pathology courses, groups of six and seven students were formed to solve puzzles. It was concluded that using crossword puzzles contributes to student learning. The researchers suggested that creating logical crossword puzzles is an effective method for transferring closely related content, discussing, recalling necessary words, thinking critically and forming small cooperative groups. In 2010, Whisenand and Dunphy (2010) concluded that the use of crossword puzzles accelerated the learning of vocabulary in an introductory management information systems class. In a study where students created crossword puzzles in the field of finance, students found the activity attractive and helpful in learning financial terms; students thought that this activity enhanced their creativity, reasoning, written communication and research skills (Serna and Azor, 2011). According to Gürdal and Arslan (2011), teaching Turkish to foreign students using puzzle activities increases the interest of the students and helps them learn.

Paper-based puzzles are frequently used, and there are few Web-based puzzles (Seçken, 2006; Tikbaş, 2011). Despite their frequent use, preparing and evaluating

paper-based puzzles can require a significant time investment; another disadvantage is the lack of immediate feedback. Based on the literature review, there is no dynamic, online puzzle system (OPS) used in Turkey for educational purposes. This study uses an OPS by which instructors can prepare puzzle activities for students to solve online. The technical and functional properties of the OPS developed and used are beyond the scope of this study. The system presents a user-friendly interface with Turkish character support and number-writing properties.

The general purpose of this study is to determine whether the use of online puzzles in the instructional process has an effect on student achievement and learning retention. To achieve this aim, the following hypotheses were tested:

H1. Using puzzle activities in lessons increases student achievement.

H2. Using puzzle activities in lessons increases retention of information learned by the students.

H3. Students have positive attitudes toward using puzzle activities in lessons.

2. Method

The current study seeks to determine the effects of using online puzzles on academic achievement and information retention. A pre- and post-test with control group experimental research design was implemented. Study participants were tenth-grade students in the Information Technologies Department of Gazi Anatolia Technical and Industrial Vocational School in Elazığ during the 2011-2012 year. Thirty students each were chosen for the experimental and control groups, totaling 60 students. During the study, a traditional instruction method was used for the control group, while the experimental group received both traditional instruction and performed activities using the OPS. The subject Fundamentals of Networking was chosen, and the implementation period lasted six weeks. Four weeks after completion of the study, the achievement level of students was calculated again to test learning retention. To remove bias, while forming the control and experimental groups, students were asked whether they wanted to participate in the study, and their test grades were taken into consideration. The views of students on which group they wanted to be in can be seen in Table I.

The students mostly preferred to be in the experimental group, as they found the online applications interesting and thought that they would learn better with the extra materials. Sixteen students in the experimental group were transferred to the control group through random selection. To determine whether the groups were equal, pre-test results of the Fundamentals of Networking Module Achievement Test collected at the beginning and at the end of the experimental process were taken into consideration. The results of the analysis are shown in Table II.

Table I. Students' preferences on group participation

Groups	No. of students	(%)
Experimental	46	76
Control	14	24
Total	60	100

As seen in Table II, there is no significant difference between the pre-test results of the groups.

2.1 Online puzzle system

OPS was developed using ASP.NET (Active Server Page) technologies and the Firebird database. The system provides three interfaces, one for the puzzle creator (e.g. a teacher), one for the puzzle user (e.g. a student) and one for the administrator. Students can only select puzzles created by the teacher and solve them according to the specified clues. The system can be divided into two main sections, the crossword puzzle generation mechanism and the puzzle filling mechanism.

2.1.1 Crossword puzzle generation mechanism. The puzzle generating mechanism consists of placing words on a grid vertically and horizontally. The generation algorithm is performed in two main steps:

(1) a puzzle definition is made in the system; and

(2) then a question pool of words and clues is created.

The server sends relevant words from the database to the client computer, and the client computer saves them to memory in a table. In this table, there are fields for the answer to the question (the word), its location in the puzzle (horizontal or vertical) and status information (placed or not placed). The words forming the puzzle are fetched from the database according to their sorted length. The first word is placed horizontally at the center of the grid, which consists of N rows and N columns. We tested our algorithm on a 100×100 puzzle. The system attempts to place the next word vertically on the grid, starting with the first row and first column. In the case of a match, the number of matched letters is stored in the memory, and the search continues. The most matched intersecting points are permanently placed in the grid. For each placed word, the status information is marked as placed in the table memory. To place a horizontal word, there must be no other horizontal words positioned immediately above or below, the next letter of the word must not exceed the limits of the grid and the last letter has to be the first letter of another horizontal word. Similarly, to place vertical words, there must be no vertical words positioned immediately to the right or left, the next letter of the word must not exceed the limits of the grid and the last letter has to be the first letter of another vertical word. The placement procedure is continued until all words are positioned in an optimum solution.

After the placement process is the recording step, where the coordinates and direction of each word are saved to the database. Thereby, the words are placed using these coordinates, creating the result puzzle. After registration, the extra free spaces are removed from the grid with the help of a trigger written into the table. For

Table II.
Pre-test results of the fundamentals of network module achievement test

Groups	*N*	X	S	*t*	Significance level
Experimental	30	25.65	4.35	0.87	0.21
Control	30	21.70	4.69		

Note: $p < 0.05$

this, the coordinates are reduced by the minimum numbers of columns and rows. Figure 2 shows the placement of the words into a puzzle that consists of six words (black, blue, yellow, white, green and red) and the result puzzle. To reach an optimal solution for the N × N diagram, the process of experimenting with the words in different sequences is repeated. As shown in the figure, the six words that make up the puzzle are placed in a 7 × 10 grid. The result puzzle is produced by removing the sections outside the new grid.

2.1.2 Puzzle filling mechanism. This is the area provided for the student, and it has four primary sections:

(1) At log in, the student is presented with a user-friendly interface for filling out the puzzle. It is simple to understand and use without any prior knowledge of the system.

(2) The user can select from a list of pre-developed crossword puzzles.

(3) After loading a specific puzzle, the clues for each word are displayed on the empty puzzle.

(4) The student enters potential words into the empty puzzle interface, and the system provides immediate color-coded feedback for each letter. Wrong letters are red, and correct ones are green.

2.1.3 The instructional features of OPS. The general purpose of the OPS is to produce puzzles that enhance the online instructional environment, making it more effective. Providing instruction in this environment can often be challenging, but finding solutions can also be entertaining. In addition, the system was developed to provide immediate feedback to students. Two puzzle activities were arranged: one at the beginning of a lesson for reviewing the previous lesson, and the other at the end of a lesson for reviewing concepts just taught. The instructor determined a time limit for completion. Figure 3 shows a screen capture of the OPS interface, and Figure 4 shows a screen capture of the solution page.

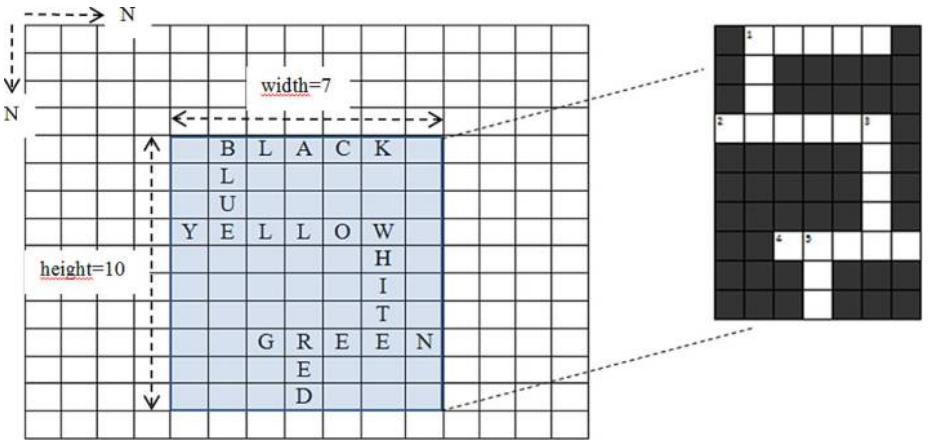


Figure 2.
Example of word placement and the production of the result puzzle

2.2 Data collection tools

Two types of measurement tools were used to collect data: the Information Technologies Course: Fundamentals of Networking Module Achievement Test assessed learning and retention levels of students in the experimental and control groups, and the Online Puzzle Use Attitude Scale determined student views.

2.2.1 Information Technologies Course: Fundamentals of Networking Module Achievement Test. This test consisted of 40 multiple-choice items in line with program gains, developed to measure achievement and retention levels of the students. To ensure the reliability of the achievement test, KR-20 value was calculated and found to be 0.63, with average difficulty as 0.47 and average distinctiveness as 0.36.

2.2.2 Online Puzzle Use Attitude Scale. This scale was developed by the researcher and applied to the experimental group. It included 25 questions, implemented to the vocational schools as opposed to the study group. The field experts analyzed the questions and made necessary corrections. A five-point Likert scale ranging from "strongly agree" to "strongly disagree" was used to determine the attitudes of the experimental group toward the use of online puzzles. The scale was tested on 101 students at four different schools of the same level as the schools where the research was conducted. For statistical analysis, Cronbach's alpha reliability co-efficient was calculated as 0.900. When the factor analysis table was analyzed, one factor showed a negative value; when one was left out, the reliability of the scale increased. Two items not suitable according to factor analysis were omitted, and Cronbach's alpha reliability co-efficient of the scale was calculated as 0.915.

3. Results

3.1 First hypothesis

The first hypothesis of the study is, "Using puzzle activities in the lessons increases the achievement of the students". Differences between pre- and post-test results of students in the study were evaluated. Average scores of students on the Information Technologies Course: Fundamentals of Networking Module Achievement Test were compared, and dependent group *t*-test results are shown in Table III.

As seen in Table III, post-test achievement scores increased for both groups. However, when post-test scores are compared, a significant difference in favor of the experimental group can be seen. According to this result, the first hypothesis was confirmed.

Figure 3.
Screen capture of OPS

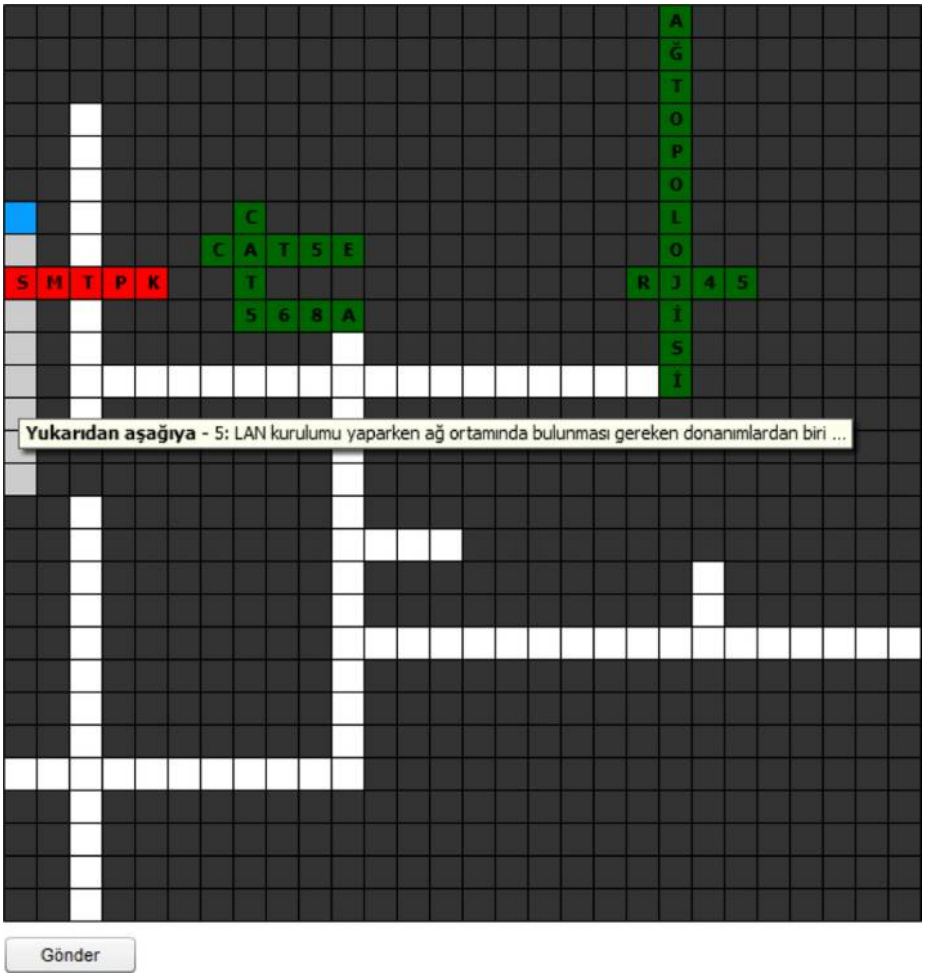


Figure 4.
Screen capture of the puzzle page of OPS

Groups	*N*	X	SS	*t*	Significance level
Experimental					
Pre-test	30	11.35	3.39	−77.6506	0.000
Post-test		38.75	3.85		
Control					
Pre-test	30	12.28	3.43	−19.65	0.000
Post-test		26.97	4.77		

Note: $p < 0.05$

Table III.
Dependent group *t*-test results of pre- and post-tests of experimental and control groups

3.2 Second hypothesis

The second hypothesis of the study is, "Using puzzle activities in the lessons increase the retention of the information learned by the students". Four weeks after completion of the study, the achievement levels of the students were calculated again to test learning retention. An independent *t*-test was conducted to compare retention scores of the two groups, and the results are shown in Table IV.

In the results of the statistical analysis, a significant difference by a level of $p < 0.05$ was found between the retention scores of the experimental and control groups. Therefore, the learning retention of the students in the experimental group is higher than that of the students in the control group. According to this result, the second hypothesis was confirmed.

3.3 Third hypothesis

The third hypothesis of the study is, "Students have positive attitudes toward using puzzle activities in their lessons". A 23-item 5-point Likert-type Online Puzzle Use Attitude Scale was developed and tested for validity and reliability by the researcher, then implemented in the experimental group. To assess the results of this scale, frequency, percentage, mean and standard deviation techniques were used. The means are listed in Table V in descending order. Gender difference was not a criterion, because the two groups consisted of only males. Moreover, students in both groups had approximately the same age and education level, so no grouping on these variables was formed in analysis. Results show that students in the experimental group had positive attitudes toward online puzzle activity. Based on these results, the third hypothesis was confirmed.

4. Conclusions and suggestions

The aim of this study is to determine whether the learning environment in which an online puzzle activity was used has an effect on student achievement scores. This activity was used in addition to traditional instruction based on narration. A six-week study was conducted in the Department of Information Technologies of Gazi Anatolia Technical and Industrial Vocational High School in Elazığ during the 2011-2012 academic year. In the teaching of the Networking Fundamentals Module of Information Technologies Course for tenth graders, a significant difference in favor of the experimental group where online puzzle activities were used in terms of the student achievement and retention of learning was found. Therefore, it is concluded that using online puzzle activities in courses such as Information Technologies where many terms exist assists the students' retention. This finding corresponds with studies conducted by Songur (2006), Saxena *et al.* (2009), Whisenand and Dunphy (2010) and Gürdal and Arslan (2011). Doing online puzzle activities accelerates learning for students and helps them learn networking terms

Table IV.
Independent group *t*-test results of retention test scores of experimental and control groups

Groups	*N*	X	SS	*t*	Significance level
Experimental	30	30.36	4.12	7.956	0.000
Control	30	22.52	3.95		

Note: $p < 0.05$

	No.	Item	X	SD
Strongly agree	2	I greatly enjoy the OPA process	4.63	0.71
	5	OPA eases the understanding of the terminology in the lessons	4.63	0.5
	17	OPA eases my learning	4.63	0.5
	23	The points gained in OPA form a competitive environment in class	4.63	0.71
	10	OPA helps me recall the terms and definitions	4.5	0.73
	12	I would like to do more exercises with OPA and similar activities	4.44	0.81
	6	OPA helps me to develop my terminology knowledge in the lessons	4.38	0.77
	7	OPA develops my self-confidence in knowing the terms	4.38	1.02
	14	It was fun to communicate with my friends while reviewing the material doing OPA	4.38	0.8
	8	OPA helped my exam preparation	4.31	1.07
	9	OPA was an entertaining activity supporting my learning of the terms in the course	4.31	0.79
	13	OPA developed my learning	4.31	0.94
	4	I want OPA to be used in other courses	4.25	1
Agree	3	Doing OPA was entertaining	4.19	1.1
	15	The time limit given for OPA was enough	4.19	0.88
	20	The words can be put meaningfully in OPA	4.19	1.04
	19	OPA provided more self-satisfaction	4.13	1.02
	11	OPA was an effective tool for arranging the terms in my mind	4.06	1.23
	1	I want to participate in an activity like OPA again	3.88	0.79
	22	I felt as if I achieved an important thing when I completed OPA	3.88	1.25
	21	I prefer OPA to fill-in-the-blanks in sentence-type questions	3.69	1.25
Hesitant	16	The questions used in OPA were appropriate for the puzzles	3.38	1.36
	18	OPA was a good method for reviewing the obscure course materials	3.25	1.36

Table V.
Means of the experimental group replies to questions of the online puzzle use attitude scale (OPA: Online Puzzle Activity)

by creating an enjoyable environment. Other studies (Franklin *et al.*, 2003; Kalyani, 2007; Lin and Dunphy, 2012; Parsons and Oja, 2008; Whisenand & Dunphy) also support that finding.

The statements of students that they like online puzzle activity, want to learn with these activities again and desire to see puzzles in other courses can be explained by motivation, one of the basic principles of learning. According to Yalın (2000), no one can learn without the desire. For this reason, instructors should use activities such as puzzles and games to arouse the interest and learning desire of their students. Prensky (2002) suggests that students feel comfortable and relaxed when entertainment is part of the learning process, allowing information to be absorbed easily. Moreover, immediate feedback is a necessity, as it increases effectiveness. The puzzle system used in this study gives students immediate feedback through color, helping students reinforce concepts to be learned. Students in the experimental group mentioned enjoying the slightly competitive atmosphere with the points earned from the puzzles. Students also mentioned the pleasure they felt after completing a puzzle. The level of difficulty compels students to try their best, releasing feelings of excitement, fear and enjoyment and satisfying their egos. There is a relationship between the difficulty level of the puzzles and self-efficacy perceptions of the students. When students complete an activity and move on to the next level, they feel a sense of accomplishment and pride.

From the findings of the study, it can be concluded that online puzzle activities help students understand subjects better and aid in exam preparation. Moreover,

these activities are effective for students in terms of increasing understanding and retention of learned terms in and outside class, forming valuable learning experiences. Doing these online activities in class as a course-end activity can be said to be more effective in students' learning than doing them outside of class. Gomez and Scher (2005) underline this conclusion by expressing that for courses in which the content is full of word-for-word important concepts, using crossword puzzles is more effective in cooperative environments.

The recommendations related to the OPS are as follows. The current study was limited to six weeks of implementation during the 2011-2012 school year at Gazi Anatolia Technical and Industrial Vocational High School in Elazığ. Similar studies could be conducted in other schools for longer periods and at different levels, so the findings can be compared with those of the current study. This study is further limited to an Information Technologies Course. Studies can be conducted with various courses using appropriate online puzzle activities. Puzzle types other than the crossword used in the OPS of the current study should be developed and added. The system should also be developed by visual multimedia objects, allowing it to be more interactive. Moreover, in the development process of such an OPS, educators, software designers, psychologists and scholars from other fields should work together. Usability tests should be conducted to improve user-friendliness of the system by adding various features related to functionality and visuality.

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