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Effect of Flipped Learning on Cognitive Load: A Higher Education Research

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ABSTRACT

The purpose of this study is to determine the effect of the flipped learning method on the cognitive load of the students. The study was conducted with a sample of 160 people who were trained in Department of Mechanical Engineering for algorithms and programming courses at a higher education level. The study, which lasted for 8 weeks, has a semi-experimental design. A 9-point scale developed by Paas and Van Merrienboer (1993) was used for cognitive load measurements. At the end of the weekly courses, the scale was filled by the experimental and control groups. Independent sample t test was applied through SPSS 24 program to the obtained data. In both instances, the cognitive load in the experimental group in which the flipped learning method was applied was found to be lower than the cognitive load in the control group in which traditional face-to-face training was applied. As a result, it can be said that flipped learning, if well structured, is a method reducing cognitive load.

Keywords: *Flipped learning, cognitive load, interactive video, EDpuzzle, higher education*

INTRODUCTION

Parallel to the developments and changes in technology, new technologies and pedagogies are used in the field of education technologies to increase the quality of education. In the last few years, special emphasis has been put on the flipped learning which is a kind of blended learning. In this model, it is aimed to benefit from advantageous aspects of distance education and face-to-face education. Flipped learning can be described as a process whereby students who are provided with various class materials can learn the theoretical subjects before the lesson and perform higher level of learning in the classroom under the guidance of an instructor. Learning in traditional face-to-face learning environments takes place with limited materials in a limited environment and limited time frame. However, it is not possible for individuals with different learning speeds and styles to evenly benefit in the same environment and at the same period of time (Kharat, Joshi, Badadhe, Jejurikar and Dharmadhikari, 2015). At flipped learning, the theoretical part where the lower level of learning takes place is reversed and moved out of the classroom while the homework is brought into the classroom. Thus, while the student can manage the learning process by himself/herself outside the classroom in a sufficient period of time through richer course material such as videos, podcasts, animations and presentations, he/she can carry out higher level of learning through more active learning activities in an extended period of time in the classroom (Roehl, Reddy, Shannon, 2013; Tucker, 2012). According to Bergmann and Sams (2012), the pioneers of the flipped learning approach, the main aim of flipped learning is to make the most of the time spent during the face-to-face learning process. In the 21st century, classes must become environments where knowledge is transferred to real life and learners must gain skills such as critical and creative thinking, problem solving, cooperation and communication. For all these gains, the flipped learning, a versatile pedagogical approach, can be benefitted from (Bradford, Muntean and Pathak, 2014).

Cognitive load is one of the important factors affecting the learning process of the individual. Cognitive load is a pressure on the cognitive system of the learner in the learning process and affects the learning process negatively (Sweller, Van Merrienboer and Paas, 1998). The excess cognitive load lowers the performance of the

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learner and affects the learning process and academic achievement negatively (Paas, Tuovien, Tabbers and Van Germen, 2003). Therefore, according to cognitive load theory, a well-designed learning environment will affect the learning process positively. There are three kinds of load in instructional material design. These are intrinsic cognitive load, germane cognitive load and extraneous cognitive load (Sweller et al., 1998). The actual cognitive load is related to the complexity and difficulty of the subject beyond the control of the instructional designer. Effective cognitive load, type of instructional material and learning efficacy can be controlled by the designer. The extraneous cognitive load is a burden caused by unnecessary items that are not of interest to the learned subject but occupies the short-term memory of the learner. These three loads cause the cognitive overload of the learner, overwhelming the short-term memory capacity. The transfer of too much information in a short period of time also causes cognitive overload. The same course content can create different cognitive loads in learning environments where different learning strategies and designs are used (Brünken, Plass and Leutner, 2003, Kılıç-Çakmak, 2007). The flipped learning can contribute to the decrease of the cognitive load level because it allows the learner to have knowledge about the subject before the lesson (Abeysekera and Dawson, 2014).

Programming education is widely used throughout the world, but there are many challenges in the programming teaching. Proulx (2000) states that initial-level programming training leads to the stumbling of students who are beginning to study in the field of computer science. Jenkins (2002) argues that programming is one of the most difficult course topics to learn. Kinnunen and Malmi (2008) state that 20% - 40% of the students enrolled in the programming introduction courses at universities around the world quit lessons or departments. This study is carried out for the teaching of programming where there are a number of difficulties and which requires a lot of information to be transferred in a short time and a lot of applications to be carried out. It is aimed to reduce cognitive load by using the flipped learning in programming teaching and to achieve higher level of learning by making a large number of applications in the classroom. It is hereby aimed to contribute to the literature through the improvement of the quality of education by using a current teaching method.

METHOD

The study was carried out within the scope of Algorithm and Programming course with a total of 160 first-graders from Aksaray University's Department of Mechanical Engineering. The study was planned and implemented in 8 weeks. Daytime education students and evening education students with no significant difference between them as a result of the pre-test were determined as experimental and control groups. While the flipped learning method was performed with the daytime education students in the experiment group, the face-to-face education was performed with the evening education students in the control group. The number of students in the experimental and control groups is shown in Table 1 below.

Table 1. The number of students in the experimental and control groups

Department	Experimental Group (f)	Control Group (f)	Toplam (f)
Mechanical Engineering	80	80	160

Interactive learning videos were developed for the subject of each week to be used for pre-class learning by the flipped learning group. These videos were shared with the students on a weekly basis through the EDpuzzle video learning management system. Different interactive features were added to each video to make the learners active recipients and to enable the learners to be involved in the learning process. With these interaction features, multiple choice questions, true or wrong sentences and open-ended questions were directed to the students and instant answers and corrections were given to the answers; sometimes with in-video links, students were directed to different learning materials. In Figure 1 below, there is an interactive video shared with the students for pre-class learning. The green question mark icons on the time bar of this video show where the interaction features are located. For example, at the 3rd minute of this video, students were asked a multiple-choice question about the topic covered at the time. The students are able to see the correct answer to the question as soon as he/she answers the question.

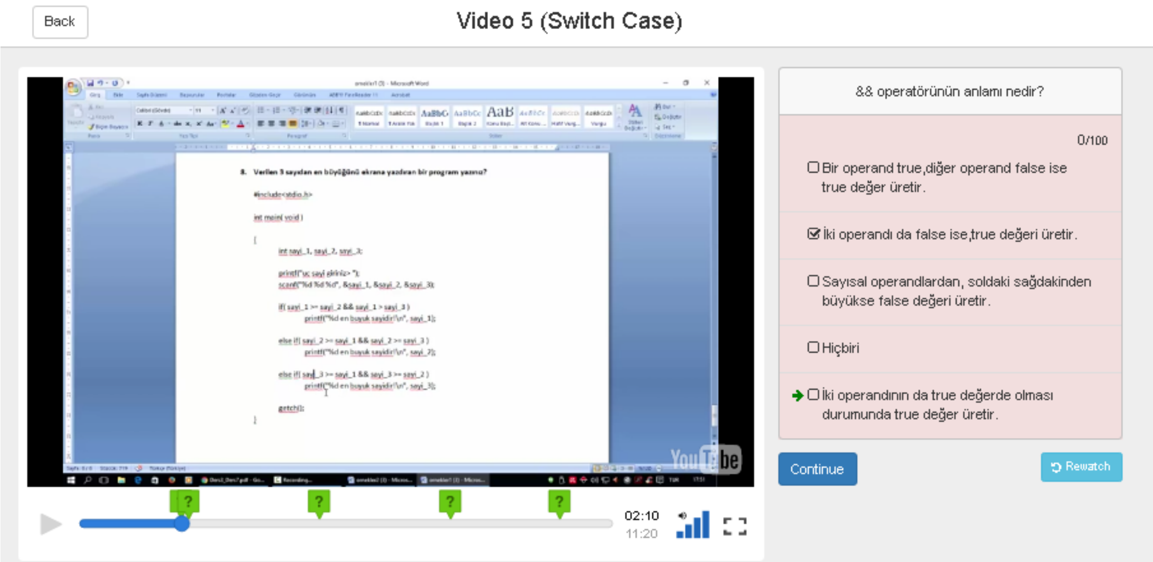

Figure 1. Interactivity features on videos shared with the students

In Figure 2 below, there are interactive videos shared with the students over the learning management system. Students can see the scores they receive from interactive videos on this page in the learning management system. They can rewatch the video from the review section and see the questions on the video and their answers from the progress section.

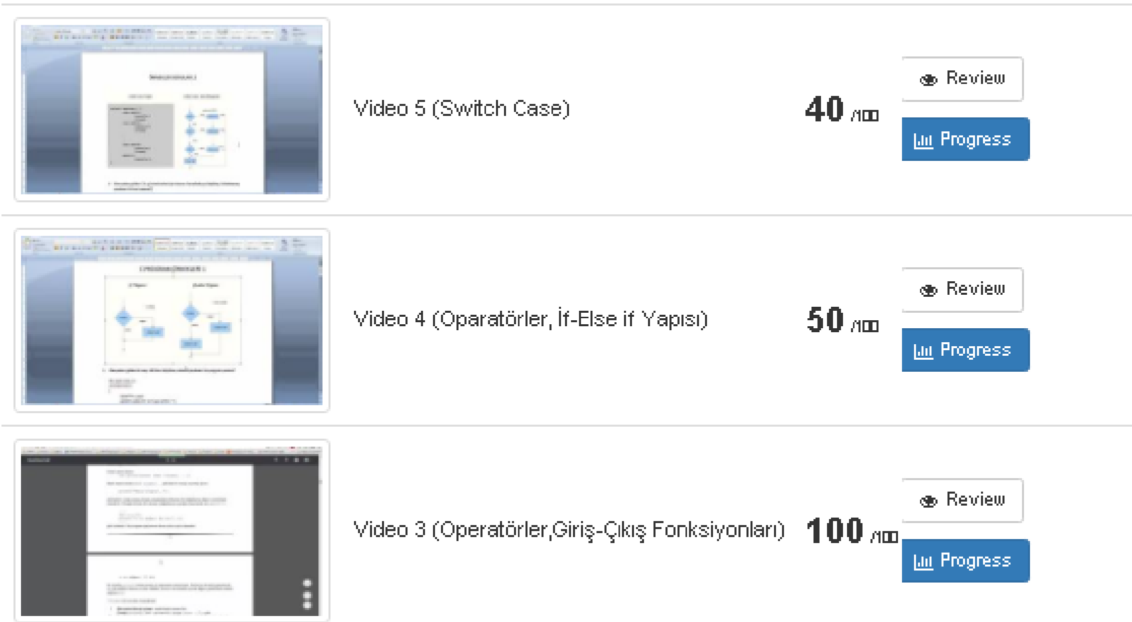

Figure 2. Videos shared with students and video-based scores of students

Figure 3 below shows the video-based scores of the students. Students' answers to the questions on a video, the number of correct answers, and the video score they get can be followed on this screen.

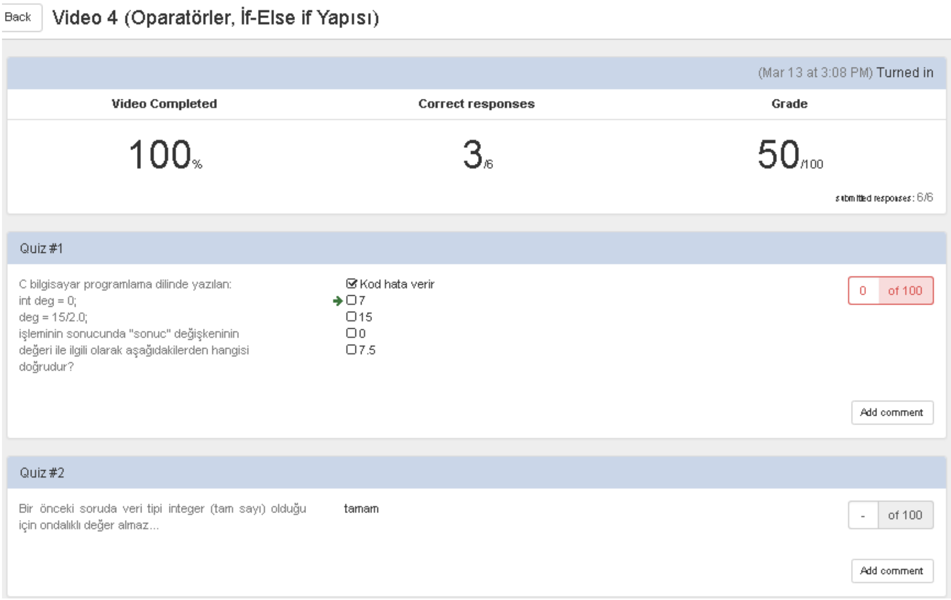

Figure 3. Video rating student screen

Interactive videos developed for each course were shared throughout 8 weeks with the experimental group including daytime education students and to whom the flipped learning method was applied and pre-learning level of the students was monitored through the video learning management system. The students who learned the theoretical parts of the course via video were engaged in applied activities in the classroom under the guidance of teaching staff. At the beginning of each lesson, if any, unlearned sections and important points were re-emphasized to overcome the missing learning.

Feedback from the students at the beginning of the face-to-face course and the answers given to the video questions shared on the learning management system were taken as basis in the determination of the unlearned sections. Figure 4 below shows the correct response rates given by the students to the questions on the video No. 5, which discusses the switch case concept. For example, in the system where 87 students were registered, 49 students responded correctly to the first question. Since the correct response rate is low compared to other questions, the subject matter of this question was repeated during the face-to-face course.

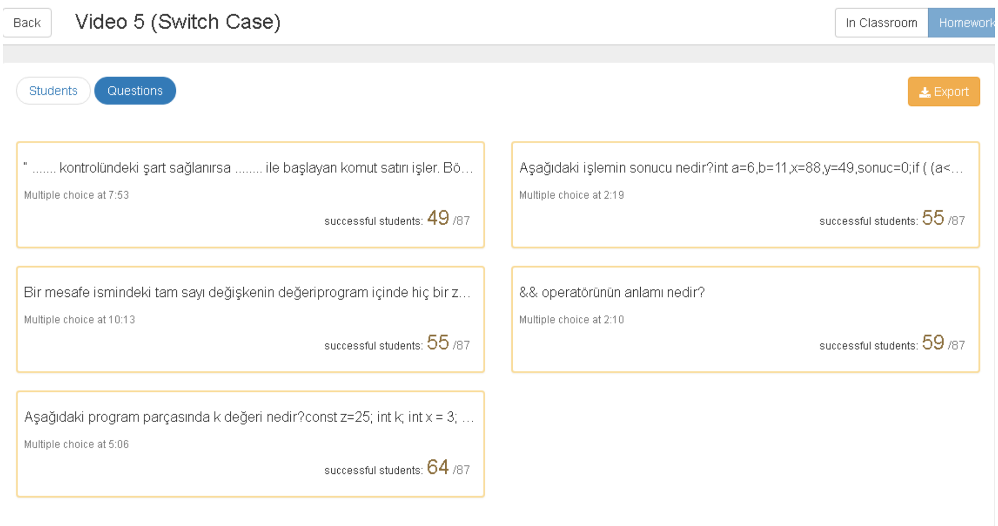

Figure 4. Teacher screen where video responses are checked

Table 2. Subject coverage of interactive videos

Subjects of interactive videos	
Week 1	Algorithm and flow charts
Week 2	Introduction to C programming
Week 3	Operators, input-output functions
Week 4	Operators, if-else if statements
Week 5	Switch case
Week 6	While, do while, for loops
Week 7	Loops, ınfinite loop, break and continue statement
Week 8	An overview - resolving examples

The subjects that were followed during the applications are shown in Table 2 according to the weeks. Every week, after the shortcomings were completed at the beginning of the face-to-face lessons, many applications were carried out in the course. Some examples of course applications were:

Application 1: Write a program's algorithm that determines whether a number entered from the keyboard is zero, positive or negative, and draw the flow diagram.

Application 2: Create the flow diagram of the program that finds the largest number of 3 different numbers entered from the keyboard.

Practice 3: Code a program that calculates the average by taking 2 midterm exam grades and 1 final exam grade that are entered from the outside and calculates the minimum final exam grade to be achieved in order to be successful in the midterm exams? (Midterm exam 1: 20%, midterm exam 2: 30% and final exam: 50%)

Application 4: The total length of a triangle's two edges cannot be less than the third edge. Moreover, the absolute value of the difference between the two edges should not be greater than the third edge. Using this information, write a program that shows whether to draw a triangle according to the given three edge lengths. (The entered edge lengths will be an integer)

Application 5: Write a C program highlighting "wear your coat" if the temperature entered from the keyboard is below 5 degrees, "wear your shirt" if the temperature is between 5-15 degrees and "wear your t-shirt" if the temperature is above 15 degrees.

The grades of the students in a 20-person class will be entered from the keyboard. Write a C program which finds the average of the class, the highest and lowest grades in the class and displays it on the screen after the grades are entered.

Face-to-face education was applied to the evening education students in the control group during the 8 weeks of the research. Following the lecture, sample applications are carried out for the remaining time and applications that could not be done due to time constraints were given as homework. The same course content was applied to both the experiment and control groups. The questions asked via the interactive videos in the experiment group were directed to the class during the lecture in the control group. Thus, equality between experiment and control group was tried to be secured.

A 9-point scale, developed by Paas and Van Merrienboer (1993), adapted to Turkish by Kılıç and Karadeniz (2004), was used for cognitive load measurement. The internal consistency coefficient of the scale was 0.78, and the Spearman-Brown split-half test correlation was 0.79. The scale was applied to both the experimental group and the control group for a period of 8 weeks after the face-to-face lessons. At the end of the application, mean scores of experimental and control groups were taken and analyzed.

FINDINGS

Independent samples t test was used to determine whether there was a significant difference between the cognitive load scores of the experimental and control groups. For the independent sample t test, the groups must be independent of each other, have normal distribution and have equal variances. In this research, groups are independent because experimental and control groups are not influenced by each other. Table of normality that required for independent samples t test is shown below. According to the Kolmogorov-Smirnov test result, experimental and control group scores show normal distribution.

Table 3. Normality test results

Tests of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
Data	Exprimental	,095	80	,069	,961	80	,015
	Control	,105	80	,031	,960	80	,013

a. Lilliefors Significance Correction

The variance equality test result and independent sample t test result of the experimental and control groups scores are shown in Table 4 below.

Table 4. Equality of variances and cognitive load mean scores t-test results

Independent Samples Test						
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig.(2-tailed)
Data	Equal variances assumed	1,563	,213	-19,275	158	,000
	Equal variances not assumed			-19,275	156,942	,000

According to T test result, it is seen that the difference of mean cognitive load scores in experimental and control groups is significant. Cognitive load average scores occurring in the experimental and control groups at the end of 8 weeks of practice are shown in Table 5 below.

Table 5. Cognitive load average scores

Department	Experimental Group Average Score ($\bar{x}$)	Control Group Average Score ($\bar{x}$)	Difference
Mechanical Engineering	4.23	6.18	1.95

CONCLUSION AND DISCUSSION

In this research where the effects of the use of the flipped learning method on the cognitive load of learners were investigated for teaching programming at higher education level. In other words, the cognitive load in the group in which the flipped learning method was used was found to be lower than that of the traditional face-to-face training and this result was statistically significant.

When the literature is examined, we don’t see many studies in which the effects of flipped learning on cognitive load were searched. Turan and Göktaş (2016) investigated the effects of flipped learning on academic achievement, motivation and cognitive load in 116 university students in a basic computer lesson and found that the cognitive load was lower in the experimental group in which flipped learning was applied than in the control group where traditional education was performed. Seery and Donnely (2012) found that learning materials given before face-to-face lessons lowered the cognitive load of the students. Abeysekera and Dawson (2014) stated that students can create cognitive schemes and reduce cognitive load with pre-course learning materials provided to them in flipped learning. On the other hand, two out of 9 ways presented to prevent excessive cognitive load are individualization and pre-learning (Mayer and Moreno, 2003). Schar and Zimmerman (2007) emphasize that students will improve their performance at their own pace and their own management. Wouters, P., Paas, F., & Van Merriënboer, J. J. G. (2008) stated that the learning control of the student does not lead to excessive cognitive load in the case of self-regulation.

The students in the sample group of the research encountered a great deal of new knowledge because they got the algorithm and programming lesson for the first time and as a natural result of the lesson. The students of the flipped learning group have benefited from the advantages of time flexibility and material diversity prior to a face-to-face lesson and have come up with cognitive schemas related to the subject (Abeysekera and Dawson, 2014). For this reason, it can be said that the cognitive load in the classroom learning process has decreased. When the flipped learning is well structured, it comes out as a way to reduce cognitive load.

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