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# THE FLIPPED CLASSROOM: INSTRUCTIONAL EFFICIENCY AND IMPACT ON ACHIEVEMENT AND COGNITIVE LOAD LEVELS

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**Keywords:** Flipped classroom, Cognitive load theory, Instructional efficiency; Media in education; Improving classroom teaching.

This research focuses on the efficiency of the flipped classroom method and its effects on students' achievement and cognitive load levels. The flipped classroom method is compared to traditional techniques in this study through quasi-experimental research. Participants included 116 prospective teachers assigned to experimental and control groups. The study was conducted over 10 weeks during the 2013–2014 spring semester. Results showed that students taught with the flipped classroom model reported higher learning achievements and lower cognitive loads than those taught with the traditional model. The instructional efficiency scores of the students in the experimental group were also higher than those of the students in the control group. Hence, when designed effectively, the flipped classroom method can be considered a useful approach in higher education settings.

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## 1 Introduction

The flipped classroom is a hot topic in today's educational research, gaining many followers and attracting the attention of teachers, academicians, and school administrators (Abeysekera & Dawson, 2014; Chen, Wang, Kinshuk, & Chen, 2014). The flipped classroom model may be adapted in many ways, but at its core, it inverts the time and place of homework and instruction, allowing students more time for collaboration and engagement in constructivist learning environments (Abeysekera & Dawson, 2014; Ash, 2012; Chen *et al.*, 2014; Love *et al.*, 2014; Street *et al.*, 2015).

The flipped classroom method was first described in 2000 by Baker, who attempted to provide students with learning materials for outside class and the opportunity to work more collaboratively with teachers and each other during class (Strayer, 2012). Lage, Platt, and Treglia (2000) employed the same process and coined the term "inverted classroom." They developed this method by showing videos and PowerPoint slides to an undergraduate economics class, receiving positive feedback from students. They also established a more active classroom environment, which is more enjoyable and leads to increased interaction with peers (Johnson & Renner, 2012).

Instructors in higher education settings may prefer the flipped classroom for many reasons. An important advantage of flipped classrooms is that they provide students with the ability to study at their own speed and in their own time (Davies, Dean & Ball, 2013); they also enhance practice time during lessons (O'Flaherty & Philips, 2015). Previous studies have found that the flipped teaching method decreases stress (Marlowe, 2012) and increases student cooperation, innovation, task orientation, and metacognition skills (Strayer, 2012). However, the number and breadth of studies about the flipped classroom method indicate that research on this subject is still in its infancy. Additionally, the impact of the flipped classroom is still being disputed. For instance, several studies have found that the flipped classroom method increases student achievement (Baepler, Walker & Driessen, 2014; Hung, 2015; Love *et al.*, 2014; McGivney-Burelle & Xue, 2013; Moravec *et al.,* 2010; Murphree, 2014; Street *et al.*, 2015; Touchton, 2015; Wilson, 2013). Conversely, many other studies have found that flipped classrooms have no impact on achievement (Bishop, 2013; Clark, 2013; Davies *et al.*, 2013; Howell, 2013; Johnson & Renner, 2012; McLaughlin *et al.*, 2013). These differences may be related to implementation types. The flipped classroom is a new culture for students and instructors and does not have a strict theoretical framework, which leads to varying results. Another factor potentially explaining these differences is related to student motivation. O'Flaherty and Philips (2015) have suggested that the impact of the flipped classroom should be examined through longitudinal study.

Further, Chin (2014) stated that there is "not strong evidence to support the claim that student learning was enhanced by this format" (p. 1). Therefore, the present study is important because it clarifies a contradiction in the literature.

Traditional instruction methods frequently do not provide enough time for both content presentation and hands-on activities (Fautch, 2015). Additionally, practical applications are important during class activities in higher education (Pluta, Richards & Mutnick, 2013). Therefore, the flipped classroom method may be a good solution for these types of courses because it frees up time for in-class activities and increases practical application. Modern teacher education demands the design of more effective technology teaching courses, yet no studies have been conducted about the implementation of flipped classrooms in these courses. The current study will also thus contribute to teacher education, especially with regard to improving technology teaching courses.

The flipped classroom method uses materials such as videos, books, and sound recordings and features several in-class hands-on collaborative activities. These instructional strategies can affect students' cognitive loads, which should be considered by educators when planning. Abeysekera and Dawson (2014) stated that it is essential to examine the impact of the flipped classroom method on students' learning, cognitive load levels, and motivation. Currently, limited study has been conducted about its effects on cognitive outcomes, so this study will contribute both to the literature and to practitioners. Cognitive load means the resources used by an individual's working memory at a certain time (Sweller, 1988). Based on the Cognitive Load Theory, efficient instruction should have a small extraneous load and an optimized germane load (van Gerven *et al.*, 2002). Clark, Nguyen and Sweller (2006) stated that efficient instruction increases learning outcomes and decreases cognitive load. Accordingly, an instruction efficiency formula based on the ratio of mental effort and test performance was developed by Paas and van Merriënboer (1993): E (instructional efficiency) = (ZPerformance – ZMentalEffort) /. This formula has two variables, standardized measures of performance and mental effort. Standardized measures are calculated through Z scores. Z score is a measure of how many standard deviations from the mean of the score. In order to calculate Z score this formula is used: Score-Mean/StandardDeviation. According to this measurement, the difference between these two variables results in positive or negative number for instructional efficiency.

A review of previous studies shows that the flipped classroom method has not been well explored or theorized so far (Ash, 2012; Chen *et al.*, 2014). Taking the advantages of this model into consideration, it is important to investigate how it can be used effectively in teacher education and to what end. As mentioned before, the model has been shown to have both positive and negative effects on instruction (Hung, 2015). Therefore, a deep investigation

must be made into a flipped classroom implementation. In the current study, the effects of a flipped classroom on students' learning achievements and cognitive load levels were investigated. It is important to investigate the efficiency of flipped classrooms in relation to students' cognitive load levels, particularly as no current studies have done so. These results will offer a new foundation to flipped learning for researchers and teachers. Due to the newness of the subject, this study introduces key ideas about the complexities of the flipped classroom method.

Within this context, three research questions will be examined:

Is there any difference between the control group and experimental group concerning the students' learning achievements?

Is there any difference between the control group and experimental group concerning the students' cognitive loads?

Is there any difference between the experimental and control group concerning the students' efficiency scores (calculated using achievement and cognitive load scores)?

## 2 Methods

This research used a pretest and posttest quasi-experimental research design. Inferential statistics were used to investigate differences between the control and experimental groups. The setting for the study was a basic computer skills and MS Office teaching class facilitated by the Early Childhood Education Department of a large university in Turkey. The implementation stage of the study was performed over 10 weeks for 2 course hours (120 minutes) each week for each group.

### *2.1 Participants*

The participants were two classes of first-year students. Both groups included 58 students: 3 males and 55 females in the control group and 10 males and 48 females in the experimental group. None of the students had any prior experience with the flipped classroom method.

### *2.2 Procedures*

Both groups covered the same topics in the same week by doing the same activities. Students in the experimental group did their homework in school, while the control group students did the same homework out of school, according to flipped classroom strategies. In the experimental group, content was delivered before class via a video lesson conducted by the instructor, but the instructor lectured directly to students in the control group. All students in

both groups registered for Moodle, which is a learning management system, as well as a designated Facebook group.

According to the flipped classroom method, content should be given before the lesson via video recordings, audio recordings, or texts. In this study, the instructor, who was also one of the researchers, posted content to the experimental group on a dedicated YouTube channel and Facebook group at least four days before class. Every week, videos were uploaded to YouTube and announced on Facebook. Students in both groups discussed their questions in their specific Facebook groups.

**Before Class (Experimental Group)**: The before-class period for the experimental group consisted of two sections, including basic knowledge and assessment. Students watched the videos before the course during the basic knowledge section. The instructor revealed course objectives at the beginning of the video and then lectured using a related screenshot. Screenshots were recorded with the Camtasia Studio program. Each video lasted approximately 15 minutes. Lectures in the control group and videos watched by the experimental group had the same content. The assessment section for the experimental group was composed of three questions about the video. This section ensured student understanding of the video and further increased motivation. The same questions were asked in the control group to enhance their understanding and motivation and to avoid the effects of external factors on the implementation process.

**During Class (Experimental Group)**: The during-class period for the experimental group consisted of two sections, recall and practical applications (in-class activities). At the beginning of the course, the instructor asked students if there were any misunderstood topic in the videos. The instructor answered students' questions and summarized the topic of the day for the experimental group. After that, a course-related activity was conducted in Kahoot, an online game-based question and answer application. Each classroom had a projector and computers for every student. The instructor displayed questions on a screen, and students answered via their mobile phones or computers, recalling their knowledge. During this practical applications section, students completed the in-class activities within course hours, sometimes individually and sometimes collaboratively. Students uploaded completed homework files to Moodle, and hands-on activities were assessed with a rubric prepared by the instructor.

**Before Class (Control Group)**: The before-class period for the control group consisted of only practical application (homework). The homework of the control group was the same as the in-class activities of the experimental group. Students did homework outside the classroom after class within two days, sometimes individually and sometimes collaboratively, and uploaded their finished assignments to Moodle.

**During Class (Control Group)**: The during-class period for the control group consisted of three sections, including basic knowledge, recalling, and assessment. The instructor lectured in the basic knowledge section, applying traditional teaching methods. The content of the in-class lectures was prepared in line with the videos. The instructor lectured with the help of PowerPoint presentations or other MS Office programs such as Excel, then summarized the lecture and asked questions to promote recall. At the end of the lecture, a question-answer activity was conducted using Kahoot to evaluate the students' learning. This Kahoot activity was the same as applied to the experimental group at the beginning of the lessons.

### *2.3 Data Collection Tools*

The data were collected via an achievement test and a subjective cognitive load scale. The achievement test included four practical questions with six sub-questions and three open-ended questions to determine students' basic computer skills. It was scored out of 100 based on a rubric developed by the researchers. In order to ensure reliability and validity, two experts and three peers were consulted. According to their feedback, the achievement test was modified and finalized. The second data collection tool, the cognitive load scale, was used to evaluate cognitive loads in both groups. This scale was developed by Paas and van Merriënboer (1993) and translated to Turkish by Kılıç and Karadeniz (2004). The cognitive load scale is a subjective rating of one question from one to nine. When the validity and reliability of this scale was tested by Kılıç and Karadeniz (*Ibidem*), Cronbach's alpha was found to be 0.77 and the Spearman Brown test result was found to be 0.79. Students in both groups filled out the scale at the end of each week, and the average of all 10 scales showed the cognitive load score of each student.

### *2.4 Data Analysis*

Data collected from the learning achievement test and cognitive load scale were analyzed using inferential statistical analysis techniques. A MANOVA was used to reveal differences between the groups concerning learning achievements and cognitive load levels. An independent samples t-test was used for determining the difference between the control and experimental group concerning efficiency scores. The learning achievement test and the means of the cognitive load level scores for each student in both groups were transformed to z-scores in order to calculate the efficiency of instruction. To find the efficiency score, the following formula was applied: E = (ZPerformance – ZMental Effort) /. If the performance of the student was greater than the

cognitive effort of the student, the effectiveness of learning was deemed high.

## 3 Findings

### *3.1 Effect on Student Learning Achievement and Cognitive Load Levels*

To understand whether students' pretest results had any significant difference between the two groups, a t-test was conducted. The results showed no significant difference between the experimental and control groups' pretest scores (t = 1.844, p =.068 >.05). A MANOVA was used to determine whether the flipped classroom method was effective in terms of achievement and cognitive load. MANOVA has many important assumptions, including multivariate outliers (Stevens, 1996). In order to determine the outliers, Mahalanobis distance was used (Tabachnick & Fidell, 2001) and revealed 12 instances with values higher than 13.82 (Pearson & Hartley, 1958). These outliers were extracted to ensure homogeneity and normality. As shown in Table 1, the MANOVA results indicated a significant difference between the experimental and control groups, Wilks's lambda =.759, F(2, 101) = 15.799, p =.000 <.05, partial η2 =.241.

Table 1
MANOVA RESULTS

| | Wilks's lambda | F | p | $\eta^2$ |
|---|---|---|---|---|
| Intercept | .015 | 3406.799 | .000 | .985 |
| Group | .759 | 15.799 | .000 | .241 |

When examining the findings in detail, one significant difference was found between the experimental and control groups (F(1-101) = 16.73, p =.000, η2 =.141) achievement results. In this line, the experimental group students ( $\overline{X}$ = 78.90, Sd = 2.05) were more successful than the control group students ( $\overline{X}$ = 67.01, Sd = 2.05). Additionally, a significant difference was found between the two groups in terms of cognitive load levels (F(1-101) = 25.61, p =.000 <.05, η2 =.201): the experimental group ( $\overline{X}$ = 4.71, Sd = 1.41) reported a lower level than the control group ( $\overline{X}$ = 6.07, Sd = 1.02).

### *3.2 Effect on Students' Efficiency Scores*

An independent samples t-test was used to determine whether there was a significant difference between the control and experimental groups concerning efficiency scores. As shown in Table 2, a significant difference was found: the experimental group's efficiency scores ( $\overline{X}$ = 1.7978) were higher than those of the control group ( $\overline{X}$ =.0148).

Table 2
INDEPENDENT SAMPLES T-TEST RESULTS FOR COGNITIVE LOAD EFFICIENCY SCORES OF STUDENTS

| | N | X | Sd | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|
| Experimental Group | 58 | 1.7978 | .20523 | 8.688 | .000 | .398 |
| Control Group | 58 | .0148 | | | | |

## 4 Discussion

In this quasi-experimental study, a flipped classroom was developed, implemented, and evaluated. The purpose of the study was to investigate the instructional efficiency of the flipped classroom method and its effect on achievement and cognitive load levels of students. The results indicated a significant difference between the experimental and control groups concerning learning achievement. The flipped classroom method did increase the achievement of students, which is consistent with some studies (Baepler *et al.*, 2014; Hung, 2015; McGivney-Burelle & Xue, 2013; McLaughlin *et al.*, 2013; Murphree, 2014; Pierce & Fox, 2012; Tune, Sturek & Basile, 2013; Wilson, 2013). In contrast, other studies found that the flipped classroom method had no effect on students' learning and achievement (Clark, 2013; Davies *et al.*, 2013; Howell, 2013; McLaughlin *et al.*, 2013). This difference may be related to the nature of the flipped classroom method: it is not only a method but also a culture. It takes time for students to become familiar with new practices. Therefore, it is important to investigate this method's effects over a long time range. Also, a flipped classroom can be implemented in various ways, resulting in different processes.

The second research question of the current study examined whether there was a significant difference between the two groups' cognitive load levels. The results suggested that students who were taught with the flipped classroom method had lower cognitive load levels than students who were taught with the traditional method. However, there is a limitation that cognitive load was calculated via self reported likert scale. Based on this finding, it can be said that when a flipped classroom method is used effectively, it can lower students' cognitive loads and affect their learning in a positive way. No previous studies have been conducted about the impact of the flipped classroom on student cognitive load levels, though Abeysekera and Dawson (2014) have asserted that the flipped classroom method may decrease such levels. Abeysekera and Dawson (*Ibidem*) put forward six prepositions about flipped classroom. One of these prepositions is related to this study which is "Student self-pacing of pre-recorded lectures may reduce cognitive load and help learning in a flipped classroom environment" (Abeysekera & Dawson, 2014, p.9). Another

study found that pre-recorded videos decreased cognitive load levels (Seery & Donnely, 2012). This finding may also be explained by the pre-training and sequencing effects of Cognitive Load Theory, which also decrease cognitive load levels (Mayer & Chandler, 2001; Mayer & Moreno, 2003). Additionally, this finding may be related to the in-class activities conducted by the experimental group, due to the availability of instructor and peer guidance. Similarly, Moreno (2004) and Artino (2008) suggested that instructional guidance decreases cognitive load and increases learning efficiency.

The third research question of this study investigated whether there was a significant difference between the efficiency scores of the control and experimental groups. Indeed, the flipped classroom method proved more efficient than the traditional method, which may be related to the active classroom environment.

### *4.1 Conclusion and Recommendations*

In conclusion, although this method will not be beneficial for every type of course, instructor, or student, in this study, students' achievement, cognitive load levels, and responses to the flipped classroom method were positive. As this method becomes increasingly ubiquitous in universities and K–12 schools, this study will be useful for researchers and educators in a variety of fields, despite its small and specific sample size of 116 students attending a basic computer course. Another noted limitation of the study was that the instructor of the course was also one of the researchers. Based on the findings and discussions presented here, the following recommendations are offered:

Further studies could apply random assignments, which were not possible for the sampling procedure in this study.

Further studies should apply other scales and methods for measuring cognitive load levels.

Further studies should investigate video, audio, and text materials' features and effects on learning in a flipped classroom.

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