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| Research Article / Araştırma Makalesi |

The Effects of a Cloud-Based Blended Learning Environment on Students' Achievement, Persistence and Cognitive Load

Bulut Tabanlı Harmanlanmış Öğrenme Ortamının Öğrencilerin Performansı, Kalıcılığı ve Bilişsel Yükü Üzerindeki Etkileri[1]

Mehtap MUTLU BİLGİN[2], Ayfer ALPER[3]

Keywords
1.MoodleCloud
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Abstract

Purpose: The aim of this study was to examine the effect of cloud-based blended learning environments on the achievement, persistency, and cognitive load of vocational high school students. Moreover, the study aimed to determine the students' opinions on the effectiveness of the blended learning environments they used.

Design/Methodology/Approach: 6-week implementation was conducted using MoodleCloud, through a course created with content prepared to be in line with multimedia design principles.The study group consisted of 33 individuals in total, with 17 students in the experimental group and 16 in the control group. The research model applied in the study was semi-experimental, with data collection tools consisting of an Achievement Test, a Practice Exam, a Scale for Measuring the Effectiveness of Blended Learning Environments, and a Cognitive Load Scale. During analysis of the collected data, t-test, ANCOVA, Mann-Whitney U test, Pearson Correlation Coefficient, and descriptive statistics were used.

Findings: The findings of the study concluded that students in the Experimental Group achieved significantly higher scores in the Achievement Test and Practice Exam than those in the Control Group. On the other hand, there was no significant difference found to exist between the two groups in terms of the Persistency Test. Regarding their cognitive load scores, a significant difference was found to exist between the students who studied within a blended learning environment and those who studied in a face-to-face learning environment, but this was only for Week 5 of the implementation, whereas there were no significant differences found for any of the other weeks. Moreover, it was concluded that there was no significant correlation found between the cognitive load and the success of the students. In addition, it was notable that the students held more positive views about the blended learning environment over the other environments.

Highlights: it may be said that the education applied within the cloud-based blended learning environment had a positive effect on the students' academic success. The significant difference revealed in Week 5 may suggest that the cognitive load of students may decrease when the implementation time is extended.

Öz

Çalışmanın amacı: Çalışmanın amacı, bulut tabanlı harmanlanmış öğrenme ortamının meslek lisesi öğrencilerinin bilişsel yüklerine, başarılarına ve öğrenmedeki kalıcılığına etkisini araştırmaktır. Ayrıca öğrencilerin harmanlanmış öğrenme ortamlarının etkililiği hakkındaki görüşlerini belirlemektir.

Materyal ve Yöntem: MoodleCloud Öğrenme Yönetim Sistemi üzerinde çoklu ortam tasarım ilkeleri doğrultusunda ders içeriği hazırlanarak 6 hafta boyunca uygulama yapılmıştır. Çalışma grubu, Deney Grubunda 17, Kontrol Grubunda 16 öğrenci olmak üzere toplam 33 kişiden oluşmaktadır. Araştırmamızın modeli yarı deneysel desen olup veri toplama araçları olarak başarı testi, uygulama sınavı, harmanlanmış öğrenme ortamların etkililiğini ölçme ölçeği ve bilişsel yük ölçeği kullanılmıştır. Verilerin çözümlenmesi sırasında t testi, ANCOVA, Mann-Whitney U testi, Pearson Korelasyon Katsayısı ve betimsel istatistikler kullanılmıştır.

Bulgular: Çalışmanın sonunda deney grubu öğrencilerinin, başarı testi ve uygulama sınavı puanlarının kontrol grubu öğrencilerinden anlamlı derecede yüksek olduğu sonucuna ulaşılmıştır. Yapılan kalıcılık testlerinde anlamlı bir farklılık bulunmamıştır. Harmanlanmış öğrenme ortamında eğitim alan öğrencilerle, yüz yüze öğrenme ortamında eğitim alan öğrenciler arasında bilişsel yük puanları açısından 5. haftada anlamlı bir fark bulunmuştur. Ayrıca öğrenciler harmanlanmış öğrenme ortamları hakkında diğer ortamlardan daha fazla olumlu görüşe sahiptirler.

Önemli Vurgular: Bulut tabanlı harmanlanmış öğrenme ortamında yapılan eğitimin başarı üzerinde etkili olduğunu söyleyebiliriz. Bilişsel yük puanları açısından 5.haftada anlamlı fark bulunması, çalışmanın uygulama zamanı uzatıldığında bilişsel yükte düşüş olabileceğini düşündürebilir.

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[2] **Corresponding Author,** Ministry of Education, Kanuni Vocational and Technical Anatolian High School, Ankara, Turkey; mehtapmutlu.bilgin06@gmail.com, https://orcid.org/0000-0003-0545-2252

[3] Ankara University, Faculty of Educational Sciences, Computer Education and Instructional Technologys,Ankara,Turkey; aalper@ankara.edu.tr, https://orcid.org/0000-0003-2312-6311

INTRODUCTION

In recent years, the relevance and implementation of distance education technologies have spread rapidly on a global scale. During the COVID-19 pandemic, many schools were forced to close, with education continued to be provided from a distance, which effectively resulted in widespread mass testing of the distance education medium (Sun, Tang, & Zuo, 2020). The COVID-19 pandemic presented the most difficult problem confronting national education systems for generations. Many governments decided that schools could no longer teach face-to-face; prompting schools to almost immediately opt for the provision of online instruction and virtual education (Daniel, 2020). Turkey also closed its schools, and the Turkish Ministry of National Education improved the infrastructure of the Education Information Network, which acts as the country's digital education portal, in order to create an efficient distance education system in collaboration with the Turkish Radio and Television Corporation (known as TRT) (Özer, 2020).

Distance education has been described by İşman (2011) as "an education system model in which teachers and students do not have to be in the same places and educational activities are carried out using postal services and information communication technologies". According to Altparmak, Kurt, and Kapıdere (2011), people who do not have the means to continue formal education may opt to continue their education and training through distance education; the most basic elements of which are e-learning and management systems.

E-learning has been defined by Clark and Mayer (2011) as teaching delivered on a digital platform such as a computer or mobile device that is intended to facilitate learning. According to Gülbahar (2017), e-learning is "providing access to knowledge regardless of time or location through information and communication technologies and performing teaching activities in electronic learning environments through interaction with multimedia applications". During the COVID-19 pandemic in Turkey, Moodle and ALMS were the learning management systems most widely used in higher education institutions that had urgently moved to distance education (Durak, Çankaya, & İzmirli, 2020). Kuzu and Balaman (2004) obtained positive findings in a study conducted with the Moodle Learning Management System about web-based education; having obtained positive findings such as students' freedom from time and space constraints, being able to construct their own individual study environment, being more comfortable in the virtual environment, not having to take notes, and being more motivated. However, they also claimed that, despite the ease of use of Moodle LMS, students also encountered certain negative aspects such as difficulty interacting with other students and their instructor, reliance upon computers and the Internet, and failure to obtain answers to questions when asked. In order to resolve these types of issues, a new learning model was needed. This learning model, which incorporates both synchronous and asynchronous delivery of instruction through technological means, is known as blended learning (or hybrid education). Over time, this model has begun to acquire new meanings and characteristics (Demir, 2015).

Singh and Reed (2001) stated the importance of blended learning, saying that "Blended learning is to achieve the highest success by combining the right learning technologies and applying the learning goals, with the right personal learning style to acquire the right skills to the right person at the right time". Blended learning, according to Osguthorpe and Graham (2003), blends face-to-face contact with remote delivery systems. Usta and Mahiroğlu (2008) discovered that students may be more successful when studying in a blended learning environment (BLE) and that they learn with more persistency, according to their study with students of Primary Education Classroom Teaching and Türk(2012) Vocational School Computer Programming departments. Jowsey, Foster, Cooper-Ioelu, and Jacobs (2020) conducted a literature review and discovered that blended learning improved student achievement, especially when used to manage and promote distance education. They came to the conclusion that when blended learning was presented purposefully and effectively in terms of handling and promoting active learning, it can positively impact on students' lessons. In the online dimension of blended learning, information technologies (IT) are employed. According to Bonk and Graham (2004), with the widespread adoption of learning management systems and technology-equipped classrooms through the introduction of blended learning within the conventional university environment, teachers and instructors are increasingly using technology to design their lessons, and LMS's actively form part of the process management.

Gülbahar (2017) defined LMS's as the management of online content and communication process, namely the education-training process, whilst Altıparmak et al. (2011) mentioned LMS's being the software used to manage learning activities, as well as functions such as organizing, presenting, sharing and discussing learning materials, performing exam and homework procedures, receiving feedback, managing course catalogs, for maintaining student, teacher and system records, and also for reporting purposes. Bonk and Graham (2006, as cited by Mountain, 2011) emphasized the central role of computer-based technologies in blended learning, stating that blended education systems combine face-to-face teaching with computer-mediated learning. Bonk and Graham (2006, as cited by Mountain, 2011) also mentioned that aside from all the benefits of blended learning, there are some difficulties that may also arise in the design and implementation of blended learning. Teaching in a blended environment is where an LMS, which is an e-learning technology, is used in conjunction with face-to-face learning as a performance support system and interaction tool. However, in blended learning, students must also have self-efficacy, hence the use of LMS's should be taught to students and technology-equipped classrooms increased as needed.

When the current literature is examined, it can be seen that the most preferred learning management system is Moodle. Aydın and Biroğul (2008) compared open-source learning management systems and observed that Moodle contained numerous features required for the delivery of quality education. Similarly, Karaman, Özen, Yıldırım, and Kaban (2009) blended four lessons using the

Moodle LMS system in their study, and reported that it was easier to follow the lessons, students were more interested in the lessons outside of the classroom, and the materials and discussions attended by the teacher were valued.

As can be understood from the explanations given, Moodle is the mostly widely used LMS due to its beneficial features. With the increases seen recently in cloud computing, the Moodle platform now utilizes cloud technology with the launch of MoodleCloud. As a cloud-computing hosted platform, MoodleCloud is the latest learning environment offered by Moodle, the world's most popular open-source learning platform. Sevli and Küçüksille (2012) considered cloud computing as a solution that could reduce the infrastructural burden of educational institutions. Students using mobile learning can access learning resources within Moodle that are stored in the cloud. In this way, educational institutions no longer need to purchase expensive web-servers in order to host their learning management systems, nor do they need to employ an information technology team just to maintain and update these systems. Students no longer need to purchase mobile devices with large storage capacity or powerful computing capabilities, as Moodle runs in the cloud and therefore data is stored in the cloud rather than locally. All students have to do is access learning materials using their mobile devices over the Internet (Wang, Chen, & Khan, 2014). Therefore, it is considered valid to examine the contribution of MoodleCloud, as a recently developed cloud-based LMS, to the blended learning solution. Baimurzayev (2016) conducted a usability analysis study of MoodleCloud's interface and determined it to be relatively usable.

However, a good instructional design is required for the effective use of LMS environments. Kuzu (2017) defined multimedia as the use of more than one form of sound, still or moving pictures, animations, and graphic tables, etc. in a digital environment in order to present effective, efficient, and attractive information to an audience in addition to plain text-based content. Mayer (2009, as also cited by Kuzu, 2017) cited 12 guiding principles for the effectiveness of multimedia, and Clark and Mayer (2003, as cited by Mayer & Moreno, 2003) found it worthwhile to investigate whether the principles of multimedia learning apply to the design of online courses that require hours of participation, problem-based simulation games, and multimedia instructions that include screen pedagogical agents. Therefore, it would be useful to examine the compatibility of online courses with multimedia design principles.

Decisions to be taken during the process of material design in teaching, especially in multimedia, can be shaped according to different theories that take into account the nature of human cognition (Akbulut, 2017); of which, Cognitive Load Theory (Paas, Tuovinen, Tabbers, & Van Gerven, 2003) is one such theory. Akbulut (2017) defined cognitive load as "all mental activities performed simultaneously in short-term memory and requiring attention". Cognitive Load Theory has its focus on the teaching methods employed so as to reduce extraneous cognitive load in order that existing cognitive resources can be fully allocated to learning (Van Merrienboer & Sweller, 2005).

Paas, Renkl, and Sweller (2003) stated there being three types of cognitive load; intrinsic, extraneous, and germane. Intrinsic cognitive load is the inherent complexity of the material, measured based upon the interaction between the components of the schema as required to process the material. Extraneous cognitive load involves the inaccurate or poor quality of activities that form the way that information is transferred to the learner, and the load required to understand the basic materials, whilst germane cognitive load relates to the motivation level of the learner (Akbulut, 2017). "Short term memory is limited in terms of time and the data it can store" (Zhang & Wang, 2009) Therefore, instructional designs that do not adequately consider this short-term memory limitation cannot be successful in terms of effective teaching. A significant part of today's teaching strategies do not take into account the characteristics of natural cognitive architecture, and thereby cause unnecessary extraneous cognitive load. For this reason, researchers interested in cognitive load mostly aim to develop teaching strategies as alternatives to traditional teaching, and also reducing extraneous cognitive load (Akbulut, 2017). Çakmak (2007) stated that in studies conducted on cognitive loading in multiple environments, excessive cognitive load decreases student achievement and that extraneous cognitive load may be reduced when design principles are correctly applied. In doing so, more space is made available in the working memory for intrinsic and germane cognitive load, and therefore the problem of cognitive overload may be negated.

When the literature is examined, experimental studies on e-learning and blended learning are mostly to be found; however, notably there have been almost no studies applied at the vocational high school level. In the majority of vocational high school course programs, the Web Design and Programming (known as WTP) course is conducted via computer for 10 hours each week when fully implemented. Therefore, the course content must be available at all times, with the relevant applications stored in a computer environment. Furthermore, since the students of this course are from the Computer Department, they have already received adequate training in the use of computers. As a result, it is expected that this environment will positively impact their performance since it does not require any installation or cost overhead such as hardware, and the students are able to access it using only a personal computer, mobile telephony device (i.e., smartphone), or tablet personal computer.

Previously, Özalp and Dügenci (2010) used Moodle LMS to support vocational secondary education in their study with vocational high school IT students. In their study that was conducted using distance education as a medium, it was observed that students were successful in reinforcing their knowledge. Moodle LMS's applicability and usability within the technical high school environment as well as within higher education has already been demonstrated. Therefore, it was deemed necessary to examine the effect of learning environments blended with the MoodleCloud LMS through application in the IT field, and the Web Design and Programming course offered by vocational high schools seems appropriate to this purpose. The aim of the WTP course is for students to learn the necessary knowledge and skills of web design and programming (Turkish Ministry of National Education, 2011). In addition, applications, assignments, and other materials generated in IT field laboratory courses should be electronically stored. However, in the storage of course materials, students may encounter problems such as files having been deleted, virus

contamination, and other related issues. However, such problems may be resolved through the use of a cloud-based learning management system (CBLMS), and students will therefore be able to concentrate more on their lessons as a result. Data can be stored in the cloud and even recovered from backups in the case of any system or data failure. Furthermore, the ease with which data can be accessed from anywhere via the Internet emphasizes the importance of cloud technology to modern-day teaching and learning (Sarıtaş & Üner, 2013).

As the preceding explanations suggest, cloud-based blended learning is important because it removes many of the communication problems that can be experienced by teachers and their students through offering both face-to-face and online learning at the same time, and with appropriate technical tools applied in conjunction with appropriate learning methods. Cloud-based learning environments, on the other hand, have yet to be included in academic studies involving vocational high schools. Generally, vocational high schools are deemed to be suitable for such environments due to the state of their technical IT infrastructure and their students' known high level of technology usage skills. Furthermore, it is assumed that a well-designed instructional design and appropriate environment, applied especially within laboratory-type lessons with high cognitive load, may reduce the cognitive load of both teachers and students by leveraging the benefits of cloud computing and thereby leading to improved levels of student success in measurable academic terms. Since it is predicted that cloud-based blended learning can positively affect persistency in success, as well as success and cognitive load, its effect on persistency was also examined as part of the current research study.

Aim of The Study

The aim of the current study was to examine the effect of cloud-based blended learning on the achievement, persistency, and cognitive load of vocational high school students enrolled to an IT field Web Design and Programming course. In order to achieve this general purpose, answers to the following research questions and sub-questions were sought

1. For vocational high school students of a Web Design and Programming course who were taught using a cloud-based blended learning environment and a traditional face-to-face classroom;
    a. Is the difference between pretest success scores significant?
    b. Is the difference between posttest success scores significant?
    c. Is the difference between Persistency Test success scores significant?
    d. Is the difference between Practice Exam success scores significant?
2. For vocational high school students of a Web Design and Programming course who were taught using a cloud-based blended learning environment;
    a. Is the difference between pretest and posttest success scores significant?
    b. Is the difference between posttest and Persistency Test success scores significant?
3. For vocational high school students of a Web Design and Programming course who were taught using a cloud-based blended learning environment and a traditional face-to-face classroom.
    a. Is the difference between their cognitive loads significant?
    b. Is the relationship between their cognitive load and achievement significant?
4. What are the opinions of vocational high school students of a Web Design and Programming course taught using a cloud-based blended learning environment about the effectiveness of blended learning environments?

METHOD/MATERIALS

Research Model

In the current study, "semi -experimental design" was preferred. "In semi-experimental designs, two of the ready groups are tried to be matched on certain variables. Matched groups are randomly assigned to transaction groups" (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, & Demirel, 2016). The patterns of the research are as follows and are detailed in Table 1.

1. Pretest-posttest paired control group design" was used when looking at the difference of Achievement Test, both between and within the two study groups.
2. When looking at the differences between the Practice Exam and the cognitive load scores between the two study groups, "posttest paired control group design" was used.

Table 1. Research pattern

Group	Pretest	Operation	Posttest
Experimental	M1 (AT)	BLE	M3 (AT), M5 (PT), M7 (CLS), M10 (PT)
Control	M2 (AT)	FFLE	M4 (AT), M6 (PE), M8 (CLS), M9 (SMEBLE), M11 (PT)

AT: Achievement test, PE: Practice exam, BLE: Blended Learning Environments, PT: Persistency Test, CLS: Cognitive Load Scale, FFLE: Face-to-Face Learning Environments, SMEBLE: Scale for Measuring the Effectiveness of Blended Learning Environments

In the current study, the Achievement Test was applied to both the Experimental Group and the Control Group as a pretest; whilst the Achievement Test, Practice Exam, and Cognitive Load Scale were applied as a posttest. In addition, the Achievement Test was also applied as the Persistency Test, and the Scale for Measuring the Effectiveness of Blended Learning Environments (SMEBLE) was applied to the Experimental Group as a posttest.

Study Group

The study group consisted of 33 individuals in total, with 17 assigned to the Experimental Group and 16 in the Control Group. All of the participants were studying in their 11th grade in the Information Technologies department of Kanuni Vocational and Technical Anatolian High School, Turkey, during the 2018-2019 academic year. In order to form equal study groups, determination of the students for each study group was based on the students' 10^{th}-grade general average scores and also on gender distribution. The Experimental Group consisted of four females and 13 males, whilst the Control Group consisted of four females and 12 males.

Data Collection

The data collection tools employed in the study were an "Achievement Test" and "Practice Exam" developed by the researcher and specifically aimed at the "Cascading Style Sheet" (CSS) module of the WTP course in order to investigate the application's effect on the students' success and persistency in learning.

In order to measure the effectiveness of the environment that was blended with the Cloud-Based Learning Management System (CBLMS), the "Scale for Measuring the Effectiveness of Blended Learning Environments," developed by Cabı and Gülbahar (2013), was used. In order to measure the cognitive load of the students, a 9-point, Likert-type Cognitive Load Scale was applied that was originally developed by Paas and Van Merriënboer (1993) and subsequently adapted by Kılıç and Karadeniz (2004) for the Turkish context. Each of the tools used are explained in detail as follows.

Achievement Test

In order to investigate the effects of the content prepared with MoodleCloud CBLMS on students' success and persistency in success, an Achievement Test consisting of 30 questions was developed that included the topics covered in the WTP course on CSS modules. The test's symptom table was prepared first, and then the opinion of a Turkish Language and Literature teacher was sought in order to assess the compatibility of the prepared text with Turkish grammatical rules. In addition, to assess the test's content validity, it was presented to two Information Technology teachers who also taught the WTP course. For the validity and reliability study of the test, a pilot study was then conducted with a total of 46 web programming students from the 12th grade who had previously taken the WTP course. The result of the pilot study was analyzed using the TAP test analysis program, and the difficulty and discrimination values of each question were examined separately for the purposes of assessing the construct validity and reliability of the test. The discrimination of the results obtained following the item analysis was evaluated according to the following criteria:

The discrimination power of the items in any test is between -1 and +1. High substance discrimination increases the validity of the test. If the discrimination index of an item is .40 or greater, the item is 'very good'; if it is between .30 and .39, then the item is 'quite good'; if it is between .20 and .29, then the item can be used in mandatory situations; but if it is .19 or less, the item is 'very weak.' If an item cannot be improved, it should be removed from the test (Tekin, 2000; Turgut, 1992).

Five questions in the Achievement Test were removed because their item discrimination value was found to be below .20. Additionally, Item 5, Item 16, and Item 24, which each had a discrimination value of .25, were corrected and accepted for inclusion in the Achievement Test. As a result of the analysis of the remaining 25 items, the reliability value of the Achievement Test was calculated as having a KR20 (Alpha) value of .732, with an average item difficulty value of .53, and an average item discrimination value of .45. It can therefore be said that developed Achievement Test, having been prepared based on these values, was deemed to be both reliable and valid.

Persistency Tests

In order to test whether cloud-based blended learning had an effect on persistency in learning in the current study, a Persistency Test was conducted. When the literature is reviewed, it can be seen that a posttest is mostly applied as a Persistency Test around 4-6 weeks following completion of the application (Aksoğan, 2011; Kâhyaoğlu, 2014; Ünlü, 2015). In the case of the current study, the Achievement Test was reapplied as a Persistency Test 5 weeks following the end of the application.

Practice Exam

Since the Web Design and Programming course is considered application-intensive, an application-based exam was developed by the researcher and two IT teachers, each with at least 15 years of experience and who also currently teach the WTP course. The Practice Exam was primarily applied to a different group of 36 students taking the course. The students' applications were then scored independently by the researcher and an expert IT teacher in line with predefined evaluation criteria. When the scores

were compared, it was seen that the two evaluations had an overlap of approximately 95%. In the Practice Exam, the students were tasked with creating a webpage using CSS in line with certain given criteria. For the exam, a set of 12 questions were asked in order to measure the students' success in practice (rather than testing their theoretical knowledge). The exam was conducted via computer and a time limit for completion of the exam was set at 80 minutes. The materials used in the exam were transferred to the students own computer environment. The application files produced by the students during the exam were later collected on a central computer for their evaluation. The exam was administered to the students during Week 6, after which the exam results were subjected to analysis.

Scale for Measuring the Effectiveness of Blended Learning Environments

In order to measure the effectiveness of the teaching environment that had been blended with CBLMS, the "Scale for Measuring the Effectiveness of Blended Learning Environments" (SMEBLE) developed by Cabı and Gülbahar (2013) was applied. The necessary permission from the scale's developers was sought prior to its application. The Cronbach Alpha internal consistency coefficient for the scale was found to be .94, whilst the Kaiser-Meyer-Olkin (KMO) value was found to be .91 (Cabı & Gülbahar, 2013). A pilot study was conducted by the researcher with a total of 32 IT students from the 11th grade who had previously taken the same WTP so as to ensure reliability and understandability of the scale prior to its application in this experimental study. The same content was applied to each of the students via MoodleCloud for a total of 5 weeks. Then, the SMEBLE was applied to the Experimental Group's students during the final (6^{th}) week. The Cronbach Alpha internal consistency coefficient of the scale was found to be .94 in a test conducted to ensure its reliability.

Cognitive Load Scale

In order to measure the cognitive load of the students, a 9-point, Likert-type rating scale was employed. The scale was originally developed by Paas and Van Merriënboer (1993) and subsequently adapted to the Turkish context by Kılıç and Karadeniz (2004). Necessary permissions from the scale's developers was obtained prior to its application. The Cronbach Alpha internal consistency coefficient of the scale was found to be .78, whilst the Spearman Brown two-sided test correlation was revealed to be .79.

Prior to the experimental study's application, a pilot study was conducted with 32 11th grade IT students taking the same WTP course in order to ensure the scale's reliability and validity. The same content were applied to each student via MoodleCloud for a total period of 5 weeks, with the participant students asked to complete the Cognitive Load Scale form after having completed five different activities. The Cronbach Alpha internal consistency coefficient was found to be .82 in the test applied to ensure its reliability, with values of X^2 / *df* = 1.065, GFI = .933, CFI = .994, and RMSA = .045 revealed in the Confirmatory Factor Analysis (CFA) to ensure its validity, the results of which showed the scale's validity to be of an acceptable level (Seçer, 2015). Following each activity, the scale was reapplied to both study groups with regards to the completed activity.

Experimental Operations

Pre-Implementation Preparation Phase

Prior to the commencement of the application, weekly course content was prepared by the researcher using the MoodleCloud LMS, taking into account the annual course plan according to the subjects contained within the Web Design and Programming course "CSS" module. Whilst preparing the course content, the design principles of Mayer (2009) for multimedia learning were applied (Kuzu, 2017).

Implementation Phase

During Week 1, the teacher informed the Experimental Group students about the use of MoodleCloud and registered each of the students in the system before providing each of them with their username and initial password. In this way, students were provided with online access to the course content whenever and from wherever they wanted to access it. In addition, the students could submit their activities and homework to their teachers, as well as taking part in the online exams that they were assigned. Using the LMS, the students were also able to access their exam results following assessment. They also used the MoodleCloud system as a storage medium.

The teacher acted according to the predefined work plan for each particular week. In Week 1, the Achievement Test was applied as a pretest to the two study groups. Each week the subject for that week was explained to the Experimental Group by their teacher via the CBLMS, and then the week's activity and quiz were conducted online. At the end of the lesson, the students were tasked with submitting their homework using the system within one week in order to reinforce the learning of that subject.

The same subject, activity, and homework were taught face-to-face to the students of the Control Group, based on a teacher-centered approach. At the end of each activity, the students of both study groups were asked to complete the Cognitive Load Scale related to the activity of that week. In Week 6, the final week of the implementation, the Achievement Test was applied to the students of both groups as a posttest, and a Practice Exam was also conducted. The Scale for Measuring the Effectiveness of Blended Learning Environments was applied only to students of the Experimental Group, whilst the Persistency Test was applied to both study groups 5 weeks following the completion of the study.

Data Analysis

Prior to analyzing the effects of learning environments on dependent variables, it is first necessary to check whether or not the study groups in question present a normal distribution, and to decide upon the statistical measures to be used in accordance with the result. For this purpose, a "Normality Test" was applied for each study group. Since the number of participants in each group was less than 50, the Shapiro-Wilk test was preferred as the normality test. The Shapiro-Wilk test is used to demonstrate whether or not the scores presented a normal distribution. If a *p* value resulting from a Shapiro-Wilk test is greater than .05, then the scores are deemed to not show a significant deviation from the normal distribution and may therefore be said to be suitable (Büyüköztürk, 2018). Parametric tests were preferred for results with a normal distribution, whilst non-parametric tests were preferred for non-normal results. It was checked as to whether the analyses used provided the necessary assumptions regarding the application.

In the current study, unrelated samples *t*-test was used to analyze the pretest success scores of the students in the Control Group and the Experimental Group, whereas Covariance Analysis (ANCOVA) was used to analyze the posttest and Persistency Test success scores, and unrelated samples *t*-test was used to analyze the Practice Exam success scores. According to Büyüköztürk (2018),

For the related samples, the *t*-test is used to test whether the difference between the two associated sample means is significantly different from zero (each other), while the unrelated samples *t*-test is used to test whether the difference between the two unrelated sample means is significant. The purpose of ANCOVA is to provide statistical control of a variable or variables that have a relationship with the dependent variable, except for a factor or factors whose effect has been tested in a research.

In order to analyze the cognitive load scores between the groups, the Mann-Whitney U test was used because the normality assumption could not be achieved according to the score from the Cognitive Load Scale results from Week 1 and Week 5, whilst the unrelated samples *t*-test was used for the other weeks. "The Mann-Whitney U test is used to test whether the scores obtained from the unrelated sample differ significantly or not" (Büyüköztürk, 2018). The relationship between achievement and cognitive load was analyzed using the Pearson Correlation Coefficient. "The correlation coefficient is a number that explains the level or amount and direction of the relationship between variables" (Büyüköztürk, 2018). The Scale for Measuring the Effectiveness of Blended Learning Environments (SMEBLE) was analyzed using descriptive statistics.

FINDINGS

RQ.1. Difference Between Pretest, Posttest, Persistency Test, and Practice Exam Success Scores

Findings for each of the four sub-questions of Research Question 1 are presented as follows.

Difference Between Pretest Success Scores (RQ.1.a)

The results of the independent samples *t*-test of the pretest success scores of the students in both the Experimental Group and the Control Group are presented in Table 2.

Table 2. Independent samples *t*-test results of students' pretest scores

Group	*N*	$\bar{X}$	*S*	*SD*	*t*	*p*
Experimental	17	14.71	12.31	31	.19	.85
Control	16	15.38	6.64			

*$p < .05$

According to the pretest results for each study group shown in Table 2, it can be seen that the difference between the students' pretest success scores was not found to be significant ($t(31) = .19$, $p > .05$). This finding indicates that students in both the study groups had equal knowledge about the course prior to the start of the application.

Difference Between Posttest Success Scores (RQ.1.b)

In order to measure the effect of Cloud-Based Blended Learning Management System (CBBLMS) on the students' success, the Achievement Test was reapplied again as a posttest. In comparing the students' posttest success scores, covariance analysis was employed, and the pretest success scores were taken as the common variable. The following four assumptions of this test were tested in order prior to conducting the analysis.

1. According to the first assumption, the regression slopes within the groups should be equal. When the test results were examined, it was seen that the common effect of "group x pretest" on the posttest success scores was insignificant ($F(1,29) = 2.07$, $p > .05$). This finding shows that the slopes of the regression lines calculated for testing the posttest success scores based on the pretest success scores were equal.
2. According to the second assumption, there should be a linear relationship between the dependent variable and the common variable. It was tested whether or not there was a statistically linear and significant relationship with the

scattering diagram and the Pearson Correlation Coefficient. According to the Pearson Correlation Coefficient analysis performed on both the Experimental Group and the Control Group, it was seen that a positive and significant relationship exists between the groups' pretest success scores and posttest success scores (r = .35, p < .05). Scatter plots also support this finding.

3. According to the third assumption, the distribution of the scores of the dependent variable in the universe for each of the groups should be normal, and that their variances should be equal. According to the results of the Shapiro-Wilk test, the scores for the Experimental Group and Control Group showed normal distribution. According to the Levene test results, it was seen that the variances were equal (F = 2.66, p > .50).
4. According to the fourth assumption, the samples whose mean scores will be compared should be unrelated. In this case, the Experimental Group and the Control Group are unrelated samples.

The success scores met all the assumptions required for covariance analysis, and as such were found to be suitable for analysis. Covariance analysis was applied and the posttest success scores corrected according to the pretest success scores of the students in both groups are presented in Table 3.

Table 3. Posttest score averages corrected according to pretest scores

Group	*N*	$\bar{X}$	Adjusted Average
Experimental	17	75.06	75.30
Control	16	60.00	59.75

*p < .05

According to the test results of the two study groups, it can be seen that the posttest success scores were 75.06 for the Experimental Group and 60.00 for the Control Group. When the posttest scores of the two study groups were examined, the corrected posttest success scores were shown to be 75.30 for the Experimental Group and 59.75 for the Control Group.

ANCOVA results regarding the posttest success scores corrected according to the pretest success scores of the students in the two study groups are presented in Table 4.

Table 4. ANCOVA results of students' posttest scores corrected according to pretest scores

Source of Variance	*SS*	*SD*	Average of Squares	*F*	Significance Level (p)
Pretest	1,596.38	1	1,596.38	5.51	.03
Group	1,988.13	1	1,988.13	6.86	.01
Error	8,692.57	30	289.75		
Total	12,158.06	32			

*p < .05

According to the test results of the two study groups shown in Table 4, it can be seen that the difference between the WTP course posttest success scores of the students in the two groups was found to be significant (F(1,30) = 6.86, p < .05).

The corrected posttest mean ($\bar{X}$ = 75.30) of the Experimental Group was shown to be significantly higher than the posttest average of the Control Group ($\bar{X}$ = 59.75). This finding shows that the learning environment presented with MoodleCloud, which was employed as a cloud-based blended learning environment for the WTP course, was shown to be effective according to the Vocational High School students' success.

Difference Between Persistency Test Success Scores (RQ.1.c)

At the end of the 5 week period following the study's application, the Achievement Test was reapplied to the students again as a Persistency Test in order to measure the effect of CBBLMS on the persistency of the students' learning. Covariance analysis was employed in comparing the Persistency Test success scores, with the students' posttest success scores taken as the common variable. The following four assumptions of this test were tested in order prior to conducting the analysis.

1. According to the first assumption, the regression slopes within the groups should be equal. When the test results were examined, it was seen that the common effect of "group x posttest" on the Persistency Test success scores was insignificant (F(1,29) = 49, p > .05). This finding shows that the slopes of the regression lines calculated for testing the Persistency Test success scores based on the posttest success scores were equal.
2. According to the second assumption, there should be a linear relationship between the dependent variable and the common variable. It was tested whether or not there was a statistically linear and significant relationship with the scattering diagram and the Pearson Correlation Coefficient. According to the Pearson Correlation Coefficient analysis

performed on both the Experimental Groups and the Control Group, it was seen that a positive and significant relationship exists between the groups' posttest success scores and the Persistency Test success scores (r = .65, p < .05). Scatter plots also support this finding.

3. According to the third assumption, the distribution of the scores of the dependent variable in the universe for each of the groups should be normal and that their variances should be equal. According to the results of the Shapiro-Wilk test, the Persistency Test scores of the Experimental Group and the Control Group each show a normal distribution. According to the Levene test results, it was seen that the variances were equal (F = .16, p > .50).
4. According to the fourth assumption, the samples whose mean scores will be compared should be unrelated. In this case, the Persistency Test success scores of the Experimental Group and the Control Group are unrelated samples.

The success scores met all the assumptions required for covariance analysis, and as such were found to be suitable for analysis. Covariance analysis was applied and the Persistency Test success scores corrected according to the scores of the students of both groups from the posttest are presented in Table 5.

Table 5. Students' persistency test score averages corrected according to the posttest scores

Group	*N*	$\bar{X}$	Adjusted Average
Experimental	17	69.88	65.60
Control	16	59.75	64.30

*p < .05

According to the test results of the two study groups, as presented in Table 5, it can be seen that the Persistency Test mean scores were 69.88 for the Experimental Group and 59.75 for the Control Group. When the scores of the two study groups in the posttest were examined, it could be seen that the average score of the corrected Persistency Test was 65.60 for the Experimental Group, whilst it was 64.30 for the Control Group.

ANCOVA results regarding the corrected Persistency Test success scores of the students in the two study groups are presented in Table 6.

Table 6. ANCOVA results of students' Persistency Test scores corrected according to posttest scores

Source of Variance	*SS*	*SD*	Average of Squares	*F*	Significance Level (p)
Posttest	3,552.90	1	3,552.90	18.35	.00
Group	11.49	1	11.49	.06	.81
Error	5,809.87	30	193.66		
Total	10,208.97	32			

*p < .05

According to the test results of the two study groups, it can be seen from Table 6 that the difference between the WTP course Persistency Test success scores was not found to be significant (F(1,30) = .06, p >.05). With this finding, it can be said that the learning environments employed had a similar effect on persistency. Therefore, it may be stated that the learning environment had no effect on the students' persistency.

Difference Between Practice Exam Success Scores (RQ.1.d)

During Week 6 of the application process, a Practice Exam was held for both of the study groups. Since the distribution of the Practice Exam success scores of the study groups was found to be normal, the unrelated samples t-test was used to examine the difference between the Practice Exam success scores of each group of students. The results of the test are presented in Table 7.

Table 7. Students' practice exam *t*-test results

Group	*N*	$\bar{X}$	*S*	*SD*	*t*	*p*
Experimental	17	61.24	22.77	31	2.14	.04
Control	16	44.31	21.98			

*p < .05

According to the test results for the two study groups, it can be seen that the difference between the Experimental Group and the Control Group students' Practice Exam success scores was found to be significant (t(31) = 2.14, p < .05). The average score for

the students of the Experimental Group in the Practice Exam ($\bar{X}$ = 61.24) was found to be higher than the average for those in the Control Group ($\bar{X}$ = 44.31). This finding is similar to that of the previously reported Achievement Test scores. The test results for the Practice Exam success scores support the finding that the MoodleCloud, which offered a cloud-based blended learning environment, had an impact on the students' success.

RQ.2. Difference Between Course Achievement Test Pretest-Posttest and Posttest-Persistency Test Success Scores

Findings for the two sub-questions of Research Question 2 are presented according to the significance of the difference between the achievement scores of the Experimental Group students.

Difference Between Pretest-Posttest Success Scores (RQ.2.a)

Since the pretest success scores of the Experimental Group's students met the normality assumption, the related samples *t*-test was performed to examine the difference between the Experimental Group pretest and posttest success scores. The results of the test are presented in Table 8.

Table 8. Related samples *t*-test results for Experimental Group students' pretest-posttest scores

Measurement	*N*	$\bar{X}$	*S*	*SD*	*t*	*p*
Pretest	17	14.71	12.30	16	15.89	.000
Posttest	17	75.06	15.59			

*$p < .05$

According to the *t*-test results for the Experimental Group, it can be seen that the difference between the students' pretest and posttest success scores was significant ($t(16) = 15.89$, $p < .05$). The posttest average of the Experimental Group ($\bar{X}$ = 75.06) was found to be significantly higher than the pretest mean ($\bar{X}$ = 14.71). According to this finding, it may be said that the cloud-based blended learning environment was effective.

Difference Between Posttest-Persistency Test Success Scores (RQ.2.b)

Since the Persistency Test success scores of the students in the Experimental Group conformed to the assumption of normality, the related samples *t*-test was used to examine the difference between the posttest and Persistency Test success scores of the Experimental Group. Results of the *t*-test are presented in Table 9.

Table 9. Related samples *t*-test results for Experimental Group students' posttest-Persistency Test scores

Measurement	*N*	$\bar{X}$	*S*	*SD*	*t*	*p*
Posttest	17	75.06	15.59	16	1.67	.16
Persistency Test	17	69.88	16.32			

*$p < .05$

According to the test results for the Experimental Group, it can be seen that the difference between the posttest and Persistency Test success scores of the Experimental Group's students was not found to be significant ($t(16) = 1.67$, $p > .05$). The average posttest success score of the students was $\bar{X}$ = 75.06, whilst the average Persistency Test success score was $\bar{X}$ = 69.88. Whilst there was a decrease seen in the Persistency Test success scores, it was not found to be statistically significant. Based on this finding, it may be said that the method applied in the Experimental Group created learning that continued to persist beyond the instructional period.

RQ.3. Cognitive Loads of Vocational High School Students

Findings for the two sub-questions of Research Question 3 are presented according to the significance of the difference between the cognitive load scores of the Experimental Group and the Control Group students.

Difference Between Cognitive Loads (RQ.3.a)

At the end of each week's lesson, the students in the two study groups were tasked with completing a given activity. The descriptive statistics of the average cognitive load scores calculated according to the Cognitive Load Scale that the students completed at the end of each week's activity, and these average scores are presented in Table 10.

Table 10. Descriptive statistics of students' average cognitive load scores

Activity	Experimental Group	Control Group

	N	X̄	*S*	*N*	X̄	*S*
Activity 1	17	4.18	2.32	16	5.44	2.63
Activity 2	17	3.88	2.06	16	4.31	2.30
Activity 3	17	5.06	2.73	16	5.50	2.34
Activity 4	17	5.06	2.28	16	5.44	2.66
Activity 5	17	3.24	2.25	16	4.94	2.05
Total	17	4.28	1.84	16	5.13	1.87

Whilst interpreting the Cognitive Load Scale, a load score of between 5 and 9 was taken to reflect a high cognitive load, whereas a load score of between 1 and 4 a low cognitive load (Paas & Merriënboer, 1993; Sezgin, 2009). According to the results presented in Table 10, it can be seen that the Experimental Group's students had a low cognitive load in Week 1, Week 2, and also in Week 5, whilst they and a high cognitive load during Week 3 and Week 4. For the Control Group's students, they were observed to have a low cognitive load during Week 2 and also in Week 5, and a high cognitive load in Week 1, Week 3, and also in Week 4. Considering the total cognitive load mean scores of the students in both study groups, it can be seen that the Experimental Group's students had a low cognitive load (X̄ = 4.28), whilst the Control Group's students had a high cognitive load (X̄ = 5.13).

The Mann-Whitney U Test was conducted in order to examine the difference between the weekly cognitive load scores of the students during Week 1 and Week 5. The results of this test are presented in Table 11.

Table 11. Mann-Whitney U Test results of students' average cognitive load scores (Week 1, Week 5)

	Group	*N*	Average Rank	Rank Sum	U	*p*
Week 1	Control	16	19.38	310.00	98	.17
	Experimental	17	14.76	251.00		
Week 5	Control	16	20.78	332.50	75.5	.03
	Experimental	17	13.44	228.50		

*$p < .05$

According to the test results for the two study groups, it can be seen that the difference between the average cognitive load scores of the students in the Experimental Group and the Control Group in Week 1 was not found to be significant (U = 98, $p > .05$). However, a significant difference was found to exist between the cognitive load scores in Week 5 in favor of the Experimental Group (U = 75.5, $p < .05$). Considering the mean ranks, the average cognitive load score of the Experimental Group was found to be lower than that of the Control Group. It can therefore be said that for Week 5, the students in the Experimental Group had a lower average cognitive load than the students in the Control Group.

While examining the difference between the mean cognitive load scores of the students in the two study groups in Week 2, Week 3, and also in Week 4, an unrelated samples *t*-test was conducted. The results of the test are presented in Table 12.

Table 12. Students' average cognitive load score *t*-test results (Week 2, Week 3, Week 4)

Week	Group	*N*	X̄	*S*	*SD*	*t*	*p*
Week 2	Experimental	17	3.88	2.06	31	-.57	.56
	Control	16	4.31	2.30			
Week 3	Experimental	17	5.06	2.73	31	-.50	.62
	Control	16	5.50	2.34			
Week 4	Experimental	17	5.06	2.28	31	-.44	.67
	Control	16	5.44	2.66			

*$p < .05$

According to the test results of the two study groups, it can be seen that no significant difference was found to exist between the weekly average cognitive load scores of the students for Week 2 ($t(31) = -.57$, $p > .05$), Week 3 ($t(31) = -.50$, $p > .05$), or in Week 4 ($t(31) = -.44$, $p > .05$).

While examining the difference between the weekly cognitive load mean scores of the students, unrelated samples *t*-test was used, and the results are presented in Table 13.

Table 13. Students' weekly average cognitive load scores *t*-test results

Group	*N*	$\bar{X}$	*S*	*SD*	*t*	*p*
Experimental	17	4.28	1.84	31	-1.31	.20
Control	16	5.13	1.87			

*$p < .05$

According to the test results of the two study groups, it can be seen that no significant difference was found to exist between the weekly average cognitive load scores of the students in the Experimental Group and the Control Group ($t(31) = -1.31$, $p > .05$). The average score of the Experimental Group ($\bar{X} = 4.28$) was seen to be lower than that of the Control Group ($\bar{X} = 5.13$). However, even though the Experimental Group students had less cognitive load, this finding was not shown to be statistically significant.

Relationship Between Cognitive Loads and Achievements (RQ.3.b)

Since the total cognitive load score averages of the Experimental Group and the distribution of Achievement Test scores obtained for all weeks of the application were found to be normal, the significance of the relationship between the cognitive load scores of the Experimental Group students and the course success scores were analyzed according to the Pearson Correlation Coefficient. The results of the Pearson Correlation Coefficient are presented in Table 14.

Table 14. Relationship between Experimental Group students' cognitive load scores and course success scores

		Achievement Test	Cognitive Load
Achievement Test	Pearson Correlation	1	-.13
	Sig. (2-tailed)		.63
	N	17	17
Cognitive Load	Pearson Correlation	-.13	1
	Sig. (2-tailed)	.63	
	N	17	17

*$p < .05$

According to the test results for the Experimental Group, it can be seen that the relationship between the achievements of the students in the Experimental Group and their cognitive loads was not found to be significant ($r = -.13$, $p > .05$).

Since the distribution of cognitive load score averages and Achievement Test scores obtained across all weeks of the application for the Control Group was found to be normal, the significance of the relationship between the cognitive load scores of these students and their course success scores was analyzed according to the Pearson Correlation Coefficient. The results of this analysis are presented in Table 15.

Table 15. Relationship between Control Group students' cognitive load scores and course success scores

		Achievement Test	Cognitive Load
Achievement Test	Pearson Correlation	1	-.16
	Sig. (2-tailed)		.55
	N	16	16
Cognitive Load	Pearson Correlation	-.16	1
	Sig. (2-tailed)	.55	
	N	16	16

*$p < .05$

According to the test results for the control group, the relationship between the achievement and cognitive loads of the Control Group students was not found to be significant ($r = -16$, $p > .05$).

RQ.4. Opinions of Vocational High School Students Taught Using a Cloud-Based Blended Learning Environment about the Effectiveness of Blended Learning Environments

In Week 5 of the study, the SMEBLE was applied to the Experimental Group students. This section presents the findings from the descriptive statistics (see Table 16) obtained from the students' given answers.

Table 16. Descriptive statistics for effectiveness of blended learning environments

Matter and Dimensions	N	Min.	Max.	X̄	SS	Likert Scale
Y1.	17	1	5	3.76	1.20	frequently
Y2.	17	1	5	4.00	1.28	frequently
Y3.	17	2	5	4.06	1.03	frequently
Y4.	17	2	5	4.12	.99	frequently
Y5.	17	3	5	4.71	.59	always
Y6.	17	1	5	3.88	1.17	frequently
Y7.	17	1	5	4.18	1.29	frequently
Y8.	17	1	5	3.71	1.21	frequently
Y9.	17	1	5	4.18	1.33	frequently
Y10.	17	1	5	3.76	1.20	frequently
In face to face learning environments ...				4.04	.30	frequently
C1.	17	2	5	3.71	1.10	frequently
C2.	17	1	5	3.76	1.30	frequently
C3.	17	3	5	4.00	.70	frequently
C4.	17	1	5	3.65	1.32	frequently
C5.	17	1	5	3.76	1.20	frequently
C6.	17	1	5	3.47	1.18	frequently
C7.	17	2	5	4.24	.83	Always
C9.	17	2	5	2,.94	1.09	Sometimes
C10.	17	2	5	3.82	1.02	frequently
C11.	17	2	5	4.24	.83	Always
C12.	17	3	5	4.47	.80	Always
C13.	17	2	5	3.82	1.07	frequently
C14.	17	1	5	3.82	1.24	frequently
C15.	17	2	5	4.53	.80	Always
C17.	17	2	5	3.88	1.05	frequently
C18.	17	3	5	3.94	.56	frequently
C19.	17	2	5	4.00	1.17	frequently
C20.	17	3	5	4.12	.78	frequently
C21.	17	3	5	3.94	.66	frequently
C22.	17	2	5	3.88	1.05	frequently

In online learning environments ...				3.90	.35	frequently
H1.	17	2	5	4.59	.80	Always
H2.	17	2	5	4.47	.80	Always
H3.	17	1	5	4.00	1.11	frequently
H4.	17	2	5	4.06	.90	frequently
H5.	17	1	5	4.29	1.04	Always
H6.	17	1	5	4.59	1.00	Always
H7.	17	2	5	4.18	.95	frequently
H8.	17	3	5	4.29	.77	Always
H9.	17	3	5	4.29	.69	Always
H10.	17	4	5	4.65	.49	Always
H11.	17	4	5	4.53	.51	Always
H12.	17	3	5	4.18	.81	frequently
H13.	17	3	5	4.00	.87	frequently
H14.	17	2	5	4.12	.99	frequently
H15.	17	3	5	4.18	.81	frequently
H16.	17	1	5	4.29	1.05	Always
H17.	17	2	5	3.94	.97	frequently
H18.	17	2	5	4.12	.93	frequently
H19.	17	2	5	3.88	1.11	frequently
H20.	17	2	5	4.12	1.11	frequently
In blended learning environments ...				4.29	.23	Always
C8.	17	1	3	1.59	.80	Never
C16.	17	1	5	2.29	1.26	Seldom
C23.	17	1	5	1.76	1.20	Never
C24.	17	1	5	1.88	1.22	Seldom
C25.	17	1	5	1.82	1.24	Seldom
In terms of technical issues				2.29	1.87	Seldom

According to the results presented in Table 16, the average scores for each sub-dimension of the SMEBLE were evaluated.

The average scores for the “face to face learning environments” sub-dimension was $\bar{X}$ = 4.04, which corresponds to the Likert-type scale option of “often.” This finding shows that the lessons taught in face-to-face environments were considered by the students to be effective. The students provided positive responses to all of the items.

The average scores for the “online learning environments” sub-dimension was $\bar{X}$ = 3.90, which also corresponds to the option of “often.” This finding shows that the courses taught within an online environment were considered by the students to be effective. In addition, while the students responded positively to all of the items, they only answered question C9 (“I felt a greater sense of responsibility compared to the face-to-face environment”) as “occasionally.”

The frequent occurrence of a similar problem in the face-to-face environment indicates that the students assumed a greater sense of responsibility in the face-to-face environment than they did within the online environment.

The average scores for the “blended learning environments” sub-dimension was $\bar{X}$ = 4.24, which corresponds to the “always” option. In other learning environments, the response was found to be on average given as “frequently.” This finding shows that

blended learning environment, within which both online and face-to-face environments are presented together, were considered by the students to be more effective than the other environments. The students provided positive responses to all of the items.

The average scores for the "technical issues" sub-dimension was $\bar{X} = 2.29$, which corresponds to the "seldom" level on the Likert-type response scale. This finding shows that the students did not experience technical problems all of the time, just seldom.

In the current study, the effect of cloud-based blended learning environment on the cognitive loads, success, and persistency of learning for vocational high school students was examined. In this context, a 6-week study was conducted with a total of 33 participating vocational high school students. According to the findings obtained in the study, the following results were revealed.

A significant difference was found to exist between the posttest and Practice Exam success scores of the students studying at the cloud-based blended learning environment (CBBLE) end the posttest and application success scores of the students studying at the face-to-face learning environment (FFLE) and that this was in favor of those studying at the CBBLE. This result shows that the applied learning environment had an effect on the students' academic success. Both of these results are mutually supportive of each other. Similarly, Acar (2014) investigated the effect of using Moodle LMS for blended learning on the academic success of high school students studying English, and reported that it increased the students' success. Yapıcı (2011) used Moodle LMS in the online dimension of blended learning in a research study conducted for a doctoral thesis, and found a significant difference existed in favor of the Experimental Group in the Achievement Test. Dürnel (2018) used Moodle LMS as a blended learning environment in mathematics, and that the students were successful. In addition, Kâhyaoğlu (2014) conducted a Practice Exam in addition to an Achievement Test in a study that investigated the effects of interrogative and blended learning environments, and as a result, a significant difference was found between the groups in terms of their Practice Exam scores in favor of inquiry learning and blended learning environments. This result coincides with the findings obtained in the current study.

No significant difference was found in the Persistency Tests of the current study. This result shows that the persistency in learning continued in a similar fashion in the application performed in the blended learning environment (BLE) and also the face-to-face learning environment (FFLE) and that it had no measurable effect. In other similar studies, researchers found no significant difference between groups in terms of persistency of mobile and face-to-face environments, online learning environment, online activities, and web-supported activities (Gümüş, 2017; Kaya, 2018; Sinanoğlu, 2017; Ünlü, 2015). These results are similar to the current study. However, somewhat differently and also contrary to the findings obtained in the current study, Aksoğan (2011) found learning to be more permanent in blended learning environments.

In the current study, a significant difference was found to exist between the pretest and posttest success scores of the students in the Experimental Group studying in CBBLE. This result, which was revealed to be significant in favor of the posttest, shows that the method used had an effect on the students' success. Previously, in a meta-analysis covering experimental studies into blended learning environments, Batdı (2014) examined three articles and six theses and concluded that blended learning environments were more affective in terms of students' academic achievement. This result supports the finding obtained in the current study. No significant difference, however, was found for the results of the Persistency Test, which demonstrates that persistency of learning in CBBLE continued.

Only in Week 5 of the current study's application was a significant difference observed between the cognitive load averages of students studying at the cloud-based blended learning environment (CBBLE) and those studying at the face-to-face learning environment (FFLE). It was determined, therefore, that students studying at the cloud-based blended learning environment (CBBLE) during Week 5 had less cognitive load and exerted less effort while performing their given activity. However, no significant difference was observed for Weeks 1 through to Week 4. When the average of the overall average cognitive load scores of the activities performed over the course of all weeks of the application are examined, it can be seen that the gap between the two study groups was insignificant. This result demonstrated that extending the number of weeks in future applications could result in decreased cognitive load for the students, although no effect on cognitive load was revealed in the current study.

In the literature, findings both support and challenge the results found in the current study. For example, Ünlü (2015) examined e-learning environment activities in terms of the cognitive load of online activities by developing them using the Moodle LMS, and reported that no significant difference between student groups in terms of their calculated cognitive load scores on the basis of the activity undertaken. As a result, the students in their experimental and control groups were found to be cognitively loaded to an equal degree at the end of their activities. Kaymak (2015) employed Google Drive as a cloud computing tool in different learning tasks for students, and concluded that it had no effect on the cognitive load. Taşkın (2011) also found no significant difference between study groups in terms of their cognitive load level according to the design features of e-learning environments. These findings also concur with the findings obtained in the current study.

According to Özer (2017), students that studied within a mobile-assisted learning environment were not found to be cognitively loaded. Sezgin (2009) concluded that instructional software can reduce students' cognitive loads more effectively than when the teachers themselves use computer-based presentations. In another study, Yılmaz (2012) discovered that using contents prepared according to multimedia design principles in Moodle LMS was found to be more efficient on students' cognitive loads. These findings are therefore inconsistent with the findings obtained in the current study.

It was concluded in the current study that no significant relationship was found to exist between cognitive loads and the achievement of students who received CBBLE and FFLE education and those who did not. Taşkın (2011) discovered that the

relationship between performance and cognitive load was reversed and important in a research study that examined the impact of students' designs on their achievement and cognitive load within e-learning environments.

As a result of the scale applied to students studying in the cloud-based blended learning environment (CBBLE) it was seen that the students responded positively to all items regarding "face-to-face learning environments," "online learning environments," and "blended learning environments." In particularly, the "blended learning environments" were more positively regarded than the other environments. In the literature, students generally have been seen to hold positive opinions about education within a blended learning environment (Aydemir, 2012; Ceylan, 2015; Demirkol, 2012; Sezgin, 2009; Uluyol & Karadeniz, 2009; Yılmaz, 2009).

CONCLUSION AND RECOMMENDATIONS

As a result, it may be stated that education in CBBLE is effective in terms of students' academic success, based on the results of both the Achievement Test and Practice Exam scores of students studying at CBBLE. The results of the Persistency Tests showed that the education provided has no effect on the persistency of the students' learning, and that the persistency continued in a similar way for students of both study groups.

The significant difference that was found to exist between the students' cognitive load scores for those studying at the CBBLE and those students studying at the FFLE but only for Week 5 of the application, may suggest that cognitive load decreases when the application time of a study is extended. In the current study, no significant relationship was found to exist between the cognitive load and success of the two study groups. Based on the results of the "Scale for Measuring the Effectiveness of Blended Learning Environments," which was applied to students from the Experimental Group, it was observed that the students responded positively to all of the items regarding face-to-face, online and blended learning environments. This showed that especially students' responses to blended learning environments, where both online and face-to-face learning environments are delivered together, held more positive views about these environments than where other environments were used singularly.

According to the current study's results, since the MoodleCloud LMS, which is a cloud-based blended learning environment, contributes positively to the success of vocational high school information technology students, it may also be used by teachers and students as a storage medium for homework follow-up, course material access, and the application of online exams.

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Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

A.A. and M.M.B conceived of the presented idea. M.M.B. developed the theory and performed the computations. A.A. encouraged A.B. to investigate [a specific aspect] and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

Ethics Committee Approval Information

An application was submitted to the Ankara University Social Sciences Sub-Ethics Committee regarding the current research, and confirmation received that it was deemed ethically appropriate (decision dated 04/11/2019 and numbered 13/401).

REFERENCES

Acar, A. (2014). *Moodle ile Harmanlanmış İngilizce Eğitimi* [Doktora tezi, Karadeniz Teknik Üniversitesi]. Karadeniz Teknik Üniversitesi Açık Erişim Sistemi. http://acikerisim.ktu.edu.tr/jspui/handle/123456789/2171

Akbulut, Y. (2017). Bilişsel Yük Kuramı ve Çoklu Ortam Tasarımı. Ö. Ö., Dursun & F. Odabaşı (Ed.), *Çoklu Ortam Tasarımı* (pp. 37-55). Pegem Akademi Yayıncılık.

Aksoğan, M. (2011). *Harmanlanmış Öğrenmenin Öğrencilerin Akademik Başarısına ve Öğrenmedeki Kalıcılığa Etkisi* [Yüksek Lisans Tezi, Fırat Üniversitesi].Yök Açık Bilim. https://acikbilim.yok.gov.tr/handle/20.500.12812/356056

Altıparmak, M., Kurt, İ. D., & Kapıdere, M. (2011). E-öğrenme ve uzaktan eğitimde açık kaynak kodlu öğrenme yönetim sistemleri. *XI. Akademik Bilişim Kongresi*, *4*(5). https://ab.org.tr/ab11/kitap/altiparmak_kurt_AB11.pdf

Aydemir, S. (2012). *Harmanlanmış Öğrenme Ortamının Fen Bilgisi Öğretmen Adaylarının Bilimin Doğası ve Bilimsel Araştırmayı Anlamaları Üzerine* [Yüksek Lisans Tezi, Fırat Üniversitesi]. Fırat Üniversitesi Kurumsal Açık Arşiv. https://acikerisim.firat.edu.tr/xmlui/bitstream/handle/11508/12549/323377.pdf?sequence=1&isAllowed=y

Aydın, C., & Biroğul, S. (2008). E- Öğrenmede Açık Kaynak Kodlu Öğretim Yönetim Sistemleri ve Moodle. *Bilişim Teknolojileri Dergisi, 1*(2), 31-36.

Baimurzayev, B. (2016). *Bulut Tabanlı Moodle Öğrenme Yönetim Sisteminin Öğrenci Arayüzünün Kullanılabilirlik Analizi* [Yüksek Lisans Tezi, Gazi Üniversitesi]. Yök Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=LLQxRIBlFmALmeLk8QOYVQ&no=SILLKRLpO39UfcgGqU8lkA

Batdı, V. (2014). Harmanlanmış Öğrenme Ortamlarının Öğrencilerin Akademik Başarılarına Etkisi: Bir Meta-Analiz Çalışması. *Çankırı Karatekin Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *5*(1), 287-302.

Bonk, C. J., & Graham, C. R. (2004). *The handbook of blended learning: Global perspectives, local designs*. Wiley.

Büyüköztürk, Ş. (2018). *Sosyal Bilimler İçin Veri Analizi El Kitabı.* Pegem Akademi Yayıncılık.

Büyüköztürk, Ş., Kılıç-Çakmak, E., Akgün, Ö., Karadeniz, Ş., & Demirel, F. (2016). *Bilimsel Araştırma Yöntemleri*. Ankara, Türkiye: Pegem Yayıncılık.

Cabı, E., & Gülbahar, Y. (2013). Harmanlanmış Öğrenme Ortamlarının Etkililiğinin Ölçülmesi İçin Bir Ölçek Geliştirme. *Pegem Eğitim ve Öğretim Dergisi, 3*(3), 11-26.

Ceylan, V. K. (2015). *Harmanlanmış Öğrenme Yönteminin Akademik Başarıya Etkisi* [Yüksek Lisans Tezi, Adnan Menderes Üniversitesi]. Adnan Menderes Üniversitesi Açık Erişim Sistemi. http://194.27.38.21/web/catalog/info.php?idx=52779301&idt=1 http://hdl.handle.net/11607/1530

Clark, R. C., & Mayer, R. E. (2011). *E-Learning and the science of instruction proven guidelines for consumers and designers of multimedia learning third edition*. San Francisco, CA: Pfeiffer.

Çakmak, E. K. (2007). Çoklu Ortamlarda Dar Boğaz: Aşırı Bilişsel Yüklenme. *Gazi Üniversitesi Eğitim Fakültesi Dergisi*, *27*(2), 1-24.

Daniel, S. J. (2020). Education and the COVID-19 pandemic. *Prospects, 49*, 91-96. doi: 10.1007/s11125-020-09464-3

Demir, E. (2015). Uzaktan Eğitime Genel Bir Bakış. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, 39*, 203-211.

Demirkol, M. (2012). *Ortaöğretim Kurumlarında Harmanlanmış Öğrenme Ortamının Akademik Başarıya ve Öğrenci Tutumlarına Etkisi* [Yüksek Lisans Tezi,Fırat Üniversitesi]. Fırat Üniversitesi Kurumsal Açık Arşiv. https://acikerisim.firat.edu.tr/xmlui/bitstream/handle/11508/12539/323368.pdf?sequence=1&isAllowed=y

Dürnel, A. (2018). *5.Sınıf Matematik Dersinin Harmanlanmış Öğrenme Ortamında İşlenmesi: Bir Durum Çalışması* [Yüksek Lisans Tezi, Bahçeşehir Üniversitesi] Ulusal Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=tsfxpfRmoODF2BvPVBAEWA&no=88tTE6A2zDJNFgINazAgOA

Durak, G., Çankaya, S., & İzmirli, S. (2020). COVID-19 Pandemi Döneminde Türkiye'deki Üniversitelerin Uzaktan Eğitim Sistemlerinin İncelenmesi. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi, 14*(1), 787-809 . doi: 10.17522/balikesirnef.743080

Gülbahar, Y. (2017). *E-öğrenme* [E-learning]. Pegem Akademi Yayıncılık.

Gümüş, H. (2017). *Karma Öğretim Tasarımına Dayalı Öğrenme Ortamında İngilizce Deyimleri Kavram Karikatürleri ile Öğrenmenin Ortaokul Öğrencilerinde Erişi ve Kalıcılığa Etkisi* [Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi]. Ulusal Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=17xKxQDcdynhzES9KvEIWQ&no=dx4ZPdY1ePkuUDjaRQYdpg

İşman, A. (2011). *Uzaktan Eğitim.* Pegem Akademi Yayıncılık.

Jowsey, T., Foster, G., Cooper-Ioelu, P., & Jacobs, S. (2020). Blended learning via distance in pre-registration nursing education: A scoping review. *Nurse Education in Practice, 44*, 102775. doi: 10.1016/j.nepr.2020.102775

Kâhyaoğlu, Y. (2014). *Bilgisayar Dersinde Sorgulayıcı ve Harmanlanmış Öğrenme Ortamlarının Etkilerinin Araştırılması* [Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi], Ulusal Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=lrODLMtnET3IlssPep69pA&no=vmWUN_u7v-Or00Y3bzJIoQ

Karaman, S., Özen, Ü., Yıldırım, S., & Kaban, A. (2009). Açık Kaynak Kodlu Öğretim Yönetim Sistemi Üzerinden İnternet Destekli (Harmanlanmış) Öğrenim Deneyimi. M. Akgül, E. Derman, U. Çağlayan, & A. Özgit (Eds.), *Akademik Bilişim Konferansı* (pp. 63-68). https://ab.org.tr/ab09/kitap/karaman_ozen_AB09.pdf

Kaya, V. D. (2018). *Öğretim Etkinlikleri Modeli'ne Dayalı Çevrimiçi Öğrenme Ortamının Öğrencilerin Akademik Başarılarına, Tutumlarına ve Öğrenmede Kalıcılığa Etkisi* [Doktora tezi, Fırat Üniversitesi]. Fırat Üniversite Kurumsal Açık Arşivi. https://acikerisim.firat.edu.tr/xmlui/bitstream/handle/11508/12275/510446.pdf?sequence=1&isAllowed=y

Kaymak, Z. D. (2015). *Bulut Bilişim Araçlarının, Çalışma Türünün ve Görev Zorluğunun Bilişsel Yük ve Öğrenme Üzerindeki Etkisi* [Doktora tezi, Sakarya Üniversitesi], Sakarya Üniversitesi Açık Akademik Arşiv Sistemi. https://acikerisim.sakarya.edu.tr/handle/20.500.12619/69584

Kılıç, A. G. E., & Karadeniz, Ö. G. Ş. (2004). Hiper Ortamlarda Öğrencilerin Bilişsel Yüklenme ve Kaybolma Düzeylerinin Belirlenmesi. *Kuram ve Uygulamada Eğitim Yönetimi*, *40*(40), 562-579.

Kuzu, A. (2017). Çoklu Ortam Uygulamalarının Kuramsal Temelleri. Ö. Ö. Dursun & F. Odabaşı (Eds.), *Çoklu Ortam Tasarımı* (pp. 1-35).Pegem Akademi Yayıncılık.

Kuzu, S., & Balaman, F. (2004). Moodle Kullanılarak Gerçekleştirilen Web Destekli Eğitim Hakkındaki Öğrenci Görüşleri. *Eğitim ve Öğretim Araştırmaları, 3*(2), 234-242.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge University Press.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, *38*(1), 43-52.

Milli Eğitim Bakanlığı. (2011). *Bilişim Teknolojileri Alanı Çerçeve Öğretim Programı*. Mesleki Eğitim ve Öğretim Sistemini Güçlendirme Projesi (MEGEP).

Osguthorpe, R. T., & Graham, C. R. (2003). Blended learning environments: Definitions and directions. *Quarterly Review of Distance Education*, *4*(3), 227-233.

Özalp, N. A., & Dügenci, M. (2010). Meslek Liselerinde Mesleki Eğitimin Açık Kaynak Yazılımlar Kullanılarak Desteklenmesi. *Akademik Bilişim Konferansı 2010* (pp. 631-636). https://ab.org.tr/ab10/kitap/ozalp_dugenci_AB10.pdf

Özer, M. (2020). Türkiye'de COVID-19 Salgını Sürecinde Milli Eğitim Bakanlığı Tarafından Atılan Politika Adımları. *Kastamonu Education Journal*, *28*(3), 1124-1129. doi: 10.24106/kefdergi.722280

Özer, Ö. (2017). *Mobil Destekli Öğrenme Çevresinin Yabancı Dil Öğrencilerinin Akademik Başarılarına, Mobil Öğrenme Araçlarını Kabul Düzeylerine ve Bilişsel Yüke Etkisi* [Doktora tezi, Mersin Üniversitesi] Ulusal Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=6N50087A4ti6clTRJuIPkA&no=xYZ9x6QPUYTF-bIuT5JZLg

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist*, *38*(1), 1-4. doi: 10.1207/S15326985EP3801_1

Paas, F., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. W. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, *38*(1), 63-71. doi: 10.1207/S15326985EP3801_8

Paas, F. G., & Van Merriënboer, J. J. (1993). The efficiency of instructional conditions: An approach to combine mental effort and performance measures. *Human Factors*, *35*(4), 737-743. doi: 10.1177/001872089303500412

Sarıtaş, M. T., & Üner, N. (2013). Eğitimdeki Yenilikçi Teknolojiler: Bulut Teknolojisi. *Eğitim ve Öğretim Araştırmaları Dergisi*, *2*(3), 192-201.

Seçer, İ. (2015). *Psikolojik test geliştirme ve uyarlama süreci: SPSS ve LISREL uygulamaları.* Anı Yayıncılık.

Sevli, O., & Küçüksille, E. U. (2012). Bulut Bilişimin Eğitim Alanında Uygulanması. *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *16*(3), 248-254.

Sezgin, M. E. (2009). *Çoklu Ortamlı Öğrenmede Bilişsel Kuram İlkelerine Göre Hazırlanan Öğretim Yazılımının Bilişsel Yüke, Öğrenme Düzeylerine ve Kalıcılığa Etkisi* [Doktora tezi, Çukuroava Üniversitesi], Çukurova Üniveritesi Kütüphanesi. http://libratez.cu.edu.tr/tezler/7408.pdf

Sinanoğlu, K. (2017). *Kavram Karikatürleri ve Kavramsal Değişim Metinlerinin 6. Sınıf Öğrencilerinin Bilişsel Yüküne, Akademik Başarısına ve Kalıcılığına Etkisi* [Yüksek Lisans Tezi, Ordu Üniversitesi]. Ordu üniversitesi Açık Arşiv Sistemi. http://earsiv.odu.edu.tr:8080/xmlui/handle/11489/646

Singh, H., & Reed, C. (2001). *A white paper: Achieving success with blended learning.* Centra software. http://www.leerbeleving.nl/wbts/wbt2014/blend-ce.pdf

Sun, L., Tang, Y., & Zuo, W. (2020). Coronavirus pushes education online. *Nature Materials*, *19*(6), 687-687.

Taşkın, B. (2011). *E-Öğrenme Ortamlarında Tasarım Özelliklerinin Öğrencilerin Başarısı ve Bilişsel Yüklenme Düzeylerine* [Yüksek Lisans Tezi, Gazi Üniversitesi]. Yök Açık Bilim. https://avesis.gazi.edu.tr/yonetilen-tez/08de7f19-b544-4d1f-a6c0-63906463edc6/e-ogrenme-ortamlarinda-tasarim-ozelliklerinin-ogrencilerin-basarisi-ve-bilissel-yuklenme-duzeylerine-etkisi

Tekin, H. (2000). *Eğitimde Ölçme ve Değerlendirme*. Yargı Yayın Evi.

Turgut, M. F. (1992). *Eğitimde Ölçme ve Değerlendirme*. Saydam Matbaacılık.

Uluyol, A., & Karadeniz, Y. (2009). Bir Harmanlanmış Öğrenme Ortamı Örneği, Öğrenci Başarısı ve Görüşleri. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, *6*(1), 60-84.

Usta, E., & Mahiroğlu, A. (2008). Harmanlanmış Öğrenme ve Çevrimiçi Öğrenme Ortamlarının Akademik Başarı ve Doyuma Etkisi. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 9*(2), 1-15.

Ünlü, M. (2015). *Ders Çalışma ve Öğrenme Stratejisi Temelli Çevrimiçi Etkinliklerin Başarı, Kalıcılık ve Bilişsel Yük Açısından İncelenmesi* [Doktora tezi, Gazi Üniversitesi]. Gazi Üniversitesi Akademik Veri Yönetim Sistemi. https://avesis.gazi.edu.tr/yonetilen-tez/3e3c08bb-3770-41f9-b182-b4fbfc2e4dfd/ders-calisma-ve-ogrenme-stratejisi-temelli-cevrimici-etkinliklerin-basari-kalicilik-ve-bilissel-yuk-acisindan-incelenmesi

Wang, M., Chen, Y., & Khan, M. J. (2014). Mobile cloud learning for higher education: A case study of Moodle in the cloud. *The International Review of Research in Open and Distributed Learning*, 15(2), 1-2.

Yapıcı, İ. Ü. (2011). *Biyoloji Öğretiminde Harmanlanmış Öğrenme Yönteminin Uygulanması ve Sonuçlarının Değerlendirilmesi* [Doktora tezi, Dicle Üniversitesi]. Dicle Kurumsal Akademik Arşiv. https://acikerisim.dicle.edu.tr:8443/xmlui/handle/11468/1188?locale-attribute=en

Yılmaz, M. B. (2009). *Karma Öğrenme Ortamındaki Üniversite Öğrencilerinin Öğrenme Yaklaşımlarına Göre Ders Başarılarının, Derse Devamlarının, Web Materyalini Kullanma Davranışlarının ve Ortama Yönelik Memnuniyetlerinin Değerlendirilmesi* [Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi]. YTÜ Kurumsal Arşivi. http://dspace.yildiz.edu.tr/xmlui/handle/1/171

Yılmaz, M. (2012). *C# Programlama Dersinde, Çoklu Ortam Tasarım İlkelerine Göre Hazırlanmış Materyallerin Moodle Öğrenme Yönetim Sistemi Üzerinden Kullanılmasının Yüksek Öğrenim Öğrencilerinin Bilişsel Yüklerine ve Ders Başarılarına Etkisi* [Yüksek Lisans Tezi, Başkent Üniversitesi]. YÖK Açık Bilim. https://acikbilim.yok.gov.tr/handle/20.500.12812/63936

Van Merrienboer, J. J., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, *17*(2), 147-177. doi: 10.1007/s10648-005-3951-0

Zhang, J., & Wang, H. (2009). An exploration of the relations between external representations and working memory. *Plos One*, *4*(8), 1-10. doi: 10.1371/journal.pone.0006513