Journal of Educational Technology
& Online Learning
Volume 6 | Issue 2 | 2023
http://dergipark.org.tr/jetol

The effect of internet of things education through distance education on student success and motivation

Emre Özgül [a *], Mehmet Akif Ocak [b]

[a] Zonguldak Bülent Ecevit University, Türkiye
[b] Gazi University, Türkiye

Suggested citation: Özgül, E. & Ocak, M. A. (2023). The effect of internet of things education through distance education on student success and motivation. *Journal of Educational Technology & Online Learning*, 6(2), 403-420.

Highlights

- Asynchronous courses with well-structured videos are more effective than synchronous courses
- 7 - 10-minute videos are ideal for practice-based courses
- There is no significant difference in motivation for synchronous and asynchronous courses
- More research is needed to provide effective ways of distance IoT education

Article Info: Research Article

Keywords: *IoT, Internet of Things, IoT Training, IoT Education, Distance Education*

Abstract

The Internet of Things (IoT) is one of those technologies with a wide range of applications, from planes to cars, from factories to homes. As IoT technology is an interdisciplinary field, it is generally one of the most difficult subjects to learn. Therefore, there is a need to use and develop new teaching methods to facilitate the teaching of IoT technology. This quasi-experimental study aims to examine the effects of synchronous and asynchronous distance courses on students' achievement and motivation in IoT education. The participants, consisting of 35 students from different engineering departments, were randomly assigned to experimental and control groups. The experimental group was instructed asynchronously on the Edpuzzle platform, where interactive videos were presented, and control group was taught synchronously on the Zoom application for 8 weeks. As a result of the research, it was concluded that the students in the asynchronous group were more successful in their academic achievement post-test scores. Although the synchronous group scored higher in terms of motivation, it was concluded that there was no significant difference from the other group.

1. Introduction

There are many studies in the literature in which different tools and methods are used to make education and training processes more effective. An important part of these studies is the integration of technology in education. However, the use of technology alone in education and training processes are not sufficient in certain cases (Karaca & Ocak, 2017). According to Clark (1994), the tools that serve to convey information are not very effective in education alone, and he emphasizes the effect of the teaching method as well as the content used to talk about success in education. With the developments in information and communication technologies, learning and teaching activities have now moved out of the physical environment and into different platforms and environments where distance learning technologies are used, especially in recent years.

[*] Corresponding author. Department of Computer Technologies Devrek Vocational School, Zonguldak Bülent Ecevit University, Türkiye.
e-mail addresses: emreozgul@beun.edu.tr, maocak@gazi.edu.tr
This study was presented at the 2nd International Conference on Educational Technology and Online Learning, June 23-26, 2022.

Doi: http://doi.org/10.31681/jetol.1241362
Received 25 Jan 2023; Revised 31 May 2023; Accepted 31 May 2023

Today's workforce is expected to be made up of individuals who are highly educated and continuously improve their skills and acquire new ones by participating in lifelong learning (Hrastinski, 2008). Undoubtedly, this increasing need for education can be met by e-learning, which is defined as the online learning and teaching process. Distance education is widely used in higher education institutions and an increasing number of students are taking advantage of the flexibility offered by e-learning (Watts, 2016). There are studies that show that distance education is an effective learning method in scientific studies (Al-Balas et al., 2020; Bernard et al., 2004; Rotimi et al., 2017). Until recently, e-learning activities mainly relied on asynchronous tools for teaching and learning (Boulos, Taylor & Breton, 2005; Romiszowski & Mason, 2013), but with the recent advances in technology and increasing bandwidth, they have become synchronous (Kinshuk & Chen, 2006). There is a slight difference between synchronous and asynchronous distance learning. Synchronous distance learning, which largely removes space constraints, is the participation of students in online courses at a fixed time. Whereas, asynchronous distance learning effectively removes the barriers of space and time, and students can take courses from anywhere at any time (Midkiff & DaSilva, 2000).

The Coronavirus (Covid-19) pandemic, which started in late 2019, has caused significant impacts and changes in health, economy, social life and especially educational practices at the global level. With the decision taken by the Council of Higher Education during the pandemic process, theoretical courses in higher education institutions in Türkiye can be held synchronously or asynchronously by distance learning, and applied courses can be held in a hybrid way in line with the needs of higher education programs (YÖK, 2020). In many engineering and fine arts programs, especially in medical education, it has been observed that the distance learning method is inadequate due to limitations in technical, infrastructure and access to technology in the delivery of courses, especially in environments that require laboratory and workshop infrastructure (Kahraman, 2020; Kedraka & Kaltsidis, 2020; Kürtüncü & Kurt, 2020; Yolcu, 2020; Zan & Zan, 2020). In addition, the main reasons for the inadequacy of the distance learning method are listed as the difficulty of the educators to give up the method adopted in the face-to-face classroom environment and switch to new methods, their belief that this situation will increase their workload, that interaction with students will remain limited, that measurement and evaluation activities will not be reliable, and that it will be difficult to conduct applied courses remotely (Özgül, 2016).

With the rapid advancement of technology, the concept of the Internet of Things (IoT) has come to the forefront with Industry 4.0. Although the concept of IoT is said to have emerged in 1982 when a modified Coke machine was connected to the internet and shared the temperature and quantity information of the drinks in the machine, the term 'IoT' was first used by Kevin Ashton at a special conference in 1999 to describe a system of interconnected devices (Farooq et al., 2015). According to Wortmann and Flüchter (2015), the definition of IoT is very broad, and there is no consensus on what IoT technologies actually encompass. IoT is generally defined as the ability of uniquely addressed objects (things) to sense and communicate with each other using internet technology (Gubbi et al., 2013). IoT technology is based on connecting objects in the physical world to the internet environment through a number of sensors, manipulating the data obtained from the objects quickly and accurately, and using the results obtained to facilitate people's lives (Banger, 2017). In summary, to talk about IoT, there must be at least two objects (electronic devices that can be connected to the internet) and an environment that enables communication or interaction between these objects.

Nowadays, IoT technologies are impacting many industries and companies are starting to invest in this technology (Ronoh et al., 2021). IoT technologies are being used in various fields (healthcare, smart homes, telecommunications, transportation, security, manufacturing, construction, agriculture, etc.), but education is one of the fields that has instantly benefited from this technological development (Agrawal & Mittal, 2019; Ronoh et al., 2021). In recent years, IoT technologies have found a wide range of applications, and the need for people trained in this field is growing by the day. For this reason, the world's leading universities have recognized the need for IoT-educated graduates and have started to include IoT in the curriculum of various higher education programs (Chang, Chen, & Huang, 2015; He et al., 2016; Ronoh et al., 2021; Raikar et al., 2018; Rout, Mishra, & Routray, 2017). However, it can be said that the education pillar of IoT is still in the development stage (Lyzhin et al., 2019). This is because IoT technology requires the teaching of different knowledge and skills as it covers disciplines such as computer science, engineering, mathematics, and social sciences (Al-Emran et al., 2020; Ning & Hu, 2012). The interdisciplinary nature of IoT technology also makes it difficult to teach this technology.

A limited number of studies on IoT teaching were found in the literature and it was observed that different learning methods were used in these studies. It can be said that problem-based learning and project-based learning methods are mainly used in these studies. On the other hand, there are almost no studies in which IoT education is carried out through distance education. For this reason, this study is very important in terms of introducing IoT to students in relevant higher education programs, especially engineering students and providing them with an alternative method of teaching IoT.

This study aims to examine the effects of synchronous and asynchronous distance courses on students' academic achievement and motivation in Internet of Things education. Answers to the following questions were sought for this purpose:

- Is there a significant difference between the two groups in terms of pre-test academic achievement scores?
- Is there a significant difference between the two groups in terms of the pre- and post-test academic achievement scores?
- Is there a significant difference between the two groups in terms of the pre- and post-test motivation levels?

2. Literature

In recent years, IoT technologies have found a wide range of applications and the need for people trained in this field is increasing day by day. For this reason, the world's leading universities have recognized the need for graduates with IoT education and have started to develop or offer IoT in various programs or courses (He et al., 2016; Ronoh et al., 2021; Rout, Mishra & Routray, 2017). Universities are offering IoT as an elective course at the undergraduate level, as a core BSc course, as a core MSc course on IoT, or as a massive online open course (MOOCs) on Coursera (Rout, Mishra & Routray, 2017). Today, e-learning and MOOCs are widely adopted and offered by universities around the world (Almatrafi ve Johri, 2018; Chow, Ho & King, 2019; Nunez, Caro & Gonzalez, 2016).

In the literature, there are several survey studies on the importance of IoT technologies in education and the areas where they are used (Abd-Ali, Radhi, & Rasool, 2020; Aldowah et al., 2017; Aydın, Usanmaz, & Göktaş, 2021; Kassab, DeFranco, & Laplante, 2020; Ramlowat & Pattanayak, 2019; Suduc, Bizoi, & Gorghiu, 2018). It is seen that these survey studies mostly focus on the effects and benefits of IoT on education. However, it was observed that there are a limited number of studies on IoT education based on a specific curriculum in the literature. A limited number of studies on IoT education based on a specific curriculum and pedagogical approach were found in the literature, and it was observed that different learning methods were used in these studies. These learning methods commonly used for IoT education include problem-based learning (Mäenpää et al., 2017), project-based learning (Abraham, 2016; Ferreira et al., 2019; Kusmin, Saar, & Laanpere, 2018; Mäenpää et al., 2015; Nelke & Winokur, 2020; Rout et al., 2017), activity-based learning (Porter, Morgan, & Johnson, 2017), collaborative learning (Kortuem et al., 2013; Maiti, Byrne, & Kist, 2019; Plauska & Damaševičius, 2014), flipped learning (Gonçalves et al., 2020; Lei et al., 2017), and some constructivist approaches (Charlton & Avramides, 2016; Kleinschmidt, 2021; Osipov & Riliskis, 2013; Ronoh et al., 2021). However, considering the multifaceted structure, interdisciplinary nature and complexity of IoT technology, it can be said that more research using different learning methods and tools is needed. Studies of IoT education in the literature and information about these studies are provided below.

He et al. (2016) asked students to design and implement solutions to real-world problems using an IoT-based laboratory development kit in an IoT education conducted with 12 undergraduate students, and found positive results for the learning method and development kit used in the study. Kleinschmidt (2021) attempted to teach IoT concepts using collaborative problem-based learning with 32 undergraduate students from different engineering programs and showed that it was possible to introduce IoT concepts and technical skills at the end of the 12-week course. Lei et al. (2017) conducted a study with 14 undergraduate students from different engineering programs using the Open edX platform, Google Forms and GitHub Classroom platforms according to the flipped classroom method. As a result of the study, it was found that video lessons i) provide flexibility in learning, ii) respond to students' individual learning styles and needs, iii) allow teachers to do more activities and use class time in a quality way. Mäenpää et al. (2017) conducted a three-year action research study on teaching IoT devices in a practical, problem-based environment and examined feasible assessment methods used in such environments. As a result, they developed a generic assessment method for multifaceted and complex student projects. Ronoh et al. (2021) compared different learning methods used to teach IoT course content with feedback from students in different undergraduate programs and concluded that the most ideal learning method is a hands-on, project-based learning approach. Rout, Mishra and Routray (2017) implemented a project-based learning approach with 10 undergraduate engineering students to incorporate IoT into the engineering curriculum. As a result of the study, it was observed that the students met 21st century skills such as using modern tools, teamwork and lifelong learning.

The only study found on IoT education through distance learning was conducted by Kortuem et al. (2013). This study was conducted as part of an online course (My Digital Life) at the Open University. It was found that the online IoT course focused on topics such as learning algorithms, developing programming skills, collaborating on projects, creative thinking in design, ethical issues and social implications of computing. In addition, SenseBoard development kit and Scratch-based Sense programming environment were used for teaching IoT concepts. It was stated that approximately 4,000 students completed this 9-month course and as a result of this study, there were many difficulties in teaching IoT concepts to first-year students. It was also stated in the study that it is possible to teach IoT concepts to students of different ages.

IoT technology is one of the most difficult subjects to learn as it is an interdisciplinary field that includes several knowledge and skill areas such as programming, basic electronics, design and project development. As a matter of fact, in order to fully learn this technology, many knowledge and skills such as hardware, software, electronics and even data science need to be acquired (Grammenos & Poole, 2019; Vochescu et al., 2017). The fact that there is no research in Türkiye in which e-learning method is used for IoT education and its effects are examined has been an important factor in the emergence of this research. E-learning can be seen as an important method to help students discover their own thinking strategies and ways of working, and to enable them to develop domain-specific problem-solving skills independently. Accordingly, there is a need to use and develop new teaching methods to facilitate the teaching process and improve the quality of education in IoT technology education. Within the framework of this study, as mentioned above, IoT courses were conducted with synchronous or asynchronous distance courses and their effects on students' educational outcomes were analyzed.

3. Methodology

3.1. Research Model/Design

This study, which examined the effects of the Internet of Things education on student achievement and motivation through distance education, was conducted as a quasi-experimental design (Cohen, Manion & Morrison, 2013). It is the most commonly used experimental design, especially in educational research, when it is not possible to control all variables (Büyüköztürk, 2007).

3.2. Study Group

The study group consisted of 35 students studying in the third and fourth grades of Computer and Electrical-Electronics Engineering at Zonguldak Bülent Ecevit University Faculty of Engineering. They were assigned to control and experimental groups using random sampling (Creswell, 2017), which is ended up with 18 participants in experimental group and 17 participants in control group. Demographic information of the study group is shown in Table 1.

Table 1.

Demographic information of the study group.

Variable		Experimental Group	Control Group	Total
Gender				
	Female	6	7	13
	Male	12	10	22
Departments				
	Electrical and Electronics Engineering	11	12	23
	Computer Engineering	7	5	12
Total		18	17	35

3.3. Data Collecting Tools

The data collection tools used in the study were the Academic Achievement Test and the Motivation Scale.

3.3.1. Academic Achievement Test

The Academic Achievement Test was developed by researchers to measure academic performance based on the learning acquired throughout the course. Before the test was developed, a table of specifications was drawn up to suit the content, instructional objectives and learning outcomes. The researchers then created question pool to cover the learning objectives in the table of specifications. In the first stage, a 35-question test selected from the pool was prepared and item analysis of the test was conducted with 122 undergraduate students from different engineering programs. Statistical analyses were performed using Test Analysis Program (TAP) software. As a result of the TAP analysis, 4 items were removed from the test due to low item discrimination power. Based on the feedback received from experts of the field, 1 additional question was removed from the test and the test was developed with 30 questions. The KR-20 reliability coefficient of the test consisting of 30 items was found to be 0.847. Since this value is close to 1, it is possible to say that the test is reliable (Fletcher, 1981). This test, which was prepared as a result of the reliability study, was applied as a pre- and post-test in order to measure students' achievement in the Internet of Things.

3.3.2. Motivation Scale

The motivation scale, a subscale of the Motivated Strategies for Learning Questionnaire “MSLQ” developed by Pintrich et al. (1991) which was adapted into Turkish by Büyüköztürk et al. (2004), was used in the study to figure out the level of students' motivation. The scale is 7-point Likert type. The scale consists of two subscales: motivation and learning strategies. Confirmatory factor analysis was performed to test the factor structure of this scale adapted to Turkish. The Motivational subscale of the MSLQ has 31 items, three sub-dimensions (value, expectancy and affect) and six factors (intrinsic goal orientation, extrinsic goal orientation, task value, students' perceptions of self-efficacy, control beliefs for learning and test anxiety). Büyüköztürk et al. (2004) conducted exploratory and confirmatory factor analysis (CFA) to examine the construct validity of the related scale, as well as internal consistency coefficient, corrected item-total correlation and t-test analysis for reliability. According to the results of the analysis, the CFA factor weights of the motivation scale ranged between 0.34 and 0.78, the internal consistency coefficient ranged between 0.52 and 0.86, and the corrected item-total correlation values ranged between 0.67 and 0.20. Permission to use this scale was obtained from the authors.

3.4. Data Collection and Development of the Learning Environment

Information on the data collection tools and implementation times used in this study are shown in Table 2.

Table 2.

Data collection tools and implementation times.

Groups	Variable	Pre-test	Intervention	Post-test
Experimental	Academic Achievement Motivation	Achievement test Motivation scale	Asynchronous courses (Edpuzzle)	Achievement test Motivation scale
Control	Academic Achievement Motivation	Achievement test Motivation scale	Synchronous courses (Zoom)	Achievement test Motivation scale

The research was conducted within the scope of a special course affiliated with Zonguldak Bülent Ecevit University Continuing Education Centre (ZBEUSEM) in the fall semester of the 2021-2022 academic year. The Internet of Things (IoT) education process was planned to last for a total of 8 weeks, three hours per week. Before starting the application, a preparatory study was carried out in which a pre-test was conducted to determine the students' prior knowledge and readiness levels for the subject. This preparatory study is the stage where general introductory information about how the teaching process will be carried out is shown and students are randomly assigned to experimental and control groups according to the results of the pre-test. Once the groups had been determined, students were given pre-prepared project development kits to enable them to follow the course and complete the projects. As most of the final-year engineering students attended the course from out of town, the process of purchasing the project development kits individually was also carried out during the preparation phase. The Academic Achievement test and Motivation scale, which were used as data collection tools in the study, were conducted face-to-face in the classroom environment during the pre- and post-test process. A cross-section of images from synchronous and asynchronous distance courses are shown in Figure 1.

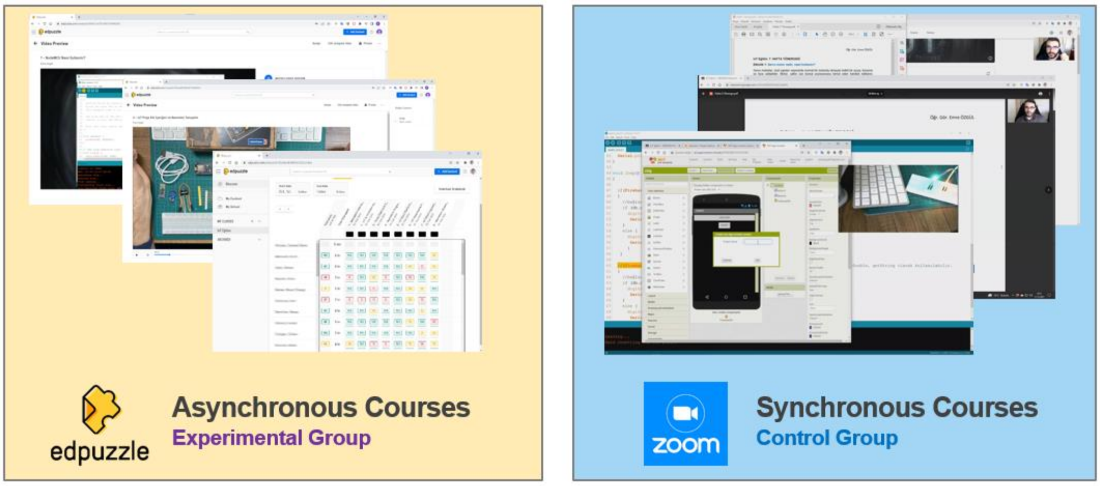

Fig. 1. A sample of weekly courses by groups.

The Internet of Things (IoT) training was delivered asynchronously via the Edpuzzle platform, where interactive training videos were presented in the experimental group. Edpuzzle is a Web 2.0 tool that allows you to create interactive videos by adding open-ended, multiple-choice questions to your videos (edpuzzle.com). In the control group, it was delivered synchronously through the Zoom application (zoom.us). In addition, Google Classroom was created to share course materials in both groups, and WhatsApp groups were created to maintain dialogue with students.

According to Eriksson et al. (2017), students who participate in distance learning courses do not complete the course at a high rate. Therefore, researchers need to take some measures to prevent the problem of dropout in an online course. During the weekly course, the instructor checked whether the topic was followed with interactive questions in the instructional videos prepared separately for the experimental group students. At the same time, the control group students were assigned weekly homework to avoid their drop-out.

3.5. Data Analysis

The data was analyzed using SPSS 20.0 package program. Before the analysis, the assumptions of the statistical techniques used were checked. The significance level was set at .05 when evaluating the results of statistical tests. To test the assumption of normality, the z-value obtained from the ratio of the skewness value to the standard error and the Q-Q normality plot were examined. In all analysis it was found that the normality assumption was met for both the experimental and control groups. As the number of participants in the analysis of the data was less than 50, the Shapiro-Wilk test was used to determine the normality of the distribution. Independent samples t-test and one-way analysis of covariance (ANCOVA) were used to analyze the research data. In addition, the Bonferroni correction was used to identify the source of significant differences between groups and to minimize the possibility of Type I errors that can arise from multiple comparisons of variables.

3.6. Findings and Discussions

The findings obtained are shown to indicate the impact of synchronous and asynchronous distance courses on the educational outcomes of students in IoT education on academic achievement and student motivation through pre and post-tests. Findings related to student academic achievement, one of the sub-problems of the research, are presented below. The 30-question multiple-choice test, which was developed by the researchers within the scope of the academic achievement test and whose reliability coefficient was calculated as .847 after a pilot study, was applied to 35 students participating in the application and the reliability coefficient was found to be .81 by calculating with the Kuder Richardson KR20 formula. According to Büyüköztürk (2019), a reliability coefficient of .70 and higher is sufficient for the reliability of the test scores.

Before starting the analysis, normality assumptions were checked to examine whether the groups were normally distributed. The results of the descriptive statistics obtained from the analysis of the pre and post-test data for both groups are given in Table 3.

Table 3.

Descriptive statistics of academic achievement pre-test and post-test scores of groups

							Shapiro-Wilk	
Groups	Measure	N	$\bar{X}$	SD	Skewness	Kurtosis	Statistic	p
Experimental	Pre-test	18	15.28	3.06	.174	-.666	.965	.690
	Post-test	18	23.72	2.02	-.197	-.496	.942	.316
Control	Pre-test	17	14.71	2.73	.392	.494	.977	.926
	Post-test	17	17.65	2.64	.388	-.698	.952	.497

The lowest score that can be obtained from the academic achievement test was calculated as 0, the highest score as 30 and the average score as 15. When Table 3 is examined, it can be said that the skewness and kurtosis coefficients of the pre-test and post-test academic achievement scores of both groups related to the experimental application show normal distribution according to Tabachnick and Fidell (2007). Levene's test and Pearson correlation analysis were performed to ensure the normality assumption. As a result of both analysis, it was seen that the variances were homogeneous between the academic achievement pre-test ($F=.414$, $p > .05$) and post-test ($F=2.268$, $p > .05$) scores of the groups and the assumption of a positive relationship between these two test ($r = .356$, $p < .05$).

Independent sample t-test analysis was performed based on the pre-test scores to determine whether the students in the experimental and control groups were equivalent in terms of academic achievement in the preparation phase before starting the application. The findings obtained as a result of the analysis are shown in Table 4.

Table 4.

Independent groups t-test results for academic achievement pre-test

Groups	N	$\bar{X}$	SD	df	t	p
Experimental	18	15.28	3.06	33	.581	.565
Control	17	14.71	2.73			

There was no significant difference between the mean achievement scores (see Table 4) of the students in the experimental ($\bar{x}$ = 15.28), and control ($\bar{x}$ = 14.71) groups in the academic achievement test ($t_{33} = .581$, $p > .05$). This finding indicates that the students in the experimental and control groups were similar in terms of achievement levels before the application. It was assumed that the groups had equal conditions as they were studying at the same faculty, the group members were almost the same age and there was no difference between their academic achievement pre-test scores.

After the application, the achievement test was reapplied to the experimental and control groups as a post-test and the data obtained were analyzed using the t-test. The t-test results obtained from the students' academic achievement post-test data are shown in Table 5.

Table 5.

Independent groups t-test results for academic achievement post-test

Groups	N	$\bar{X}$	SD	df	t	p
Experimental	18	23.72	2.02	33	7.660	<.001
Control	17	17.65	2.64			

There was a significant difference between the academic achievement post-test scores (see Table 5) of the students in the experimental group and the control group ($t_{33} = 7.660$, $p < .05$). According to this finding, it can be said that asynchronous education had a positive effect on the academic achievement of the experimental group students. However, ANCOVA analysis is needed to control the effect of the pre-test scores of both groups, which were found to have a significant difference in terms of academic achievement scores. First, the assumptions of the ANCOVA analysis were checked. It was found that the groups were normally distributed and that there was a significant positive correlation between the pre-test and post-test scores for academic achievement (see Table 3). Then, the joint effect of the independent variable (Group) and the academic achievement pre-test variable (Group X AA_pretest) was analyzed to determine whether the assumption of homogeneity of the regression slopes was met. According to the results of the analysis, the joint effect of group and academic achievement pre-test score was not significant ($F(1,31) = 3.957$, $p > .05$). Based on this information, it can be said that the assumption of homogeneity of the regression slopes was met. It has been shown that the assumptions needed for the ANCOVA analysis of the obtained data are provided. The post-test mean scores adjusted according to the pre-test scores of the experimental and control groups are shown in Table 6.

Table 6.

Adjusted post-test mean scores of groups' academic achievement

Groups	N	$\bar{X}$	SD	Adjusted $\bar{X}$	SE
Experimental	18	23.72	6.67	23.607	.372
Control	17	17.65	7.11	17.884	.383

According to Table 6, there is an increase in the academic achievement scores of both groups at the end of the application and the increase observed in the experimental group is higher than the control group. Again, it can be said that the mean achievement of the experimental group ($\bar{x}$ = 23.607) students is higher than the control group ($\bar{x}$ = 17.884) in terms of adjusted post-test mean scores according to the pre-test scores. In order to control the effect of pre-test scores, the results of ANCOVA analysis in which academic achievement pre-test scores were considered as covariate variable are shown in Table 7.

Table 7.

ANCOVA results of achievement post-test scores

Source of Variance	Sum of Squares	*df*	Mean Square	*F*	p	Partial (η^2)	Obs. Power
Pre-test (reg.)	519.962	1	519.962	55.793	.106	.635	1.000
Group	179.224	1	179.224	19.238	<.001	.375	1.000
Error	298.135	32	9.316				
Total	14572.000	35					

According to the ANCOVA results, when the achievement test scores of the students in the experimental group and the control group applied as a pre-test was taken under control, a statistically significant difference was found between the achievement test scores applied as post-test in favor of the experimental group ($F(1,32) = 19.238$, $p < .05$, $\eta^2 = .375$). The relationship between academic achievement pre- and post-test scores indicates a very large effect size of η^2 = .375 according to the general guideline proposed by Cohen (1988). According to the partial eta-square (η^2), it can be seen that the asynchronous courses affected the achievement scores by 38% (see Table 7). Based on this finding, it can be seen that asynchronous distance courses have a positive effect on student achievement compared to synchronous courses. The interactive course videos on Edpuzzle were found to be an important factor in increasing the academic achievement of students in the experimental group.

The findings on student motivation, another sub-problem of the research, are presented below.

Before starting the analysis, normality assumptions were checked to examine whether the groups were normally distributed. The results of the descriptive statistics obtained from the analysis of the pre and post-test data for both groups are given in Table 8.

Table 8.

Descriptive statistics of motivation pre-test and post-test scores of groups

							Shapiro-Wilk	
Groups	Measure	N	$\bar{X}$	SD	Skewness	Kurtosis	Statistic	p
Experimental	Pre-test	18	155.41	12.75	.095	-.240	.987	.995
	Post-test	18	166.18	15.27	.303	-.156	.985	.990
Control	Pre-test	17	156.83	11.23	.436	-.441	.941	.306
	Post-test	17	172.17	12.62	-.800	.136	.926	.165

The lowest score that can be obtained from the motivation scale is 31, the highest score is 217 and the average score is 124. When Table 8 is examined, it can be said that the skewness and kurtosis coefficients of the pre-test and post-test motivation scores of both groups related to the experimental application show normal distribution. Levene's test and Pearson correlation analysis were performed to ensure the normality assumption. As a result of both analysis, it was seen that the variances were homogeneous between the motivation pre-test ($F=.280$, $p > .05$) and post-test ($F=.390$, $p > .05$) scores of the groups and the assumption of a positive relationship between these two test ($r = .628$, $p < .01$).

It was examined whether there was a significant difference between the motivation scores of the students in the synchronous (control group) and asynchronous (experimental group) education. For this purpose, an independent sample t-test analysis was performed based on the pre-test scores to determine whether the students in the experimental and control groups were equivalent in terms of motivation in the preparation phase before starting the application. The findings obtained as a result of the analysis are shown in Table 9.

Table 9.

Independent groups t-test results for motivation pre-test

Groups	N	$\bar{X}$	SD	df	t	p
Experimental	18	155.41	12.75	33	.351	.728
Control	17	156.83	11.23			

There was no significant difference between the mean motivation scores (see Table 9) of the students in the experimental and control groups on the motivation scale ($t_{33} = .351$, $p > .05$). This finding indicates that the students in the experimental and control groups were similar in terms of motivation levels before the application. After the application, the motivation scale was applied again to the both groups as a post-test and the data obtained were analyzed using the t-test. The t-test results obtained from the students' motivation post-test data are shown in Table 10.

Table 10.

Independent groups t-test results for motivation post-test

Groups	N	$\bar{X}$	SD	df	t	p
Experimental	18	166.16	15.27	33	1.268	.214
Control	17	172.17	12.62			

There was no significant difference between the mean motivation scores (see Table 10) of the students in the experimental and control groups in the post-test motivation scale ($t_{33} = .214$, $p > .05$). On the basis of this finding, it can be said that the training had no effect on the change in the motivation levels of the students in the experimental and control groups. However, due to the structure of the motivation scale used in the research, it is useful to examine in detail the effect of the sub-dimensions and factors that make up the relevant scale. ANCOVA analysis was required to examine in detail the effect of the training on the students' motivational factors. First, the assumptions of the ANCOVA analysis were checked. It was found that the groups were normally distributed and that there was a significant positive correlation between the pre-test and post-test scores for motivation (see Table 8). Then, the joint effect of the independent variable (Group) and the motivation pre-test variable (Group X M_pretest) was analyzed to determine whether the assumption of homogeneity of the regression slopes was met. According to the results of the analysis, the joint effect of group and motivation pre-test score was not significant ($F(1,31) = .342$, $p > .05$). Based on this information, it can be said that the assumption of homogeneity of the regression slopes was met. It has been shown that the assumptions needed for the ANCOVA analysis of the obtained data are provided. The motivation post-test mean scores of the experimental and control groups adjusted according to the pre-test scores were calculated for each motivational factors and the results are shown in Table 11.

Table 11.

Adjusted post-test mean scores of groups' motivational factors

Dimensions	Factors	Group	N	Pre-test		Post-test		Adjusted Mean	
				$\bar{X}$	SD	$\bar{X}$	SD	Adj. $\bar{X}$	SE
Value	IGO	Experimental	18	17.47	2.90	18.35	3.26	18.404	.685
		Control	17	18.28	2.72	20.44	2.26	20.396	.665
	EGO	Experimental	18	17.90	2.97	18.44	5.35	18.951	.897
		Control	17	19.35	2.91	21.76	5.28	21.229	.923
	TV	Experimental	18	34.83	3.97	35.94	5.87	35.637	.799
		Control	17	35.47	5.38	36.50	4.99	36.787	.776
Expectancy	PSE	Experimental	18	24.39	5.08	24.48	4.33	24.256	.594
		Control	17	23.18	3.94	25.78	2.44	25.357	.577
	CBL	Experimental	18	41.00	5.07	41.35	4.83	41.611	1.012
		Control	17	41.83	4.64	44.67	5.22	44.423	.984
Affect	TA	Experimental	18	18.94	6.06	22.35	7.37	22.522	.856
		Control	17	19.61	4.45	23.33	6.51	23.174	.809

IGO: Intrinsic Goal Orientation, EGO: Extrinsic Goal Orientation, TV: Task Value, PSE: Perception of Self-Efficacy, CBL: Control Beliefs for Learning, TA: Test Anxiety.

According to Table 11, at the end of the application, the increase in motivation observed in the control group was higher than the experimental group in terms of all factors (IGO, EGO, TV, PSE, CBL and TA). The Bonferroni correction was used to examine whether the change in each factor was significant and to minimize the possibility of Type I error that may arise from multiple comparisons of variables. The results of the ANCOVA analysis are shown in Table 12.

Table 12.

ANCOVA analysis results for motivational factors

Dependent Variable	Sum of Squares	*df*	Mean Square	*F*	p	Partial (η^2)	Obs. Power
IGO	33.956	1-32	33.956	4.305	.046	.119	.521
EGO	56.585	1-32	56.585	2.897	.107	.086	.392
TV	11.508	1-32	11.508	1.063	.310	.032	.170
PSE	18.925	1-32	18.925	3.219	.082	.091	.413
CBL	68.583	1-32	68.583	3.952	.055	.110	.487
TA	115.526	1-32	115.526	2.489	.125	.072	.334

* $p < 0.0083$ (Bonferroni correction applied)

As the significance value was calculated as $p < 0.0083$ according to the result of the Bonferroni correction, no significant difference was found for each variable compared (see Table 12). According to these results, there was no significant difference between the students in both groups in terms of general motivation levels and motivational factors at the end of the application.

4. Conclusion and Suggestions

The purpose of this study is to examine the effects of synchronous and asynchronous distance courses on students' academic achievement and motivation in the Internet of Things (IoT) education. The study was conducted in 8 weeks in a special course affiliated with Zonguldak Bülent Ecevit University Continuing Education Centre (ZBEUSEM) in the fall semester of the 2021-2022 academic year. The study was carried out with 35 students in the third and fourth years of Computer and Electrical-Electronic Engineering at the Faculty of Engineering of the same university. In this study, the students were divided into two groups. In the experimental group, the lessons were conducted asynchronously through the Edpuzzle platform, where interactive videos were presented, while in the control group, the lessons were conducted synchronously through the Zoom application.

As a result of the study, it was concluded that the students in the experimental group, where the asynchronous method was used, were more successful in terms of academic achievement scores. Perveen (2016) also compared asynchronous and synchronous language learning in her study and found that asynchronous learning was highly effective: however, she suggested that both types should be used together. In another comparison by Wang and Wang (2021), of pre-service teachers, no significant relationship was found between cognitive learning processes and either distance learning method. Taking into consideration the results obtained in this study, this study also suggests and supports the fact that asynchronous learning was highly effective as Perveen (2016) put forward. The instructional videos prepared on Edpuzzle consist of videos with an average duration of 7-10 minutes, which were prepared by the authors according to the Internet of Things education curriculum, covering the target outcomes and following a specific storyboard. In this sense, this study has shown that short videos prepared for this purpose are more effective than lessons conducted on Zoom, which last an average of three hours. As Milman (2012) states low-quality and very long course videos can be a problem for students: thus, the results of this study are consistent with Milman (2012).

Keskin and Yurdugül (2022) suggest that when designing e-learning courses, discussion forums should be included to ensure collaboration and communication between learners and e-assessment tools that students can test themselves. Many web platforms that provide online learning and discussion opportunities with graphical user interfaces significantly shorten the learning process and project development time of students

(Tianbo, 2012). In this study, Google Classroom was used to share course materials in both synchronous and asynchronous groups. The Google Classroom platform is very effective as it allows students to easily access files, documents, videos, etc., and can also be used as an interaction tool. In addition, WhatsApp groups were created in this study to maintain dialogue and instant communication between students and the instructor. As a result of this study, it was seen that Google Classroom, WhatsApp and Edpuzzle platforms used in the research process gave positive results in providing distance Internet of Things education. In this respect, it can be said that the study supports the views of Keskin and Yurdugül (2022) and Tianbo (2012). In addition, the current study showed that IoT concepts and technical skills can be acquired by students from different engineering programs that constitute the study group, and similar results were obtained in the related studies (Kleinschmidt, 2021; Lei et al., 2017).

The analysis of the students' motivation levels concluded that although the motivation levels of both groups increased, there was no significant difference between the groups. According to Eriksson et al., (2017), students who participate in distance learning courses do not complete the course at a high rate. Thus, as Gürer et al., (2016) states, teachers should make more efforts to ensure students' participation and attendance in distance learning courses. Accordingly, during the study, researchers took certain precautions to prevent dropout in the online course. Regular checks on whether the topic was followed up with interactive questions in the course videos prepared separately for the experimental group students were conducted. The control group was assigned weekly homework to avoid drop-out. In this study, separate Whatsapp groups were created for the experimental and control groups of students, and student-teacher interaction was encouraged through asking and answering student questions during and at the end of each lesson. At the end of the application, although it was found that the motivation level of the control group students was higher than that of the experimental group students, it was concluded that there was no significant difference between the two groups in terms of motivation levels.

Currently, engineering education is mostly conducted in face-to-face learning environments, and it is based on students' gaining technical skills by completing classroom activities in a limited time (Lau et al., 2018). Distance education is a good alternative to acquire these technical skills in a limited time, and it offers many opportunities and innovations. This study provides important information in terms of providing practical as well as theoretical knowledge with distance education methods and tools, especially with well-structured course content and materials.

Considering that IoT technology contributes to improving the quality of life and satisfaction, safety and security, innovation and sustainability of a society (Davidoff et al., 2006), it is very important to develop IoT-based systems in Türkiye to ensure global competitive advantage. The need for people trained in this field is increasing day by day. Considering the limited number of studies in the field of IoT in Türkiye, it is thought that the data obtained in this study are important for researchers and higher education institutions that will conduct studies in this field. As mentioned in Kortuem et al. (2013), there are some difficulties in providing IoT education especially to beginner students. It may be useful to develop effective e-learning contents in order to prevent problems arising from the complex structure of IoT technology. As IoT technology continues to penetrate our daily lives, it is thought that the need to educate individuals about the basic principles, applications and effects of this field will increase. More research can be done in this area to enable students to access resources independent of time and space and to support personalized learning processes. In addition, it is recommended to use and develop different methods and tools for teaching IoT technology.

References

Abd-Ali, R. S., Radhi, S. A., & Rasool, Z. I. (2020). A survey: the role of the internet of things in the development of education. *Indonesian Journal of Electrical Engineering and Computer Science, 19*(1), 215-221.

Abraham, S. (2016). Using internet of things (IoT) as a platform to enhance interest in electrical and computer engineering. In *2016 ASEE Annual Conference & Exposition*.

Agrawal, S. R., & Mittal, D. (2019). Constructive usage of whatsapp in education sector for strengthening relations. *International Journal of Educational Management, 33*(5), 954–964.

Al-Balas, M., Al-Balas, H. I., Jaber, H. M., Obeidat, K., Al-Balas, H., Aborajooh, E. A., Al-Taher, R., & Al-Balas, B. (2020). Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: Current situation, challenges, and perspectives. *BMC Medical Education, 20*(1), 1–7.

Aldowah, H., Rehman, S. U., Ghazal, S., & Umar, I. N. (2017). Internet of Things in higher education: a study on future learning. In *Journal of Physics: Conference Series, 892*(1), 012017.

Al-Emran, M., Malik, S. I., & Al-Kabi, M. N. (2020). A survey of internet of things (IoT) in education: Opportunities and challenges. In *Toward social internet of things (SIoT): Enabling technologies, architectures and applications* (pp. 197–209). Cham, Switzerland: Springer.

Almatrafi, O., & Johri, A. (2018). Systematic review of discussion forums in massive open online courses (MOOCs). *IEEE Transactions on Learning Technologies*, *12*(3), 413-428.

Aydın, A., Usanmaz, B., & Göktaş, Y. (2021). Nesnelerin İnterneti'nin Eğitimde Kullanıldığı Alanlar ve Bu Alanlara Etkileri. *Yükseköğretim ve Bilim Dergisi, 11*(2), 425-436.

Banger, G. (2018). *Endüstri 4.0.* Dorlion Yayınları.

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., Wallet, P. A., Fiset, M., & Huang, B. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research, 74*(3), 379–439.

Boulos, M. N. K., Taylor, A. D., & Breton, A. (2005). A synchronous communication experiment within an online distance learning program: A case study. *Telemedicine Journal & e-Health*, *11*(5), 583-593.

Büyüköztürk, Ş. (2007). *Deneysel desenler öntest-sontest kontrol grubu desen ve veri analizi.* Pegem A Yayıncılık.

Büyüköztürk, Ş. (2019). *Sosyal bilimler için veri analizi el kitabı*. Pegem Akademi.

Büyüköztürk, Ş., Akgün, Ö. E., Kahveci, Ö. ve Demirel, F. (2004). Güdülenme ve öğrenme stratejileri ölçeğinin Türkçe formunun geçerlik ve güvenirlik çalışması. *Kuram ve Uygulamada Eğitim Bilimleri, 4*(2), 207-239.

Chang, F. C., Chen, D. K., & Huang, H. C. (2015). Future Classroom with the Internet of Things-A Service-Oriented Framework. *J. Inf. Hiding Multim. Signal Process.*, *6(*5), 869-881.

Charlton, P., & Avramides, K. (2016). Knowledge construction in computer science and engineering when learning through making. *IEEE Transactions on Learning Technologies, 9*(4), 379-390.

Chow, R., Ho, M., & King, I. (2019). Online micro-modules library production for fundamental programming courses with active learning. In *2019 IEEE International Conference on Engineering, Technology and Education (TALE)* (pp. 1-5). IEEE.

Clark, R. E. (1994). Media will never influence learning. *Educational Technology Research and Development*, *42*(2), 21-29.

Cohen, J. (1988). F tests on means in the analysis of variance and covariance. In J. Cohen (Ed.), *Statistical power analysis for the behavior science* (pp. 273-406). *NJ: ERLbaum.*

Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education*. Routledge.

Creswell, J. W. (2017). *Eğitim Araştırmaları: Nicel ve Nitel Araştırmanın Planlanması, Yürütülmesi ve Değerlendirilmesi.* (H. Ekşi, Çev.) İstanbul: Edam Yayıncılık.

Davidoff, S., Lee, M. K., Zimmerman, J., & Dey, A. K. (2006). Socially-aware requirements for a smart home. In *Proceedings of the international symposium on intelligent environments* (Vol. 1, No. 2006, pp. 41-44).

Eriksson, T., Adawi, T., & Stöhr, C. (2017). "Time is the bottleneck": a qualitative study exploring why learners drop out of MOOCs. *Journal of Computing in Higher Education, 29*(1), 133-146.

Farooq, M. U., Waseem, M., Mazhar, S., Khairi, A., & Kamal, T. (2015). A review on internet of things (IoT). *International Journal of Computer Applications*, *113*(1), 1-7.

Ferreira, L. C. B. C., Branquinho, O. C., Chaves, P. R., Cardieri, P., Fruett, F., & Yacoub, M. D. (2019). A PBL-based methodology for IoT teaching. *IEEE Communications Magazine*, *57*(11), 20-26.

Fletcher, R. (1981). A nonlinear programming problem in statistics (educational testing). *SIAM Journal on Scientific and Statistical Computing*, *2*(3), 257-267.

Gonçalves, A. C., Neto, V. V. G., Ferreira, D. J., & Silva, U. F. (2020). Flipped classroom applied to software architecture teaching. In *Frontiers in Education Conference (FIE)* (pp. 1-8). IEEE.

Grammenos, R., & Poole, C. (2019). Teaching the internet of things: The first three years. In *2019 26th International Conference on Telecommunications (ICT)* (pp. 265-269). IEEE.

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): a vision, architectural elements, and future directions. *Computer Networks, 29*(7), 1645–1660.

Gürer, M. D., Tekinarslan, E., & Yavuzalp, N. (2016). Çevrimiçi ders veren öğretim elemanlarının uzaktan eğitim hakkındaki görüşleri. *Turkish Online Journal of Qualitative Inquiry, 7*(1), 47-78.

He, J., Lo, D. C. T., Xie, Y., & Lartigue, J. (2016). Integrating Internet of Things (IoT) into STEM undergraduate education: Case study of a modern technology infused courseware for embedded system course. In *2016 IEEE frontiers in education conference (FIE)* (pp. 1-9). IEEE.

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *Educause quarterly, 31*(4), 51-55.

Kahraman, M. E. (2020). The effect of COVID-19 epidemic on applied courses and the implementation of these courses by distance education: example of basic design course. *Journal of Medeniyet Art*, *6*(1), 44-56.

Karaca, C., & Ocak, M. A. (2017). Effects of flipped learning on university students' academic achievement in algorithms and programming education. *International Online Journal of Educational Sciences*, *9*(2), 527-543.

Kassab, M., DeFranco, J., & Laplante, P. (2020). A systematic literature review on Internet of things in education: Benefits and challenges. *Journal of computer Assisted learning, 36*(2), 115-127.

Kedraka, K., & Kaltsidis, C. (2020). Effects of the Covid-19 pandemic on university pedagogy: students' experiences and considerations. *European Journal of Education Studies, 7*(8), 17-30.

Keskin, S., & Yurdugül, H. (2022). E-learning experience: Modeling students'e-learning interactions using log data. *Journal of Educational Technology and Online Learning, 5*(1), 1-13.

Kinshuk, & Chen, N. S. (2006). Synchronous methods and applications in e-Learning. *Campus-Wide Information Systems, 23*(3). https://doi.org/10.1108/cwis.2006.16523caa.001

Kleinschmidt, J. H. (2021). Teaching internet of things for engineering courses: A project-based cooperative approach. *The International Journal of Electrical Engineering & Education*, *58*(4), 858-873.

Kortuem, G., Bandara, A. K., Smith, N., Richards, M., & Petre, M. (2013). Educating the Internet-of-Things generation. *Computer*, *46*(2), 53-61.

Kürtüncü, M., & Kurt, A. (2020). COVID-19 pandemisi döneminde hemşirelik öğrencilerinin uzaktan eğitim konusunda yaşadıkları sorunlar. *Avrasya Sosyal ve Ekonomi Araştırmaları Dergisi*, *7*(5), 66-77.

Kusmin, M., Saar, M., & Laanpere, M. (2018). Smart schoolhouse-Designing IoT study kits for project-based learning in STEM subjects. In *2018 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1514-1517). IEEE.

Lau, E., Lei, C. U., Kwok, T. T., Lui, K. S., Hew, T. K., & Tam, V. (2018). Improving student technical skills learning experience: designing engineering training with the first principles of instruction. In *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)* (pp. 1197-1200). IEEE.

Lei, C. U., Yau, C. W., Lui, K. S., Yum, P., Tam, V., Yuen, A. H. K., & Lam, E. Y. (2017). Teaching Internet of Things: Enhancing learning efficiency via full-semester flipped classroom. In *2017 IEEE 6th International Conference on Teaching, Assessment, and Learning for Engineering (TALE)* (pp. 56-60). IEEE.

Lei, C. U., Yau, C. W., Lui, K. S., Yum, P., Tam, V., Yuen, A. H. K., & Lam, E. Y. (2017). Teaching Internet of Things: Enhancing learning efficiency via full-semester flipped classroom. In *2017 IEEE 6th International Conference on Teaching, Assessment, and Learning for Engineering (TALE)* (pp. 56-60). IEEE.

Lyzhin, I., Efremov, S., Rolich, A., Voskov, L., & Abrameshin, D. (2019). Development of an Educational Kit for Learning IoT. In *Journal of Physics: Conference Series*, *1163*(1), 012015. doi:10.1088/1742-6596/1163/1/012015

Mäenpää, H., Tarkoma, S., Varjonen, S., & Vihavainen, A. (2015). Blending problem-and project-based learning in internet of things education: Case greenhouse maintenance. In *Proceedings of the 46th ACM technical symposium on computer science education* (pp. 398-403).

Mäenpää, H., Varjonen, S., Hellas, A., Tarkoma, S., & Mannisto, T. (2017). Assessing IOT projects in university education-A framework for problem-based learning. In *2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering Education and Training Track (ICSE-SEET)* (pp. 37-46). IEEE.

Maiti, A., Byrne, T., & Kist, A. A. (2019). Teaching internet of things in a collaborative laboratory environment. In *2019 5th Experiment International Conference (exp. at'19)* (pp. 193-198). IEEE.

Midkiff, S. F., & DaSilva, L. A. (2000). Leveraging the web for synchronous versus asynchronous distance learning. In *International Conference on Engineering Education* (Vol. 2000, pp. 14-18).

Milman, N. (2012) The flipped classroom strategy: what is it and how can it be used?. *Distance Learning*, *9*(3), 85-87.

Nelke, S. A., & Winokur, M. (2020). Introducing IoT subjects to an existing curriculum. *IEEE Design & Test*, *37*(6), 24-30.

Ning, H., & Hu, S. (2012). Technology classification, industry, and education for Future Internet of Things. *International journal of communication systems, 25*(9), 1230-1241.

Nunez, J. L. M., Caro, E. T., & Gonzalez, J. R. H. (2016). From higher education to open education: Challenges in the transformation of an online traditional course. *IEEE Transactions on Education*, *60*(2), 134-142.

Osipov, E., & Riliskis, L. (2013). Educating innovators of future internet of things. In *2013 IEEE Frontiers in Education Conference (FIE)* (pp. 1352-1358). IEEE.

Özgül, E. (2016). *The opinions of students and faculty members about distance summer school* [Unpublished M.A. thesis]. Anadolu University, Eskişehir.

Paganelli, F., Mylonas, G., Cuffaro, G., & Nesi, I. (2019). Experiences from using gamification and IoT-based educational tools in high schools towards energy savings. In *European Conference on Ambient Intelligence* (pp. 75-91). Springer, Cham.

Perveen, A. (2016). Synchronous and asynchronous e-language learning: A case study of virtual university of Pakistan. *Open Praxis, 8*(1), 21-39.

Pintrich, P. R., Smith, D., Garcia, T., ve McKeachie, W. J. (1993). *Reliability and predictivevalidity of the motivated strategies for learning questionnaire (MSLQ).* Washington, DC: Office of Educational Research and Improvement.

Plauska, I., & Damaševičius, R. (2014). Educational robots for internet-of-things supported collaborative learning. In *Information and Software Technologies: 20th International Conference, ICIST 2014, Druskininkai, Lithuania, October 9-10, 2014. Proceedings 20* (pp. 346-358). Springer International Publishing.

Porter, J. R., Morgan, J. A., & Johnson, M. (2017). Building automation and IoT as a platform for introducing STEM education in K-12. In *2017 ASEE Annual Conference & Exposition*.

Raikar, M. M., Desai, P., Vijayalakshmi, M., & Narayankar, P. (2018). Upsurge of IoT (Internet of Things) in engineering education: A case study. In *2018 International Conference on Advances in Computing, Communications and Informatics* (ICACCI) (pp. 191-197). IEEE.

Ramlowat, D. D., & Pattanayak, B. K. (2019). Exploring the internet of things (IoT) in education: a review. In *Information Systems Design and Intelligent Applications: Proceedings of Fifth International Conference INDIA 2018 Volume 2* (pp. 245-255). Springer Singapore.

Romiszowski, A., & Mason, R. (2013). Computer-mediated communication. In *Handbook of research on educational communications and technology* (pp. 402-436). Routledge.

Ronoh, K., Muli, E., Ngwawe, E., & Njuki, S. (2021). Internet of Things learning methodologies, teaching tools and teaching platforms. In *2021 International Conference on Electrical, Computer and Energy Technologies (ICECET)* (pp. 1-6). IEEE.

Rotimi, O., Orah, N., Shaaban, A., Daramola, A. O., & Abdulkareem, F. B. (2017). Remote teaching of histopathology using scanned slides via Skype between the United Kingdom and Nigeria. *Archives of Pathology and Laboratory Medicine*, *141*(2), 298–300.

Rout, K. K., Mishra, S., & Routray, A. (2017). Development of an Internet of Things (IoT) based introductory laboratory for undergraduate engineering students. In *2017 International Conference on Information Technology (ICIT)* (pp. 113-118). IEEE.

Suduc, A.-M., Bizoi, M., & Gorghiu, G. (2018). A Survey on IoT in Education. *Revista Romaneasca pentru Educatie Multidimensionala,10*(3), 103-111.

Tabachnick, B. G., Fidell, L. S. (2007). *Using Multivariate Statistics (5th ed).* Boston: Pearson Education Inc.

Tianbo, Z. (2012). The internet of things promoting higher education revolution. In *2012 Fourth International Conference on Multimedia Information Networking and Security* (pp. 790-793). IEEE.

Vochescu, A., Goran, S., Culic, I., & Radovici, A. (2017). Open source platform for sharing Internet of Things educational materials. In *2017 16th RoEduNet Conference: Networking in Education and Research (RoEduNet)* (pp. 1-5). IEEE.

Wang, J., & Wang, Y. (2021). Compare synchronous and asynchronous online instruction for science teacher preparation. *Journal of Science Teacher Education, 32*(3), 265-285.

Watts, L. (2016). Synchronous and asynchronous communication in distance learning: A review of the literature. *Quarterly Review of Distance Education*, *17*(1), 23.

Wortmann, F., & Flüchter, K. (2015). Internet of things. *Business & Information Systems Engineering, 57*(3), 221-224.

Yolcu, H. H. (2020). Preservice elementary teachers' distance education experiences at the time of coronavirus (covid-19) pandemic. *Açıköğretim Uygulamaları ve Araştırmaları Dergisi*, *6*(4), 237-250.

Yükseköğretim Kurumu - YÖK. (2020, March 18). *Basın Açıklaması.* Retrieved from https://www.yok.gov.tr/Sayfalar/Haberler/2020/universitelerde-uygulanacak-uzaktan-egitime-iliskin-aciklama.aspx

Zan, N., & Zan, B. U. (2020). Education in emergency at coronavirus: overview of faculty of letters students included to distance education system from different regions of Turkey. *Turkish Studies, 15*(4), 1367-1394.