International Journal of Engineering Education Vol. 38, No. 2, pp. 408–420, 2022
Printed in Great Britain

0949-149X/91 $3.00+0.00

Online Learning Perceptions amid COVID-19 Pandemic: The Engineering Undergraduates' Perspective*

MELTEM ERYILMAZ[1], GULER KALEM[2], HUREVREN KILIC[1], GUZIN TIRKES[1], DAMLA TOPALLI[1], CIGDEM TURHAN[2], BURCU ALAKUS[2] and ALI YAZICI[2]
[1] Department of Computer Engineering, Atilim University, Ankara, Turkey; [2] Department of Software Engineering, Atilim University, Ankara, Turkey. E-mail: damla.topalli@atilim.edu.tr

The COVID-19 pandemic caused face-to-face education in just about all universities worldwide to shift to online education. For most students, this educational model was a compulsory first experience. In this study, the survey results are analyzed and discussed related to a group of students in the Engineering Faculty of a university in Turkey regarding their online education perceptions. Briefly summarized, the findings of the study indicate that: (a) most of the students still prefer face-to-face learning, which is also favored if accompanied by distance learning; (b) the concentration level of the students has dropped due to the concerns about the COVID-19 pandemic which affects their learning negatively; and (c) around half of the students participating in the study feel that the online exams conducted without a secure exam software, is considered unsafe. Additionally, the study's results were further extended to evaluate the questionnaire results and reported along with the suggestions of necessary actions in emergency online learning (EOL).

Keywords: COVID-19; online learning; emergency online learning (EOL); distance education

1. Introduction

Nowadays, information has become the most critical indicator of societies and university students' development in the educational sphere [1]. Along with the technological developments, the educational system is also experiencing day-to-day changes [2]. As a result, new approaches have come to the fore. Distance education systems are examples of such approaches, enabling time and location flexibility and offering personalized learning for the students [3].

Through this flexible structure, university students can access various resources and mobile applications suitable for their learning styles [4]. After the declaration of the COVID-19 pandemic by the World Health Organization (WHO) on March 11, 2020, all institutions offering educational degree programs started to search for alternative ways of delivering lectures online using the existing tools and technologies. One such alternative is distance education, which uses Information Technologies (IT) used globally for more than 25 years [5, 6], establishing itself as a useful tool for many users.

Several studies in the literature aim to gather insights from students and faculty regarding online learning. Caliskan, Suzek & Ozcan (2017) conducted a study in the 2016–2017 spring semester to determine undergraduate students' satisfaction level of distance education. 107 students participated in this study, and the data was gathered through an online survey [5]. The results indicate that the students have a high satisfaction level with distance education. In another study, Liu, Geertshuis & Grainger (2020) conducted a systematic literature review of 131 articles to gather information on the academicians' adoption of the technologies [6]. According to this study, universities tend to apply new technologies in the learning process, but the academicians' adoption of the technologies does not occur quickly. Also, it is found that technology adoption itself is a complicated procedure that is affected by many factors such as the faculty, technologies utilized in the learning, context, and strategies.

Within this perspective, the present work is a qualitative study that aims to guide universities providing online education during the COVID-19 pandemic. In the research, only engineering students' perceptions of online learning during this exceptional period have been analyzed from different perspectives to gather insight in achieving effective learning on online platforms. Moreover, the study was further extended to evaluate the questionnaire results and report them to the university administration and provide suggestions for necessary actions in emergency online learning (EOL).

2. Related Work

After the outbreak of the COVID-19 pandemic, universities started to implement EOL to cover the spring semester syllabi in time. The only possibility of pursuing education was using video conferencing

* Accepted 8 November 2021.

tools (MS Teams, Zoom, Adobe Connect, and others) to deliver lectures online and imitate face-to-face teaching.

During the COVID-19 pandemic, Peking University offered 100 existing online courses and, as a result, is considered a forerunner institution in China concerning online education [7]. In this study, the authors present instructional strategies for the online teaching experiences of the faculty.

For the unprepared universities, in a noticeably short time, it is expected from the faculty to prepare online course materials such as video content, PowerPoint slides, or pdf material, re-design the courses, and re-plan their teaching strategies. During this period, the need has emerged to move all courses entirely to an online education platform. Additionally, the lack of online learning experience and some of the academicians being non-native to technology are two of the other unseen problems. Gewin (2020) states that the transition from face-to-face education to online education requires many hours of work and patience for a faculty member [8]. There also exist studies that compare face-to-face education with distance education in engineering programs [9].

3. Purpose of the Study

This study aims to determine the effectiveness of EOL, investigate students' experiences and degree of satisfaction, and reveal the difficulties encountered in this transformation during the COVID-19 pandemic.

3.1 Students' Attitude

According to the study by Aguilera-Hermida (2020), research on how the negative emotions created by the pandemic affect the learning process of students is needed since the increased stress and anxiety levels of students have led to a lack of motivation [10]. Moreover, Prior et al. (2016) also present similar findings, suggesting that students' attitude affects the learning process [11]. Against this backdrop, the following research questions have been formulated to gather feedback on students' attitudes towards online learning during the pandemic.

RQ1. Considering the COVID-19 pandemic period, do the weekly course hours in distance education impact the students' concentration levels?

RQ2. Does the anxiety caused by the COVID-19 pandemic affect the weekly study hours of the students?

3.2 Security and Execution of Online Learning

In addition, since online examinations' effectiveness depends on several factors, including reliability, validity, and dishonesty, the absence of face-to-face monitoring raises concerns that online exams can pave the way to cheating [12]. Therefore, the following research question is proposed.

RQ3. Do students find online exams secure?

Moreover, it has also been argued that the technical skills acquired from the physical manipulation in a traditional laboratory setting cannot be acquired as effectively just from simulations [13]. The following research question is formulated to test this argument.

RQ4. Is the use of simulation technologies in performing laboratory activities effective in online learning?

3.3 Self-Assessment

In previous studies, it is reported that "being a digital native does not directly equate to being a digital learner" [14, 15]. To investigate the preference of students regarding the available learning channels, the following research question is proposed.

RQ5. Which of the learning channels (interactive class hours, videos, web resources, textbooks, web meetings, etc.) are preferred by students during the pandemic?

In the study by Keller (2008), we have many overlapping concepts and phrases related to the learning modes, such as distance learning, e-learning, distributed learning, blended learning, hybrid learning, online learning, mobile learning, and so on, and no effort has been made to investigate which mode is better than the others. Instead, it was pointed out that it would be far more productive to define and apply the basic principles of learner motivation to the learning mode under consideration. The same approach can be adopted for EOL [16]. However, the starting step could be to understand the students' attitude towards their former and existing experience comparisons. To examine this problem, the following research question is formulated.

RQ6. Which learning modes are preferred among students during the pandemic?

Lastly, the differences on the students' attitudes, security and self-assessment factors among the classes were investigated by setting the research question below.

RQ7. Do the results of students' attitudes, security and self-assessment factors differ according to their classes during the pandemic?

Table 1. The distribution of students according to age and gender

	Gender					
	Female		Male		Total	
Age	***F***	**%**	***F***	**%**	***F***	**%**
Before Jan 1, 2000	287	27.9	570	55.3	857	83.2
After Jan 1, 2000	70	6.8	103	10	173	16.8
Total	357	34.66	673	65.34	1030	100.0

4. Materials and Methods

A qualitative research methodology was employed in the study and conducted during the 2019–2020 Spring term in the Engineering Faculty of a Turkish University. For this purpose, a survey consisting of 29 questions was designed and applied to the students. The University was closed to face-to-face teaching starting from March 13, 2020 due to the COVID-19 pandemic and afterward continued with the academic activities online using Zoom video conferencing and course material on the University's Moodle Learning Management System (LMS).

4.1 Sample

A total of 1030 (out of 2818) undergraduate engineering students, from 12 4-year degree programs (Computer, Information Systems, Electrical-Electronics, Industrial, Energy Systems, Aerospace, Manufacturing, Civil, Chemical, Mechanical, Mechatronics, Metallurgical and Materials, Automotive and Software Engineering) participated in this study through the ''COVID-19 Online Learning Perception'' survey. It is worth mentioning that there are no online counterparts for these programs in Turkey. The detailed information about the participants, including their age group, gender, and class information, is presented in Table 1 and Table 2, respectively.

4.2 Case Study Learning Environment

The online learning activities are carried out using Zoom video conferencing and course material on the University's Moodle LMS. Zoom has a wide range of functionality to facilitate an interactive and engaging virtual learning environment, such as screen sharing, virtual whiteboard, polling, chatting, and facilitating group work with breakout rooms.

Table 2. The distribution of students according to their class

Current Class	***F***	**%**
1st year	265	25.72
2nd year	225	21.84
3rd year	295	28.64
4th year	245	23.78
Total	1030	100.0

During the sudden transition from face-to-face to online teaching, several adaptations and changes in the teaching methodology were required to minimize the negative side-effects of the process. University administration prepared a set of guidelines and recommendations for this purpose. Some of the changes and adaptations are outlined below:

- Instead of 2–3 midterm examinations, a single online examination was applied in most of the courses.
- All tutorial sessions, and laboratory activities became online whenever possible. For the laboratory activities, remote laboratory tools and simulators were utilized.
- In line with these changes, the course syllabi, and assessment percentages were modified.
- All examinations were held online using Moodle. Invigilation during the examinations were managed using the Zoom video capability.
- Several secure online examination tools were reviewed by the University Distance Education Center. Respondus Monitor/Lockdown Browser and SafeExam Browser options were then offered by integrating both into Moodle LMS for promoting a secure environment during the conduct of the examinations. However, because of the personal data protection law in Turkey, these tools were only utilized in sample examinations.
- Online course duration was reduced from 50 to 45 minutes, allowing a 15-minute break between lecture hours.
- In addition to the existing digital course materials on the respective Moodle sites, instructors provided students with extra course content, videos, and/or animations.
- Online office hours on the Zoom facilitated access to the instructor in an efficient manner.

4.3 Data Collection

On 31 March 2020, the survey was implemented to explore the effectiveness of online learning, students' experiences, and satisfaction, and identify the transformational challenges of EOL at Atilim University. For this purpose, an online survey tool was utilized, and the collected data was analyzed

Table 3. The questionnaire items

Q#	Questionnaire Item
1	Date of Birth *(Before Jan 1, 2000, After Jan 1, 2000)*
2	Gender *(Female, Male)*
3	Current Class *(1, 2, 3, 4)*
4	Total number of online hours/week – H ($H \leq 15$, $15 < H \leq 20$, $20 < H \leq 25$, $25 < H \leq 30$, $H > 30$)
5	What is the maximum number of hours a day in online education including the tutorials and lab sessions? *(3, 4, 5, 6, 7, 8 hours)*
6	Which learning mode would you choose to have your lessons in? (*I would like to be able to take all the lessons without having to come to school, I would like to take all the lessons face to face in school, I would like to be able to take some lessons without having to come to school, I have no idea).*
7	The absence of a physical laboratory environment in distance education prevents learning in some courses.
8	The lack of time and place restrictions in distance education provides continuity of education.
9	Distance education provides the flexibility to repeat as many times as desired.
10	Distance education provides effective learning through audio, visual designs, and technology.
11	Access to information is fast due to the sharing of knowledge on the internet in distance education.
12	Distance education improves self-assessment skills.
13	I would like some courses in my education to be taught online in the future.
14	The laboratory courses are conducted effectively online.
15	The anxiety involving the COVID-19 outbreak affects my concentration on online classes negatively.
16	Assigning homework every week in online learning contributes to my learning process.
For questions 17–23 below, consider your EOL experience, methods, and indicate their contributions to your individual learning	
17	I learn during live interactive class hours.
18	I learn when I watch the course videos prepared by course instructor(s).
19	I learn via existing Internet resources.
20	I learn from course textbook and its materials.
21	I learn when I study together with my friend(s) via Web Meetings.
22	I learn when I do given assignments (like homework, project etc.).
23	The time that I spent on my academic studies during the EOL period is increased when I compare with the past.
For questions 24–27, based on EOL experience, which of the following learning modes do you prefer, in what degree?	
24	Face to Face as it was before
25	Distance Learning as in the current EOL setup
26	Face to Face but together with Distance Learning support
27	Only Distance Learning but not in the EOL setup
28	Online exams carried out without using any security software tools are secure
29	I would like our university to take measures using software tools for online exam security.

using SPSS. A questionnaire including 29 questions was prepared as given in Table 3.

There are various scales in literature that measure students' experiences, attitudes, and satisfaction levels regarding Online Learning effectiveness. The findings obtained by examining these scales indicate that such scales can be collected from various sources and in different terms.

In this study, a new scale based on the existing scales was used. The views of 8 experts were gathered about content validity and assessment criteria relevance of the tests. Then, the necessary arrangements were made in line with the corrections from the experts. The multiple-choice tests' validity and reliability were assessed by applying the test to a sample group of 100 students studying in social sciences.

The scale is a 5-point Likert-type scale with the following level of agreements: Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly Agree (SA), and Not Applicable (NA). Note that the NA response is not considered as part of a 5-point type Likert scale. To test the validity, the Cronbach Alpha coefficient was calculated as 0.87 for internal reliability showing a high degree of internal reliability. In testing the hypothesis of the research, the 0.05 significance level was utilized.

4.4 Data Analysis and Interpretation

In this study, data analysis is performed using SPSS (version 21; IBM Corporation, New York, USA) within a 95% confidence level. To better understand the students' perceptions of online learning during the pandemic, their responses to each question are analyzed descriptively. A correlation analysis is performed to assess the relationship between the students' anxiety and their concentration level with their weekly study hours. The normality test (Shapiro-Wilk) was performed on the data set, and it

Table 4. Descriptive statistics of Q4 and Q15

Descriptive Statistics			
Questions	***M***	***SD***	***N***
Q4. Total number of online hours / weeks.	2.73	1.051	1030
Q15. The anxiety involving the COVID-19 outbreak affects my concentration on online classes negatively.	4.27	1.222	1030

was determined that the distribution was not normal ($p < 0.05$). For this reason, the analysis was made with non-parametric tests, and the Spearman Correlation is used for the analyses. Additionally, non-parametric Kruskal-Wallis H test is conducted for non-normally distributed data to observe the differences of students' preferences among the classes of students.

5. Findings

To answer the research questions of the study, the findings are given under three main sections: students' attitudes, execution of online learning, and students' self-assessment during the pandemic. Participation by students in the survey was voluntary.

5.1 Results on Students' Attitude to Online learning during COVID-19

RQ1. Considering the COVID-19 period, do the weekly course hours in distance education impact the students' concentration levels?

To test RQ1, the results of Q4 and Q15 are analyzed. Since Spearman's correlation coefficient is 0.021, which is less than 0.05 and positive, it is understood that there is a significant relationship between the two variables. Additionally, the descriptive results of the students' responses based on the weekly course hours in EOL and concentration levels are given in Table 4.

5.2 Results on Execution of Online learning during the COVID-19 pandemic from the Students' Perspective

RQ2. Does the anxiety caused by the COVID-19 pandemic affect the weekly study hours of the students?

To test RQ2, Q15 and Q23 are analyzed, and the distribution of the students' responses is given in Table 5.

Most of the students (81.9%) agreed that the anxiety involving the COVID-19 outbreak negatively affected their concentration in online classes. In contrast, only 13.3% of the students think their concentration is not affected negatively (regarding responses of Q15). Additionally, 62.7% of the students disagree that the time spent on their academic studies is increased compared to the past, whereas 29.8% of the students agree that they spent more time on this task during the pandemic. Additionally, most of the students' agreed with the statement, "The anxiety involving the COVID-19 outbreak affects my concentration on online classes negatively" ($M = 4.27$, $SD = 1.22$) regarding responses of Q23.

To assess the relationship between the students' anxiety and their study hours, since not all the variables were normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.05$), a Spearman's rank-order correlation was executed. The results show a statistically significant, moderate negative correlation between the students' anxiety and their study hours $rs = 0.324$, $p < 0.001$.

RQ3. Do students find online exams secure?

To test RQ3, the results of Q28 and Q29 are analyzed, and the distribution of students' answers are presented in Table 6.

47.7% of the students disagreed that online exams carried out without any security software tools are secure, whereas 33.8% of the students agreed that such online exams are secure (regarding Q28). However, 42.3% of the students would not prefer to use software tools for online exam security. In

Table 5. Distribution of Students' responses to Q15 and Q23

	Q15		**Q23**	
Questions	***F***	**%**	***F***	**%**
NA	3	0.3	3	0.3
SD	60	5.8	395	38.3
D	77	7.5	251	24.4
N	47	4.6	74	7.2
A	176	17.1	171	16.6
SA	667	64.8	136	13.2
Total	1030	100.0	1030	100.0

Table 6. Distribution of Students' responses to Q28 and Q29

	Q28		**Q29**	
Questions	***F***	**%**	***F***	**%**
NA	19	1.8	305	29.6
SD	326	31.7	131	12.7
D	165	16.0	240	23.3
N	172	16.7	222	21.6
A	150	14.6	132	12.8
SA	198	19.2	1030	100.0
Total	1030	100.0	305	29.6

Table 7. Distribution of Students' responses to Q7 and Q14

	Q7		Q14	
Questions	***F***	**%**	***F***	**%**
NA	38	3.7	16	1.6
SD	83	8.1	395	38.3
D	73	7.1	244	23.7
N	62	6.0	142	13.8
A	257	25.0	164	15.9
SA	517	50.2	69	6.7
Total	1030	100.0	1030	100.0

comparison, 34.4% of the students agreed that the university should employ online software tools for exam security (Q29).

RQ4. Is the use of simulation technologies in performing laboratory activities effective in online learning?

To test RQ4, Q7 and Q14 are analyzed, and the students' answers are presented in Table 7.

Most students (75.2%) think that the lack of laboratory environment in EOL hampers learning in some courses. In contrast, only 15.2% of the students think that such absence does not hinder learning in distance education (M = 3.91, SD = 1.47) regarding the results of Q7. Supportively, 62% of the students disagreed that the laboratory courses are conducted effectively online, while 22.6% think that the online lab sessions are effective (M = 2.24, SD = 1.33) regarding Q14.

5.3 Results on Students' Self-Assessment on Online learning during the COVID-19 pandemic

RQ5. Which of the effective learning channels are preferred by students during the pandemic?

To test RQ5, the results of Q17 to Q22 are analyzed, and the distribution of the students' answers for their learning channel preferences is presented in Table 8.

34% of the students agreed that they did learn during live interactive class hours (M = 2.64, SD = 1.3), whereas 30% of the students did so when they watched course videos prepared by the course instructor(s) (M = 2.58, SD = 1.27). 66.2% of the students agreed that they learned using the existing Web resources (M = 3.47, SD = 1.19). 50.9% of the students agreed that they learned by studying from the course textbook and related materials (M = 3.08, SD = 1.28). Moreover, 38.5% of the students agreed that they learned by studying together with their friends via Web meetings (M = 2.73, SD = 1.44) while 47.3% of the students learned when they worked on given assignments (such as homework, project, etc.) (M = 2.98, SD = 1.38).

RQ6. Which learning modes are preferred among students during the pandemic?

To test RQ6, the results of Q24 to Q27 are analyzed, and the distribution of students' answers is presented in Table 9.

Most of the students (75.1%) agreed that they

Table 9. The distribution of the Students' Answers on their preferences of "Learning Modes"

	Face-to-Face		Distance Learning during COVID19 pandemic		Face-to-Face with Distance Learning		Only Distance Learning-classical	
Learning Modes	***F***	**%**	***F***	**%**	***F***	**%**	***F***	**%**
Not Applicable	5	0.5	18	1.7	5	0.5	14	1.4
Strongly disagree	64	6.2	385	37.4	138	13.4	377	36.6
Disagree	105	10.2	272	26.4	129	12.5	238	23.1
Neutral	83	8.1	135	13.1	146	14.2	170	16.5
Agree	252	24.5	144	14.0	349	33.9	164	15.9
Strongly agree	521	50.6	76	7.4	263	25.5	67	6.5
Total	1030	100.0	1030	100.0	1030	100.0	1030	100.0

Table 8. The distribution of the Students' Answers on their preferences of "Learning channels"

Learning Channels	Interactive class hours		Watch course videos		Web resources		Course textbook, materials		Web Meetings with friends		Assignments Projects	
	F	**%**	***F***	**%**	***F***	**%**	***F***	**%**	***F***	**%**	***F***	**%**
NA	2	0.2	15	1.5	1	0.1	1	0.1	24	2.3	1	0.1
SD	238	23.1	224	21.7	102	9.9	150	14.6	254	24.7	213	20.7
D	318	30.9	307	29.8	142	13.8	242	23.5	212	20.6	213	20.7
N	122	11.8	175	17.0	104	10.1	113	11.0	144	14.0	116	11.3
A	275	26.7	247	24.0	532	51.7	420	40.8	278	27.0	354	34.4
SA	75	7.3	62	6.0	149	14.5	104	10.1	118	11.5	133	12.9
Total	1030	100	1030	100	1030	100	1030	100	1030	100	1030	100

prefer classical face-to-face education (M = 4.02, SD = 1.28), and 59.4% of the students prefer face-to-face supplemented with distance learning (M = 3.44, SD = 1.37). The results for the items related to distance learning preferred in lower percentages are: 21.4% of the students agreed that they prefer EOL during the pandemic (M = 2.22, SD = 1.32), whereas a similar percentage (22.4%) prefer distance learning in the classical setup (M = 2.29, SD = 1.32). Another question (Q6) is asked in the survey to understand the students' learning mode preferences better to test RQ6. The distributions show that 45.1% of the students would like to take some lessons without having to come to school (face-to-face but together with distance learning). 40.5% of the students would like to take all the lessons face-to-face in school as it was before. Only 13.6% of the students would like to take all the lessons without having to come to school (distance learning).

RQ7. Do the results of students' attitudes, security and self-assessment factors differ according to their classes during the pandemic?

To test RQ7, the results of Q17 to Q29 are analyzed. A Kruskal-Wallis H test was conducted to determine if there were differences in the results of students' attitudes, security, and self-assessment factors during the pandemic between groups that differed in their classes: "1st" (n = 265), "2nd" (n = 225), "3rd" (n = 295) and "4th" (n = 245) year classes. Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons, and the post hoc analysis results were reported.

5.4 Students' Attitude

The mean ranks of the scores for Q23 were statistically significantly different between groups, $\chi 2(3) = 17.248$, $p = 0.001$. The post hoc analysis revealed statistically significant differences considering "the time spent on the academic activities is increased during pandemic period compared to the past" between the 1st (mean rank = 504.47) and 4th (mean rank = 579.82) ($p = 0.017$), 2nd (mean rank = 480.21) and 4th ($p = 0.001$), and 3rd (mean rank = 498.92) and 4th ($p = 0.006$) year groups, but not between any other group combination.

5.5 Security

The mean ranks of the scores for Q28 were statistically significantly different between groups, $\chi 2(3) = 13.084$, $p = 0.004$. The post hoc analysis revealed statistically significant differences considering the item "Online exams carried out without using any security software tool are secure", between the 1st (mean rank = 570.17) and 3rd (mean rank = 488.56) ($p = 0.005$), and 1st and 4th (mean rank = 499.51) ($p = 0.036$) year groups, but not between any other group combination.

5.6 Self-Assessment – Learning Channels

The mean ranks of the scores for Q18 were statistically significantly different between groups, $\chi 2(3) = 14.276$, $p = 0.003$. The post hoc analysis revealed statistically significant differences considering the learning channel preference as "watch the course videos prepared by course instructor(s)", between the 1st (mean rank = 466.19) and 4th (mean rank = 560.71) ($p = 0.001$) year groups, but not between any other group combination.

5.7 Self-Assessment – Learning Modes

The mean ranks of the scores for Q27 were statistically significantly different between groups, $\chi 2(3) = 10.818$, $p = 0.013$. The post hoc analysis revealed statistically significant differences on their learning mode preference as "Only Distance Learning but not in the EOL setup", between the 1st (mean rank = 472.75) and 4th (mean rank = 555.85) ($p = 0.006$) year groups, but not between any other group combination.

6. Discussion

6.1 Discussions about Research Questions

RQ1. Considering the COVID-19 period, do the weekly course hours in distance education impact the students' concentration levels?

Before starting EOL, the university decided that the duration of the online courses would be the same in terms of the number of hours as that of the courses given face-to-face. Accordingly, the average time the students spent on online courses are more than 20 hours each week. Yet, it is recommended to summarize the course material in online learning, in at most 30 minutes for every 3-hour class [8].The findings indicate that online courses' long hours have not affected the students' concentration levels negatively in the present study. This result may be explained by the fact that the students can interact with their instructor during the live online lectures, which help relieve their anxieties related to the pandemic. However, the findings significantly indicate that most of the students' concentration levels have declined due to the anxiety about the COVID-19 pandemic. Similarly, Daniel & Kamioka (2017) also state that each individual's emotional status affects the learning process, and an increased stress level decreases the learning rate [2].

RQ2. Does the anxiety caused by the COVID-19 pandemic affect the weekly study hours of the students?

Distance education students are time-poor, and some drop out of their studies because they fall behind their coursework [17]. The relationship between the module design, environment setup, and students' engagement to study in distance education is apparent and crucial. However, the situation is much more problematic when we consider our indispensable EOL experience. Both instructors and students are under pressure to complete their course-related requirements. The mandatory course syllabus and content, along with coverage updates throughout the pandemic, naturally affected the students' weekly study hours. The updates were made mostly based on the assumption that the students' overall status remained unchanged. However, one cannot deny that the students' attitudes can undergo many changes given the circumstances.

In O'Shea, Stone & Delahunty (2015), a qualitative exploration of undergraduate and graduate students' online learning experience in Australia has been reported [18]. The sentence in the article's title showing students' attitude is impressive: "*I 'feel' like I am at university even though I am online.*" In our view, the new updated narrated response to the EOL given by the students could be: "*I 'feel' like I am online because I have to.*" According to the findings, there is a statistically significant, moderate negative correlation between the students' anxiety and their weekly study hours. This brings us to the same point: The reality of "pandemic distance education"!

RQ3. Do students find online exams secure?

Around half of the students participating in the study feel that the online exams conducted without using a secure exam software would be considered questionable. Despite this outcome, 42% of the students do not wish the university to integrate such software into the online assessment procedures. According to Casey et al. (2018), the three everyday activities that damage online education's academic integrity are plagiarism, improper use of resources, and contract cheating [19]. Academic plagiarism involves presenting someone else's work as one's own, improper use of resources utilizes unauthorized material during exams, and contract cheating involves a paid or unpaid surrogate to replace the students in examinations.

RQ4. Is the use of simulation technologies in performing laboratory activities effective in online learning?

The results indicate that most students feel that the absence of a physical laboratory environment in online learning hinders learning in some courses. Besides, 62% of the students do not perceive that online laboratories are conducted effectively. In contrast to our finding, in their study, Rowe et al. (2018) found that the majority of their participants perceived the online laboratory experience to be the same or better than their experiences in the traditional settings since the online laboratories did not require a physical setup, produced fast results, and could be repeated several times, thereby allowing students to have more time in understanding the goals of the experiments [20]. Other research has also shown that a well-designed, non-traditional laboratory can be as effective as a traditional one in achieving the desired learning outcomes [21].

RQ5. Which of the effective learning channels are preferred by students during the pandemic?

Moore's, [22] mode of learner–content, learner–instructor, and learner-learner modes defines a robust framework for much research and practice [23]. In the study by Martin & Bolliger (2018), the students' perceptions of engagement strategies in the online learning environment have been investigated using the online engagement strategies questionnaire [24]. According to the results obtained, the learners valued learner–instructor engagement strategies most among Moore's three interaction categories [22]. The other interaction mode is the learner–content interaction that occurs when students are involved in studying instructional content in alternative formats. We can classify the different learning channels as in Table 10.

Different from the results attained in [24], a majority of our students prefer classical learning channels based on the learner-content type of interaction mode that occurs in the form of usage of Web resources and course textbook and materials during the pandemic. These results are supported by the answers given to Q11. The respondents agree that access to information in distance education is fast due to the sharing of knowledge on the web with a considerable mean value of 3.25 on the 5-point Likert-scale. The responses point out the importance of accessibility of learner-content interaction, which is known to be a crucial component of

Table 10. Learning Mode Interaction Classification of Learning channels

Learning channels	**Learning Mode Interaction**
Live online courses	*Learner–instructor*
Course videos that are prepared by course instructors/assistants	*Learner–content*
Existing Web resources	*Learner–content*
Course textbook and its materials	*Learner–content*
Web meetings with my friends	*Learner–learner*
Given course assignments like homework, projects, etc.	*Learner–instructor*

engagement to student success in distance education [25]. In conclusion, the obtained contradictory results can still be explained by the unique experience gained by both the students and the instructors during the pandemic.

RQ6. Which learning modes are preferred among students during the COVID-19 pandemic?

From the responses given to Q6, it is seen that 41% of our students prefer to take all the courses face-to-face and at school, while another 45% prefer to come to school while taking some courses online as well. The responses to Q24, the cross-question of this question, support the answers to Q6, and they are consistent since 75% of our students still prefer the face-to-face education mode. On the other hand, from Q26, which is a complementary cross-question of Q6, it is seen that our students prefer face-to-face education with distance learning support at a rate of 59%, and the answers are partially supportive of the answers given to Q6.

In the related Q27, it is understood that only 22% of our students are interested in distance learning but not under the current setup. The present circumstances can only partially provide us with a proper assessment of the students' online learning experiences instead of classical distance learning. Consequently, one cannot conclude that the "classical face-to-face education mode supported by distance education" will be appropriate in the future.

RQ7. Do the results of students' attitudes, security and self-assessment factors differ according to their classes during the pandemic?

- According to the results, 4th year students allocate more time on the academic activities during the pandemic when compared to the other classes.
- 3rd and 4th year students find online exams less secure compared to the 1st year students.
- 4th year students prefer watching the course videos prepared by course instructor(s) more than the 1st year students.
- 4th year students prefer classical type of distance learning more than the 1st year students.

These findings imply that the more experienced students have extra abilities to adapt to EOL when compared to the entry-level undergraduates. Especially the 1st year students have not had a chance to adjust to the university life, get acquainted with their classmates or faculty which negatively affect their concentration and motivation levels. Similarly, Kalman et al. (2020) also found that student in upper-level courses were more interested and successful in online classes when compared to the students taking entry-level courses [26].

6.2 Post-Survey Suggestions to the University Administration

Exceptional periods, such as the one the world is currently facing, force all to take desperate measures. For their part, academic institutions can start by understanding the precise impact of pandemics on the learning/teaching process and, subsequently, give advice to respective authorities to take a course of action that protects the interests and welfare of all those involved.

This attitude's validity and correctness are observed and proven to be accurate, especially during the COVID-19 pandemic, taking student-aware quick actions that are inevitable and urgent. Consequently, following our recognition of the necessity of gathering the students' preferences and opinions to be considered by our university administration throughout the period, we applied the questionnaire and received feedback from those involved. The next stage was to evaluate the questionnaire results and report to the university administration our suggestions and necessary actions to be taken or initiated by them. Notice that the suggested actions were not decided because of a detailed analysis of the questionnaire's answers but were based on the author's quick evaluations during the de-facto pandemic situation.

In the following, we discuss our suggested actions during the period. Notice that the report's scale and coverage encompass the entire university while, in this paper, we focus on the perceptions related to the engineering students only.

6.3 Related to Questions: Q4, Q5, and Q15

According to the answers given to Q4, considering that the total weekly online course hours of the students vary between 15–25 hours a week and that online lessons are held for an average of 5 days a week, a great majority of the students were observed to take 3 to 5 hours of online courses per day. Also, from the responses to Q5, it is seen that students demand at most 3 to 4 hours of such lessons per day, which is again a considerable rate.

Furthermore, the response "The anxiety caused by the COVID-19 pandemic affects my concentration in distance learning negatively" given by students (see Q15) indicates that the current form of education should be handled differently from the classical distance learning process. Those specific measures should facilitate this process and make it easy to be adopted by our students.

Action plan: The weekly number of lesson hours is better to be reduced, for example, either not to conduct 1 hour of lesson every two weeks, or the

instructors could reserve this hour for communication and idea exchanges about the current way the classes are held.

Action status: The suggested action was not taken, nor was such an announcement made by the University Administration to reduce the class hours per week. Instead, the courses were required to be held by the course instructors and assistants. The University Senate decided that even if a student fails a course, it would be counted as withdrawal from the course to compensate for and prevent the negative impacts on students' Grade Point Averages (GPA).

6.4 Related to Questions: Q7, Q13, Q17, and Q25

As seen from the responses given to Q13, approximately 55% of our students prefer to take some of their courses online in the future. However, 38% of the students do not prefer this. No predominant majority has been observed.

According to the answers given to Q25, only 21% of our students indicated that they prefer online distance education as in the format conducted during the pandemic. Around 64% of the respondents, on the other hand, dominates the results in favor of rejecting distance learning under the current pandemic conditions. In Q17, it is seen that 54% of our students believe that their learning was not supported through live interactive lessons, but 34% believe that live interactive lessons were a useful tool for their learning. Regarding the course lab applications (see Q7), only 15% of our students think that remote lab sessions are conducted successfully. Notice that for some courses, labs that require device and field involvement cannot be conducted remotely.

As a result, we can conclude that our students are interested in online education. However, it is impossible to say that this kind of online learning is successful, at least from the students' perspective. Instead, the importance of question/answer, question/comment, and solving together type of interactions in both face-to-face and online synchronized education became apparent.

Table 11. Contribution rates of different learning channels to students' learning

Learning Channel	Contributes to my individual learning (~ %)	Do NOT contribute to my individual learning (~ %)
Live online courses	40	48
Course videos that are prepared by course instructors / assistants	35	47
Existing Web resources	58	30
Course textbook and materials	58	32
Web meetings with my friends	33	50
Given course assignments like homework, projects, etc.	43	42

Action plan: Especially in the problem-solving-intensive and lab-oriented courses having no recitation hours, for example, at least 1 hour per 2 weeks of recitation, can be dedicated by course instructors and/or assistants.

Action status: The suggested action was realized by arranging a time slot from June 1 to June 12 for recitation and course content compensation. During this period, the course instructors were also recommended to complete and grade their midterm exams.

6.5 Related to Questions: Q15, Q16, and Q22

In Q16, 57% of our students think that homework assignments given every week do not contribute to their learning, whereas 33% stated that the application contributes to this process. In Q22, the rates of students who agree and disagree that they have learned while performing tasks such as assignments and projects were 47% and 41%, respectively.

Under the current pandemic conditions, for most of the courses, we can say that assignments, usually given to keep students' attendance, interest, and learning levels high and fit, are not given in the same frequency as its typical "normal time" conditions within the syllabus, but more. However, we understand that given the existing high anxiety situation, 81.9% of the students feel that frequent assignments create a cumulative burden on students; it does not contribute to their learning processes as they believe. This indicator is particularly important when considering our students' overall status, which is different from the "normal time" conditions, making them less susceptible to learning.

Action plan: These actions were based on departmental coordination, making necessary announcements, and taking precautions to reduce the amount of frequent weekly course assignments given to students.

Action status: No such coordination could be materialized, either at the university or department level, but course instructors took their related preventions based on their observations.

6.6 Related to Questions: Q15, Q17 to Q23

This question group was prepared to understand the extent to which our students' learning channels, which are thought to be effective during the pandemic, contributed to their individual learning. In Q23, it was asked whether the time allocated by our students to their academic studies during the pandemic has increased compared to the past.

The learning channels mentioned in Q17 to Q22, and the results of these channels' contribution to students' learning are summarized in Table 11.

From Table 11, we can conclude that the textbooks and materials, which constitute the traditional learning channel, and the available web resources contribute the most to our students' individual learning. However, course videos and web meetings with friends do not contribute to individual learning too much.

Notice that it is difficult to decide in the context of these survey results whether live online lectures, video tutorials, and web meetings with friends, which have been experienced by most of our students and instructors for the first time, are effective channels in individual learning. However, it can be said that students prefer to use classical channels as in the case of face-to-face education in ''normal times.''

From the relatively high demand for and usage of web resources, we can conclude that it is useful that our instructors share their course links to related web resources and study materials on their course Moodle pages (while obeying the copyright issue for limited student access).

As an essential finding (see responses to Q23), despite the dominant 63% response that our students did not spend more time on their studies during the pandemic, around 30% responded positively. When we consider the responses to Q23 together with Q15 in which ''The anxiety caused by the COVID-19 pandemic affects my concentration in distance learning negatively'' is 81.9% (see Q15), all the actions and measures mentioned in this paper for our students to learn more effectively and efficiently should be taken into consideration in the context of this question group.

Action plan: All the actions and measures mentioned in this paper.

Action status: In addition to the already mentioned actions, materialized or not; the University Administration required the course instructors to share their course materials and add the links for the course content to the Moodle sites. Student clubs were encouraged to arrange web meetings and invite field experts to maintain their members' and all students' social interactions as much as possible. The administration took another positive action to transfer the existing psychological support services and guidance unit online, where regular therapy sessions with students having trouble during the pandemic can be held.

Based on the information obtained through the survey, we summarize the positive and negative practices experienced during the pandemic in Table 12.

Provided that the above-mentioned actions continue, hybrid education has been started in the 2019–2020 Fall term, with the decision taken by the University Senate. By installing a camera system in the classrooms, online education was also provided while face-to-face education continued. At the same time, the lessons were recorded and made available to students in the cloud environment, and most of the exams were started to be conducted face-to-face in classes.

Table 12. Summary of positive and negative practices of EOL

Action	Experience
Reduce the number of lesson hours per week	Positive practice
Set up periodical online recitation/ office hours	Positive practice
Reduce the amount of weekly course assignments given	Positive practice
Improve learner-content type of interaction mode by providing accessibility to web resources and study materials	Positive practice
Conducting online exams and labs	Negative practice

7. Conclusion

This study aims to gather insight into the perceptions of engineering students on EOL during the COVID-19 pandemic from different perspectives. For this purpose, a survey was conducted with 1030 engineering students to collect feedback from their experiences in three categories: students' attitude, self-assessment, and online learning execution. The study's findings indicate that most of the students still prefer face-to-face learning mode. At the same time, face-to-face education with distance learning support model also demonstrated a certain weight. Moreover, the results show that the students' concentration level has decreased due to the concerns about the COVID-19 pandemic, thereby affecting their learning negatively. Lastly, concerns regarding the exams' security and not being able to conduct physical laboratory sessions were also revealed by the findings.

In terms of the students, the positive issues related to our EOL experience can be reported as efficiency, accessibility of time and place, and variety of learning styles, whereas negative issues include sense of isolation, and lack of technological infrastructure.

As future work, the perceptions of faculty members' who had to go through this extraordinary teaching experience can be gathered and analyzed to get further feedback on the current practices. As for the personal view of the authors who have all experienced online teaching through the pandemic, when compared to face-to-face learning, online

learning suffers the most in faculty-student interaction. During the online lectures, the instructors are not fully capable of perceiving the students' understanding of the subject because of the lack of non-verbal clues such as eye contact, body language and facial expressions. Moreover, the students are more reluctant in answering the instructor's questions in online settings and their concentration levels are much lower. The students' motivation to attend the lectures decrease since they rely on the recordings of the lectures. Finally, even though the students prefer online exams, it is particularly difficult for the instructor to prevent cheating even with the utilization of online testing applications. In terms of the positive experiences with online teaching, the instructor can offer the course content in a variety of forms such as videos, slides, etc., and more content can be taught in a less amount of time.

Hopefully, the results of the study will provide insight into the EOL conducted during the pandemic to provide guidance in such an exceptional period to institutions who have decided to continue with such learning in the upcoming semesters and to increase the level of preparedness if faced with other unanticipated crises in the years to come.

References

1. H. Collins, H. Glover, F. Myers and M. Watson, Automation in distance learning: An empirical study of unlearning and academic identity change linked to automation of student messaging within distance learning, in *10th International Conference on e-Learning*, Funchal, Madeira, 2016.
2. K. N. Daniel and E. Kamioka, Detection of learner's concentration in distance learning system with multiple biological information, *Journal of Computer and Communications*, **5**(4), pp. 1–152, 2017.
3. R. Brown, Blending learning: Rich experiences from a rich picture, *Training and Development in Australia*, **30**(3), pp. 14–17, 2003.
4. O. Akdemir and T. A. Koszalka, Investigating the relationships among instructional strategies and learning styles in online environments, *Computers & Education*, **50**(4), pp. 1451–1461, 2008.
5. S. Caliskan, S. Suzek and D. Ozcan, Determining student satisfaction in distance education courses. *Procedia Computer Science*, **120**, pp. 529–538, 2017.
6. Q. Liu, S. Geertshuis and R. Grainger, Understanding academics' adoption of learning technologies: A systematic review, *Computers & Education*, p. 103857, 2020.
7. W. Bao, COVID-19 and online teaching in higher education: A case study of Peking University, *Human Behavior and Emerging Technologies*, 2020.
8. V. Gewin, Five tips for moving teaching online as COVID-19 takes hold, *Nature*, **580**(7802), pp. 295–296, 2020.
9. D. Naylor, M. F. Stewart and L. Li, Comparison of Online and In-Class Instruction in Introductory Fluid Mechanics, *International Journal of Engineering Education*, **36**(6), pp. 1967–1975, 2020.
10. A. P. Aguilera-Hermida, College students' use and acceptance of emergency online learning due to COVID-19, *International Journal of Educational Research Open*, 1: p. 100011, 2020.
11. D. D. Prior, J. Mazanov, D. Meacheam, G. Heaslip and J. Hanson, Attitude, digital literacy and self efficacy: Flow-on effects for online learning behavior, *The Internet and Higher Education*, **29**, pp. 91–97, 2016.
12. I. J. Arnold, Cheating at online formative tests: does it pay off? *The Internet and Higher Education*, **29**, pp. 98–106, 2016.
13. J. R. Brinson, Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research, *Computers & Education*, **87**, pp. 218–237, 2015.
14. E. E. Gallardo-Echenique, L. Marqués-Molías, M. Bullen and Jan-Willem Strijbos, Let's talk about digital learners in the digital era, *International Review of Research in Open and Distributed Learning*, **16**(3), pp. 156–187, 2015.
15. A. Iglesias-Pradas Santiago, J. Hernández-García, P. Chaparro-Peláez and L. José, Emergency remote teaching and students' academic performance in higher education during the COVID-19 pandemic: A case study, *Computers in Human Behavior*, **119**, p. 106713, 2021.
16. J. M. Keller, First principles of motivation to learn and e3-learning, *Distance education*, **29**(2), pp. 175–185, 2008.
17. D. M. Whitelock, Thorpe and R. Galley, Student workload: a case study of its significance, evaluation and management at the Open University, *Distance Education*, **36**(2), pp. 161–176, 2015.
18. S. O'Shea, C. Stone and J. Delahunty, "I 'feel' like I am at university even though I am online." Exploring how students narrate their engagement with higher education institutions in an online learning environment, *Distance Education*, **36**(1), pp. 41–58, 2015.
19. K. Casey, M. Casey and K. Griffin, *Academic integrity in the online environment: teaching strategies and software that encourage ethical behavior*, Institute for Global Business Research, Nashville, TN, USA, p. 58, 2018.
20. R. J. Rowe, L. Koban. A. J. Davidoff and K. H. Thompson, Efficacy of online laboratory science courses, *Journal of Formative Design in Learning*, **2**(1), pp. 56–67, 2018.
21. E. K. Faulconer and A. B. Gruss, A review to weigh the pros and cons of online, remote, and distance science laboratory experiences, *International Review of Research in Open and Distributed Learning*, **19**(2), 2018.
22. M. G. Moore, Editorial, Three types of interaction, *American Journal of Distance Education*, **3**(2), pp. 1–7, 1989.
23. R. M. Bernard, P. C. Abrami, E. Borokhovski, C. A Wade, R. M. Tamim, M. A. Surkes and E. C. Bethel , A meta-analysis of three types of interaction treatments in distance education, *Review of Educational Research*, **79**(3), pp. 1243–1289, 2009.
24. F. Martin and D. U. Bolliger, Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment, *Online Learning*, **22**(1), pp. 205–222, 2018.
25. C. Vrasidas, Constructivism versus objectivism: Implications for interaction, course design, and evaluation in distance education, *International Journal of Educational Telecommunications*, **6**(4), pp. 339–362, 2000.
26. R. Kalman, M. Macias Esparza and C. Weston, Student views of the online learning process during the COVID-19 pandemic: A comparison of upper-level and entry-level undergraduate perspectives, *Journal of Chemical Education*, **7**(9), pp. 3353–3357, 2020.

Meltem Eryilmaz, PhD, has a Bachelor of Science degree in Statistics from METU, Ankara-Turkey, completed her MS degree in Computer Engineering Department at ATILIM University in Ankara. She then was awarded a PhD degree from CEIT (Computer Education and Instructional Technology) Department of Ankara University. Dr. Eryilmaz currently conducts research on flipped learning, e-learning, adaptive learning, data mining, artificial intelligence technologies and augmented reality at Computer Engineering Department of ATILIM University, as well as jointly continuing to publish articles with international institutions on the same and similar topics regarding Statistical Risk Assessment of Cyber Educational Systems.

Guler Kalem, PhD received her BSc and MSc degrees from the Computer Engineering Department of Atılım University in 2003 and 2005, respectively. She studied at Medical Informatics Department of METU for her PhD studies. Later, she received her Ph.D. degree from the Software Engineering Department of Atılım University in 2017. She is currently working as an instructor in the Department of Software Engineering, Atılım University, Ankara, Turkey. Her research interests include medical informatics, information systems, healthcare/mobile technologies, reasoning systems, and the semantic web technologies.

Hurevren Kilic, PhD has BSc, MSc and PhD degrees all earned from Computer Engineering Department of Middle East Technical University, Ankara, Turkey, in 1989, 1992 and 1998, respectively. He is an Associate Professor of Computer Science & Engineering at Atılım University, Ankara, Turkey. His current research interests include Agent-Based Modeling and Simulation, Multi-Agent Systems, Natural Computing, Search-Based Software Engineering, Applications of Artificial Intelligence and Computer Science and Engineering Education. He has 50 around conference/journal publications. He is a member of IEEE Computer Society and Association for Computing Machinery (ACM).

Guzin Tirkes, PhD graduated from Bilkent University Computer Technology and Information Systems Department in 2001. After graduation, she worked in private institutions and started her graduate education at Atılım University Computer Engineering Department in 2004. Simultaneously, she worked as an IT specialist at Atılım University Information and Communication Technologies Directorate. She completed her master's degree in 2007 and started to work at the Atılım University Computer Engineering Department as a lecturer. In 2016, she completed the Modeling and Design of Engineering Systems doctoral program. She is still working as a lecturer and vice chairman in the Department of Computer Engineering. Her areas of interest are optimization, scheduling, mathematical modeling, distance education, and decision support systems.

Damla Topalli, PhD received the BSc and MSc degree in the Department of Computer Engineering at Baskent University in 2009 and Atilim University in 2013, respectively. She has completed her PhD in the Department of Software Engineering, Atilim University in 2018, where she had the opportunity to do research on many fields such as data mining, classification, hand and eye-movement event analysis for the skill level assessment in medical field. She has been with the Department of Computer Engineering, Atilim University, since 2010. Her research interests include software engineering, data mining and medical informatics.

Cigdem Turhan, PhD is currently working as an Associate Professor in the Department of Software Engineering, Atilim University, Ankara, Turkey. She has a PhD degree in computer engineering from the Middle East Technical University, Ankara, Turkey. She is the author of a number text books in the area of programming. Her research interests include natural language processing, machine translation, semantic web technologies and engineering education.

Burcu Alakus is a research assistant in the Department of Software Engineering at Atilim University, Turkey since September 2019. She received the BSc in the Department of Software Engineering at Atilim University in 2019. She is currently doing her MSc studies in the Department of Cognitive Science at Graduate School of Informatics, in Middle East Technical University, Turkey. Her research interests include software engineering and cognitive science.

Ali Yazici, PhD is the Chairperson of the Software Engineering Department at Atilim University, Ankara, Turkey. He received BS (1972), and MS (1974) degrees in Mathematics from METU, Ankara, Turkey. He has completed his PhD dissertation (1983) at the Computer Science Department, Waterloo University, Canada. His research interests include Parallel and Distributed Computing, Cloud Computing, Big Data Programming, and Database Systems. During his academic career, he acted as thesis supervisor of about 30 MS and PhD students. He is the writer of more than 130 scientific articles, books and research reports in the field of Computing and Informatics.