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Student performance under asynchronous and synchronous methods in distance education: A quasi-field experiment

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ABSTRACT

This study examines student performance under asynchronous and synchronous methods in a microeconomics course during COVID-19 pandemic. We conduct a quasi-field experiment in a state university in Turkey. In the experiment, students were divided into synchronous and asynchronous groups and were taught the same weekly material of microeconomics by the methods respective to their group. At the end of the week, both groups took the same multiple question test. Our results showed that asynchronous group performed significantly better than the synchronous group. While showing the comparative advantage of the asynchronous method, our study also underlines the importance of interaction between instructors and students. We discuss our findings from a socioeconomic perspective, where we argue that the flexibility that the asynchronous method offers might have compensated for the accessibility issues (internet and/or computer) during the COVID-19 outbreak. As a policy recommendation, universities can offer lectures with a recorded option to allow students to interact with the course material multiple times.

1. Introduction

The COVID-19 outbreak has distorted everyday life worldwide. Since the World Health Organization (WHO) announced that the virus became a pandemic on March 11, 2020, countries started to adopt extensive measures against its spread. Although the stringency of the policies has varied across the countries, the major policy has been targeted to reduce human mobility.[3] Meanwhile, the challenge has been protecting the economies and keeping them as operational as possible (Kochańczyk and Lipniacki, 2021). As a response, most of the services moved online, and teleworking has become almost the default setting for many sectors, including higher education. Although education had to be suspended at the beginning of the pandemic, schools and higher education institutions in several countries were quick to return to online platforms and TV or radios (UNESCO, 2020). In this study, we aim to compare the effects of synchronous and asynchronous methods of delivery in distance education on academic performance. By a quasi-field experiment, we investigate whether student success varies between the two teaching formats in a microeconomics course in a Turkish university.

Education is vital for human capital accumulation, and its interruption- due to external shocks such as epidemics, natural disasters, terrorism, and war- hinders economic development and growth (Baez et al., 2010; Kuecken et al., 2014; Akbulut-Yuksel, 2014). The

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current pandemic has affected 90% of all students worldwide, and it still imposes significant uncertainties in higher education (UNESCO, 2020). Kissler et al. (2020) claim that the necessity of social distancing may last until 2022, and the state of emergency for COVID-19 might last until 2024. Therefore, it becomes clear that analyzing distance education practices is of great interest both from a human development perspective and also for understanding the best practices for the post-COVID era. The latter is crucial as the experience gained during this period will inevitably contribute to the future development of distance education systems (Neuwirth et al., 2020). In fact, higher education institutions, including well-known universities (see the online courses in Princeton or Harvard), were already integrating online classrooms in their curriculums in the pre-COVID period, and online courses had already become alternatives to university-based courses.

Especially during the pandemic, distance education proved to be a handy solution that ensured continuous academic activities, but not all students could benefit from online courses in an equal manner. The sudden transition caught countries unprepared, especially in terms of the internet infrastructure, and disadvantaged students who could use university infrastructure during face-to-face education did not have the same opportunities at home. While preparing online materials and lectures, universities worldwide had to take into account this digital divide and potential socioeconomic inequalities in access to education. Two main tools are available to distance education services and are potentially relevant to this discussion: synchronous and asynchronous methods (Means et al., 2010).

This study aims to compare the student success between synchronous and asynchronous lectures by a quasi-field experiment. Several papers studied the quality of distance education (Shih et al., 2007; Hart, 2012; Tallent-Runnels et al., 2006; Melo et al., 2021) also in comparison to in-person delivery (see. Means et al., 2010), however, there has been little interest in the methods of delivery in distance education. Although literature offers a few works on the comparisons of synchronous and asynchronous methods (see, Beyth-Marom et al., 2005; Offir et al., 2008; Kunin et al., 2014; Wang and Wang, 2020), the pandemic imposed unique challenges to implementation of the two methods, and therefore these studies must be repeated. Furthermore, the recent transition to distance education was adopted almost universally; a change in such a scale will inevitably change the way higher education is organized in the future. Hybrid or blended models of education are already being discussed. This means that distance education and its synchronous and asynchronous systems must be studied in detail, especially from a policy perspective.

Synchronous lectures have the advantage of mimicking traditional education, where one-to-one and real-time interaction between students and teachers can be made possible through online platforms, however, they are also more demanding in terms of good internet connection and immediate availability of computers. On the other hand, the asynchronous method lacks real-time interaction but is relatively more flexible, allowing students to access education when they have a good internet connection or use the only available computer if there are more than one student at home or teleworking parents. At first glance, the asynchronous method seems appropriate for allowing students to overcome accessibility issues to a certain extend. However, since the aim of the higher education institutions has been to deliver services as efficient as the pre-COVID period, we must also pay attention to the effectiveness of the two methods from a comparative perspective.

We conduct a quasi-field experiment that examines the effects of synchronous and asynchronous lectures on students' achievement in undergraduate microeconomics course. The experiment for this study was conducted at a state university in Turkey. Undergraduate students in a total of four classes of two different instructors took part in the experiment. Each instructor of microeconomics course determined one of their classes as synchronous and the other as asynchronous group. The experiment permitted comparing the scores of the students in the synchronous and asynchronous groups in 10 multiple-choice questions for the microeconomics course. While the students in the synchronous groups attended the lesson on the Zoom platform as usual, the students in the asynchronous groups were provided with access to the video recording of the same lecture as the synchronous group. Afterwards, the students in the synchronous and asynchronous groups took the exam together.

A total of 138 students, 90 from engineering departments and 48 from social sciences, participated in the experiment. At the end of the experiment, the students in the asynchronous group scored 18% higher scores than the students in the synchronous group. However, the analysis by gender showed no statistically significant differences between the scores of females and males in synchronous and asynchronous lectures.

This paper contributes to the literature by providing comprehensive analysis on the differences between synchronous and asynchronous methods of online education during COVID-19.

The remainder of the paper is organized as follows: the following section presents the relevant literature about synchronous and asynchronous methods. The third section introduces the experimental design and the hypotheses of the study. The fourth section presents the findings, and the last section concludes with discussions.

2. Literature review

This section presents the literature on distance education and in particular, on the synchronous and asynchronous teaching methods.

Distance education has attracted great attention due to the circumstances since the COVID-19 pandemic started. It should be noted, however, that the majority of the studies on distance education build on general comparisons of face-to-face and distance education systems with mixed findings. For instance, Aucejo et al. (2020) find that a significant percentage of students delayed graduation and now have less optimistic expectations about their future earnings during in this period. They also underline the heterogeneous effects of the pandemic by socioeconomic groups. On the effectiveness of the e-learning practices in Economics lectures taught at five major Romanian faculties, Roman and Plopeanu (2021) show that psychological stress and the pressure of COVID-19 related lockdowns have negatively affected the efficiency of e-learning especially for male students. Similarly, Adedoyin and Soykan (2020) list socioeconomic factors among the challenges imposed by the sudden transition to distance education during the pandemic. In difference from other

studies, they also highlight the opportunities- such as technological innovations, socioeconomic interventions- that the pandemic brought to the higher education agenda. Melo et al. (2021) show that students in Latin America were not satisfied with the quality of online education and found the quality of teaching relatively low. Meanwhile, Gonzalez et al. (2020) undertake a field experiment and find that distance education has positively affected students' performance in Spain. Similarly, Engelhardt et al. (2021) compare students' performances between post-COVID and pre-COVID semesters and show that they have performed equivalently well and that socioeconomic factors have not played a significant role during the pandemic. Interestingly, they also note that female students have been able to catch up their male counterparts in economics lectures.

Recent studies also report opposite opinions about the sudden transition to distance education by instructors and students. For example, while Zizka and Probst (2021) argue that despite difficulties in time management, faculty members will use the experience gained in this period and the blended teaching method will be preferred in Switzerland, Blizak et al. (2020) find that students perceive the transition to online education unfavorably due to limited access to internet and computer and also because of psychological and pedagogical issues in Algeria.

The mixed findings emphasize the socioeconomic dimension of distance education and the new vulnerabilities that distance education has created. These findings might also indicate that different teaching strategies of the world universities might have created a degree of heterogeneity in student outcomes. Therefore, it becomes pertinent to examine the tools such as synchronous and asynchronous methods.

Synchronous learning allows students to interact with the instructor in real-time. Additionally, in synchronous learning, students might pay more attention and be present because of the possibility of instant questions from the instructors (Hrastinski, 2008). However, students who do not have access to the necessary equipment and access to a good internet connection (preventing participation in the class and continuous interaction during the lecture) might fail to benefit from the advantages of the synchronous meetings. Synchronous lectures also impose challenges to instructors in that it requires the design of active learning practices and also a suitable online learning environment (Cole et al., 2021). Meanwhile, asynchronous lectures offer students flexibility in organizing their study times. This is especially relevant for students who have to work or help their families with household chores during the pandemic. However, asynchronous method requires more autonomous learning, which is one of the instructional strategies indicated by Carroll et al. (2021) and might be triggered only in a well-designed learning environment.

The few studies on synchronous and asynchronous forms of education focus, for instance, on the effect of the interaction possibilities between the instructor and students on academic performance and motivation. For example, Szeto and Cheng (2014) show that blended system- where both synchronous and face-to-face student groups are present- might enhance learning environment and interaction between students. Regarding the effectiveness of the methods, Kunin et al. (2014) study face-to-face, synchronous and asynchronous lectures with 169 dental degree students. In a university in the US, lectures were given as live and compressed videoconferencing, prerecorded lectures, audio explanations, and a transcription of the presentation. The results show that students believe that face-to-face and asynchronous lectures are more effective than synchronous lectures regarding the clarity of the delivery. On the comparison between synchronous communication through instant messages and asynchronous communication via emails, Hrastinski (2006) find that students who were exposed to synchronous medium report higher sense of participation and spend more time on the content.

Recent distance education practices were organized as a response to the ongoing pandemic. This means that students could choose neither the delivery system (in-person or distance) nor synchronous and asynchronous methods. Earlier studies document a few findings on this preference discussion. For instance, Beyth-Marom et al. (2005) show that interaction is the primary factor for students who prefer synchronous lectures, and autonomy is less important for this group of students than those who prefer asynchronous lectures at the Open University of Israel. Meanwhile, Offir et al. (2008) compare students' satisfaction between synchronous and asynchronous learning methods. The results of the study show that students prefer synchronous learning method over asynchronous learning method. Moreover, students with high cognitive ability benefit from synchronous learning more than the students with low cognitive ability.

Clearly, the literature does not offer enough studies on the methodological dimension of distance education. In the present paper, we aim to fill this gap by building upon the few previous studies in constructing our hypotheses and conduct a quasi-field experiment to examine the effectiveness of synchronous and asynchronous teaching methods from a comparative perspective. The following section presents the experimental design.

3. Experimental design

Field experiments are considered as one of the most significant tools that permit analyzing the casual impact of policy practices (Sadoff, 2014). It is difficult to measure the effectiveness of a newly-practiced policy or any other implementations since the real life is complex and integrated, and changes occur simultaneously in many factors at a time. However, field experiments enable us to measure the impact of new policies (Sadoff, 2014). Especially when compared to other experimental studies, it appears as a great advantage for such issues as external validity and generalization of the results since participants are observed in their natural environments (Shadish et al., 2002).

In this study, a quasi-field experiment was designed to examine the effectiveness of synchronous and asynchronous lectures in a comparative setting. The main purpose of the experiment was to measure the differences between the test performances of the students who took microeconomics course and attended a synchronous lecture and those who did not but were provided with asynchronous lecture recording only. The experiment was conducted in a state university in 2020 fall semester, when all higher education was moved to online solutions in Turkey.

There were two instructors teaching microeconomics (with the same material) participated in our experiment. Each instructor conducted the experiment with two groups of students who attended their microeconomics courses in different days of the week (in total of four groups). During the experiment the same weekly subject was taught to all sections. A total of four sections were taught on Monday (Instructor 1), Tuesday (Instructor 2), Wednesday (Instructor 1) and Thursday (Instructor 2), where sections on Monday and Wednesday were chosen as synchronous groups and Tuesday and Thursday sections as asynchronous[4] groups. The students in synchronous group attended the class on Zoom platform as usual. However, those who were in the asynchronous group were informed that there would not be synchronous lecture for them for that week, but a lecture video involving the subject would be shared on the internet. After the synchronous lecture was carried out for synchronous group and the lecture video was shared for the asynchronous group, both groups were told that they would take a multiple choice test for evaluation about their knowledge of the subject they learned in that week specifically.

Online lectures which the students in synchronous group attended were recorded on Zoom platform. These recordings were shared with the students in asynchronous group. In order to minimize the possible difference between the synchronous and asynchronous group, a great effort was made so that the conditions of both groups were as similar as possible. As there might be differences in the content of the course, the use of language or fluency of the lecture in the lecture video to be prepared for the students in asynchronous group, the recordings of the lectures that the students in synchronous group attended were shared with the students in asynchronous group, which prevented possible differences. In addition, the students in the synchronous group were asked to write down all the questions they would like to ask, and to repeat them at the end of the lecture if they wanted. For this, the chat feature of the Zoom platform was used. Using chat feature in Zoom to ask questions or to express opinions is rather a common practice now. This is particularly the case for the university we conducted our experiment. Because it offers lectures 100% in English and -as being not native speakers- students prefer writing their questions rather than talking. During the synchronous sessions a total of 10 questions were asked on Monday and 8 question on Tuesday.

Meanwhile, the students in asynchronous group did not have the benefit of asking questions, which is one of the main differences between the synchronous and asynchronous groups. Finally, the recordings of lecture were shared with the students in synchronous group as well only after the exam.

Two weeks after the lectures took place in the synchronous group, and the records of these lectures were shared with the students in asynchronous group, the students in each group were given a multiple-choice test exam[5] consisting of 10 questions in order to test their knowledge about the subjects taught only in these lectures. Each instructor held a Zoom meeting for both synchronous and asynchronous students, thus the students in both synchronous and asynchronous groups took part in the same testing environment, which was done for the purpose of preventing the possible differences in testing environments of the students in both groups from affecting the results of experiment. As mentioned previously, the exam consisted of 10 multiple-choice questions, which ensured objective evaluation.

Since the design of experiment was not completed before the beginning of term, and there was no information about the percentage of grading in the lecture notes shared with the students then, the students were provided with an incentive of 5 additional points to their final grades based on their success from the test. In other words, 5 points would be added to the final exam grade of a student who answered all 10 questions correctly. We believe that this was a sufficient incentive, because the final exam has had the highest weight in overall assessment. Moreover, we thought that the incentive was delivered successfully since this exam was the first one that the students would take in the academic term.

In total, 138 students, 90 from engineering departments and 48 from social sciences departments-participated in the experiment. We designed a specific topic to be taught during the experiment in order to minimize the effect of synchronous lectures that the students in asynchronous group attended in previous weeks.

3.1. Hypotheses

As a part of the experimental design mentioned above, the following hypotheses are analyzed.

3.1.1. Null hypothesis

There is no difference between asynchronous lecture and synchronous lecture in terms of learning.

This hypothesis suggests that there is no difference between these two systems of lectures and that we will not observe statistically

[4] Note that synchronous groups are the first sections for each instructor. Unfortunately, there was no random assignment for the treatment groups. We tried to conduct the experiment in the natural setting as much as possible. The courses were scheduled on different weekdays. For this reason, the first groups were chosen as the synchronous group and the recording of these lectures were shared with the asynchronous groups a day after on their usual lecture time. The weekly schedule was designed by the Student Affair Department before the students selected their courses and the semester started. We would like to emphasize that there was only one session for the second instructor's students who were in different departments so they had no choice for a time preference. On the other hand, for the first instructor's students, there were in fact two sessions and students might be able to choose one of the sessions based on their time preferences. However, we believe that this is not an issue since they had other compulsory courses, there were elective courses which they really wanted to take and they really did not have several choices in order to prevent overlapping of the courses in their weekly schedules. In addition, although these sessions were on different days (Monday and Wednesday), both sessions started at the same time, 17:20.

[5] Exam questions can be seen in the Appendix (A1).

significant differences between the students' exam scores in two groups.

Ha1. Asynchronous lecture is more effective than synchronous lecture in terms of learning.

This hypothesis presented as the first alternative hypothesis, where the students' exam scores in the asynchronous group should be statistically higher than the students' exam scores in the synchronous group.

The reason is that there may be problems with the students' participation in the lectures during online education due to internet connection problems in general or during synchronous sessions. Moreover, another factor we may face in synchronous lectures is that the students might not have the necessary opportunities to access the mobile phones or the computers. Students might have to share these devices with other family members and might not be able to use them when needed. However, asynchronous lectures allow students to access education when they have a good internet connection or are able to use the available devices. All of these issues might lead students in the synchronous group to underperform.

Ha2. Synchronous lecture is more effective than asynchronous lecture in terms of learning.

According to this hypothesis, the students' exam scores in the synchronous group should be statistically higher than the students' exam scores in the asynchronous group.

Undoubtedly, one of the most important reasons for this case is that the students can always ask questions about unclear subjects to the instructors easily and learn without much effort owing to this real-time interaction. The students in asynchronous lecture, on the other hand, have to spend much more time clarifying the unclear subjects. They might not even possibly find the answers to their questions.

On the other hand, it is claimed that in-class activities such as the interaction of the instructors with the students and asking questions to them during the lectures increase their motivation (Hrastinski, 2008). Thus, they follow the lectures much more carefully because they are always alert about instant questions. Therefore, synchronous lecture, in comparison with asynchronous lecture, may be more efficient in terms of learning.

4. Results

As mentioned above, field experiment was conducted with students taking the same courses in a total of four different classes. Each instructor identified one of the two classes he taught as a synchronous group and other as an asynchronous group. In Table 1 below, the departments of the participants are presented numerically on a group basis. The numbers in parentheses show the number of female and male students in that group, respectively.

As can be seen from Table 2, the average score of female students in Asynchronous group is 59.35 and 51.79 for the female students in Synchronous group and the difference between these two groups is statistically significant. The t-test result gives a p-value of 0.06, while Mann-Whitney U test gives as 0.1001. On other hand, the average score of male students in Synchronous group is 52.09 whereas it is 55.20 for the male students in Asynchronous group. The difference between the average scores of male students is not statistically significant according to both tests.

At the intersection of the third row and the third column of the table, the students in the Asynchronous and Synchronous groups were gathered in a single group regardless of gender, and the averages of their test scores were shown (57.50 and 51.95, respectively).[6] This difference is statistically significant with a p-value of 0.06 according to the t-test and a p-value of 0.08 according to the Mann-Whitney U test.

In Fig. 1, the frequency distributions of grades of the students in the synchronous and asynchronous groups are shown.

In Table 3, we present the linear regression results that are obtained from econometric model shown in Eq. (1). Meanwhile, Score variable is a dependent variable that evaluates the students' test scores out of 100, β_0 is the constant term of the model. Asynch is a dummy variable that is equal to 1 for the students in asynchronous group and is equal to 0 for the students in synchronous group. Gender is another dummy variable that is equal to 1 for the female students and 0 for the male students. Duration is an independent variable that shows how many minutes students spent in the synchronous lecture (see Table A3 for descriptive statistics). We also add the square of Duration variable into the model since the relationship between student success and the duration might not be linear. On the other hand, Asynch*Gender is an interaction term consisting of the product of the Asynch and Gender variables. Lastly, FinalGrade is the grade that students got for the course at the end of the semester.

$$Score_i = \beta_0 + \beta_1 Asynch_i + \beta_2 Gender_i + \beta_3 Duration_i + \beta_4 Duration_i^2 + \beta_5 Asynch * Gender_i + \beta_6 FinalGrade + \varepsilon_i \quad (1)$$

As can be seen from the first column of the table, the coefficient of the Asynch is 18.02 and it is statistically significant at the 1% level. This shows that the students in the asynchronous group are 18.02 points more successful than the students in the synchronous group, on average. Moreover, the coefficient of the Gender variable, which is equal to 1 for female students and 0 for male students, has a negative value but it is not statistically significant. We conclude that there is no significant difference in test scores between male and female students taking the exam. The Duration variable, on the other hand, includes the values in minutes of the time spent in the synchronous lecture as explained above.

[6] Question-level success rates can be found in the Appendix (Table A2), where success rates are provided for each question by synchronous and asynchronous groups and a test of significance between the means of the two groups for each corresponding question.

Table 1
Departments of the participants.

Department	Asynchronous Group-1	Synchronous Group-1	Asynchronous Group-2	Synchronous Group-2
Industrial Engineering	32 (8–24)	13 (5–8)	–	–
Computer Engineering	5 (3–2)	3 (2–1)	–	–
Electrical and Electronic Engineering	1 (1–0)	7 (6–1)	–	–
Civil Engineering	5 (5–0)	21 (13–8)	–	–
Business Administration	–	–	–	37 (16–21)
Politics	–	–	11 (7–4)	–
Mechanical Engineering	2 (0–2)	1 (1–0)	–	–
Total	45 (17–28)	45 (27–18)	11 (7–4)	37 (16–21)

Table 2
Average test scores.

	Male	Female	Total (Male + Female)
Asynchronous	55.20	59.35	57.50
	(20.23)	(20.15)	(20.11)
Synchronous	52.09	51.79	51.95
	(22.63)	(19.85)	(21.22)

Note: Standard deviations are in parentheses.

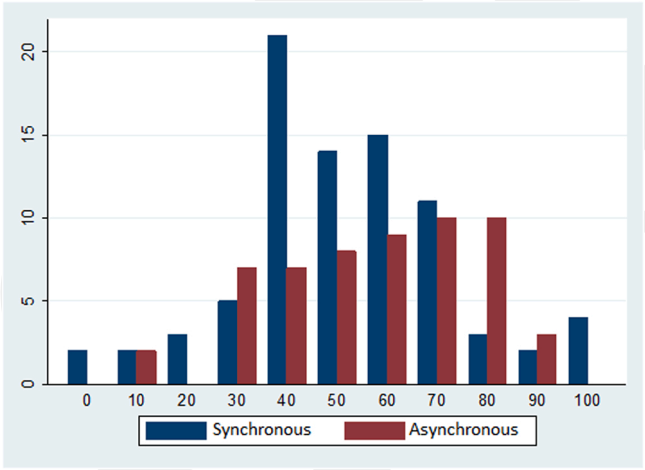

Fig. 1. Frequencies of the test scores.

In the second column of the table, the results obtained by adding the interaction term to the regression model in the first column are shown. The results are consistent with the results of the previous model (Column 1). The Gender variable is statistically insignificant and Asynch and Duration variables are significant at the 1% level. The added interaction term coefficient is not statistically significant. In addition, the sum of coefficients of Gender and Asynchronous*Gender variables is not statistically different from zero. Therefore, it is possible to conclude that there is no significant difference between male and female students in terms of their test scores for different groups.

On the other hand, in the third column of the table, the regression output includes an additional variable the Duration (squared). These results are also consistent with the previous results shown in the first and the second columns. The coefficients of the Gender variable and the interaction term are still statistically insignificant. Although the value of the coefficient of the Asynch variable changes compared to the previous results, there is no change in the sign of the coefficient and the significance level. The variable Duration (squared) is added to the model to estimate any non-linear effect of the time spent in the synchronous lecture. As can be seen from the table, the coefficient of the variable has a negative sign. While this implies that the time spent in a synchronous lecture might have an inverted U-shape relationship with grades, when we include the final grade of the students (fourth column), the coefficient of the Duration(squared) becomes insignificant. The result points out the possibility of heterogeneous behavior toward synchronous lecture attendance by student success.

All observations were used to estimate the regression models discussed above. However, only observations of the students attending the synchronous lecture at least for one minute were used to estimate the regression model of which the results are shown in Column 4. The purpose of this model is to focus on the effect of the time spent in the synchronous lecture on students' test scores. As can

Table 3
Linear regression results.

	Score (1)	Score (2)	Score (3)	Score (4)	Score (5)	Score (6)
Asynch	18.02***	14.71***	25.97***	21.25***	–	23.95***
	(5.73)	(6.42)	(7.28)	(7.34)		(5.96)
Gender	-3.86	-3.65	-4.43	-3.97	-3.26	1.14
	(3.55)	(4.70)	(4.57)	(4.07)	(4.17)	(4.01)
Duration	0.14***	0.16***	0.591***	0.41**	0.55***	0.31***
	(0.05)	(0.05)	(0.17)	(0.16)	(0.20)	(0.09)
Asynch * Gender	–	7.80	8.59	5.72	–	–
		(7.18)	(7.11)	(6.75)		
Duration^2	–	–	-0.002**	-0.001	-0.002	–
			(0.001)	(0.001)	(0.001)	
FinalGrade	–	–	–	0.42***	0.53***	–
				(0.14)	(0.11)	
Constant	39.68***	40.48***	29.22***	-0.02	-15.46	34.24***
	(4.94)	(4.99)	(6.04)	(11.16)	(10.11)	(5.09)
Observation	138	138	138	138	76	90
R^2	0.07	0.08	0.12	0.21	0.31	0.12

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Asynch is a dummy variable that is equal to 1 for the asynchronous group and is equal to 0 for the synchronous group. Gender is equal to 1 for the female students and 0 for the male students. Duration variable shows how many minutes students spent in the synchronous lecture. Asynch * Gender is an interaction term consisting of the product of the Asynch and Gender variables. FinalGrade is the grade that students got for this course at the end of the semester. Robust standard errors are in parentheses. The regression model results shown in Column 5 include the observations from the students who spent at least one minute in the synchronous lecture. The regression model results shown in Column 6 include the observations just from the engineering students.

be seen from the results, the coefficient of the Duration variable is statistically significant at the 1% level. This result is consistent with the previous results and suggests that as students spend more time in the online lecture, they attain better results. Again, the coefficient of the variable Duration (squared) is not significant after controlling for general success.

Lastly, the regression model is run only for the engineering students, and the results are shown in Column 6. As it can be seen from the results, we find the same treatment effect, in accordance with the full population model.

5. Discussion and concluding remarks

The COVID-19 outbreak has pushed a significant share of everyday activities online. As a major policy against the spread of the virus, spatial mobility has substantially decreased and almost everywhere in the world, strict measures have been taken aiming to limit human contact in general. This, of course, required a sudden transition from in-person to distance delivery of services, including higher education. It is worth noting that the recent developments in Information and Telecommunication Technologies (ICTs) and better access to the internet and computers might have facilitated this transition. Indeed, as mentioned above, the trend towards online delivery in education was already in place in the pre-COVID period. Several reputable universities had integrated remote learning in their curriculums, and an increasing number of online platforms were offering online education such as online training, undergraduate and graduate courses, online certificate programs. However, despite the previous trends and recent experiences, best practices in distance education are yet to be established.

In the present paper, we have conducted a quasi-field experiment to compare the differences in student outcomes between synchronous and asynchronous teaching methods during COVID-19 in Turkey. The results indicate that asynchronous delivery proves to be more effective in student outcomes from undergraduate microeconomics course. This finding highlights the importance of providing students with flexibility of organizing their learning schedules especially under crises periods such as the pandemic. However, this does not imply that the interaction between instructors and students is less crucial now that we have distance education practices all over the world. As suggested by our second analysis, each minute spent in synchronous sessions also improves student performance. This means that one-to-one lecturing and interaction possibilities between students and instructors are still essential for a healthy learning environment but class lengths must be re-designed to ensure efficient learning.

Therefore, it is plausible to conclude that a strict line between the two methods in terms of effectiveness is hard to draw. Instead, our results indicate that hybrid models where both synchronous and asynchronous methods take place can ensure best practices.

Several policy lessons can be derived from this study. First, distance education provides students with higher flexibility in organizing their learning schedules. Previous literature shows that learning outcomes are best reached when students are ready and willing to receive the information and that reducing the classroom time (by online learning environments) do not reduce learning outcomes (Müller and Mildenberger, 2021). In this respect, asynchronous delivery fully exploits the benefits of distance education, where students determine the learning time. Additionally, asynchronous lectures can be stored in online platforms for students' use for an extensive period of time. As indicated by the famous hypothesis of Ebbinghaus's "forgetting curve," 75% of the information is lost in only six days after it is acquired (Ebbinghaus, 1885). Asynchronous lecture materials can offer students the opportunity to retain fast-clouding information they learn. Indeed, the benefit of unlimited access to study material goes beyond recalling the information embedded in lecture videos or slides. Many developing countries are subject to a digital divide, especially between rural and urban

areas (Lu, 2001). Next to this, considering the unequal access to good internet connection and personal computers in many locations, it becomes clear that asynchronous lectures can be used as supplementary to synchronous sessions for those students for whom the internet and personal computers are not always immediately available.

It should be noted that our sample had the opportunity of interacting with the professors during synchronous lectures throughout the semester before the experiment. Thus, even though our design ensured that the topics covered in the tests were specific to the week of the experiment, pedagogically, students benefitted from one-to-one interaction with the instructor, which might have helped them "learn to learn" (Brown et al., 1981). Therefore, the findings of the study might not be suitable for a general comparison between online-only courses-where all teaching materials are delivered asynchronously- and synchronous-only courses. Nevertheless, our study was an attempt to discuss the best practices in distance education organized by higher education institutions as a new practice.

The present paper has contributed to a comprehensive understanding of distance education with two primary tools available in delivery: synchronous and asynchronous methods. Our findings are relevant beyond the COVID-19 period, as we believe that distance education practices will take place more frequently both as online-only courses and at traditional universities. Given the several advantages, including no-space requirements for classrooms, flexible teaching schedules and creative, active learning opportunities, universities worldwide will integrate online delivery in their teaching strategies.

Our study is not without limitations. Although the experiment's findings strongly resulted in favor of the asynchronous method, the success of the asynchronous group can be attributed to the decreased psychological burden of following lectures in real-time. Many students were infected during the academic term, and others were exposed to a high risk of infection. The possibility of studying the teaching material when they are ready and avoiding anxious periods might have contributed to better learning at a higher degree than it would have in a "normal" period. Therefore, this study must be repeated in a post-COVID period. Another limitation is that synchronous teaching might involve student-instructor interactions, for instance, during office hours. Further studies might explore the effects of the possibility of this interaction on academic performance. Finally, the linear relationship between academic success and duration of online lectures must be investigated further. The attention span of students during in-class lectures was suggested to reach a maximum approximately after 10–15 min and decline thereafter (see for instance Davis, 2009). But this claim is still under debate and there are several studies arguing that it is not the length of the lecture but it is the lecturer who can manage the attention span (Bradbury, 2016). Whether student attention is better held during online lectures than in-class ones is an interesting question and left for further studies.

CRediT authorship contribution statement

Conceptualization: B.K.D. and U.T. Data curation: B.K.D. and U.T. Formal analysis: B.K.D. and U.T. Funding acquisition: U.T. and B.K.D. Investigation: U.T. and B.K.D. Methodology: B.K.D. Project administration: U.T. Resources: B.K.D. and U.T. Software: B.K.D. and U.T. Writing – original draft: U.T. and B.K.D. Writing – review & editing: U.T. and B.K.D. All authors have read and agreed to the published version of the manuscript.

Declaration of Interest

None.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.iree.2022.100244.

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