

Students' Perspectives on Online Lecture Delivery Methods for Programming Courses: A Survey-based Study during COVID-19

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Abstract—This Research to Practice Full Paper presents a detailed study on the perspectives of students on different online lecture delivery method for programming classes, amid the COVID-19 pandemic. During the period of spring, summer, and fall 2020, a total of 770 students across six different courses, and spanning the freshman, sophomore, and junior years, were surveyed to express their opinions in three different online lecture delivery methods, in the school hosting this study. The survey was designed to capture the main problems and obstacles the student had faced in an online learning environment. The authors analyze the obtained results and recommend best practices to successfully lead programming classes in an online learning environment.

I. INTRODUCTION

After the World Health Organization declaration of COVID-19 [1] as a pandemic, educational institutions in the US and worldwide were obligated to migrate to online learning. Both the instructors and students were abruptly forced to this new learning environment [2], which resulted in different online teaching styles, depending on the provided resources; online learning platform; and the corresponding majors and disciplines [3]. This sudden change gave instructors little to no time to prepare for switching to online learning environment, which created major discrepancies in the lecture delivery style, even between instructors of the same department and University [4]. On the other hand, students, unprepared, had to cope with the new online learning method used, with all its unprecedented challenges and obstacles [5], [6].

Without loss of generality, most of the online lecture delivery methods can be projected as either fully-asynchronous, fully-synchronous, or a mix of both, where each approach has its own advantages and disadvantages [5]. For the former, the instructor would pre-record the lecture materials to be discussed and make it available to the students for reviewing before class time. During the class time, the instructor would meet virtually with the students to have an interactive discussion about what they have learned from the pre-recorded video and answer any questions. Solving more example problems can also have place. Since this lecture delivery style is very close to a flipped classroom style [7], [8], it shares the same advantages of this technique; and one of them is that it allows

the students to go each at their own pace. However, in many cases, the fully-asynchronous method may lead to doubling the amount of effort and time put in each class, due to the absence of immediate student-instructor interaction at the time of reviewing the pre-recorded lecture. The fully-synchronous method can help solve the latter problem, by being the closest to a traditional classroom, where the students meet the instructor virtually online, instead of in-person. For this method, the instructor can choose to record the virtual meeting and make the recording available to the students for later review, creating two variants of the fully-synchronous method. Some of the disadvantages of this style are the need for a fast and stable internet link for both parties involved, access to a distraction-free environment for maximum engagement, and the challenges it dictates on students trapped in a different time zone.

In this work, we study the students' perspectives on online lecture delivery methods and the obstacles they encounter in a remote learning environment, targeting programming classes. The results obtained will be further investigated and analyzed to comprehend the pain-points that the student struggle with, and, accordingly, the authors will recommend best practices to successfully navigate an online programming class.

The rest of the paper is organized as follows: section II discusses the details about the programming courses involved, along with survey questions and the conduction method. The results obtained are discussed and further analyzed in section III, in addition to the authors recommendation for best practices. Finally, section IV concludes the paper.

II. ASSESSMENT OF STUDENTS' PERSPECTIVE ON ONLINE LECTURE DELIVERY STYLES

A. Courses Covered and Delivery Styles

The survey conducted in this work covered six courses offered during Spring, Summer, and Fall of 2020, with more than 400 students participating in it. The student body spanned freshman; sophomore; and junior students, in the Freshman program and the Electrical and Computer Engineering department at the school hosting this study. Four of the courses

TABLE I
SURVEY QUESTIONS

Lecture Delivery	
What is the lecture method chosen by your instructor?	Live (Synchronous) Lecturing, without recording the meeting Live (Synchronous) Lecturing, with meeting recording uploaded after Asynchronous (pre-recorded videos) Lecturing, with live discussion during lecture time
How do you think this lecturing method has helped you in achieving the learning objectives of the course?	Completely helpful Somehow unhelpful Somehow helpful Completely unhelpful Neutral
How would you rate the chosen remote lecturing method?	Completely satisfied Somehow unsatisfied Somehow satisfied Completely unsatisfied Neutral
Why did you give this rating? Please choose all that apply.	Multiple choices, removed for conciseness
If it were up to you, what would you have chosen as a remote lecturing method?	Live (Synchronous) Lecturing, without recording the meeting Live (Synchronous) Lecturing, with meeting recording uploaded after Asynchronous (pre-recorded videos) Lecturing, with live discussion during lecture time

TABLE II
OVERALL SATISFACTION WITH REMOTE LEARNING EXPERIENCE (SUMMER AND FALL 2020)

Overall Satisfaction	
Judging by your prior experience with in-person lecture meetings and your experience with remote lecture meetings in this class, which of the following statements best describe your experience.	I prefer remote class to in-person labs I have found the remote class to be comparable to the in-person classes I would have preferred an in-person class to remote class If I go back in time, I would defer my enrollment in this class until in-person classes are resumed

were pure programming classes, ranging from introductory courses in C/C++ and MATLAB® for the freshman students, to advanced data structures and algorithms for junior students. The other two classes were online labs with both hardware and software components. One of them dealt with Embedded Microprocessors and Assembly language and the other was about Advanced Digital Design using Field Programmable Gate Arrays (FPGAs). For both labs, the students were provided with a take-home lab kit [9] at the beginning of the semester and access to the software developing IDE through the university servers. Seven instructors taught the investigated courses and three different online lecture delivery methods were incorporated, namely: Live (Fully-Synchronous) Lecturing, without recording the meeting; Live (Fully-Synchronous) Lecturing, with the meeting recording uploaded after; Fully-Asynchronous (pre-recorded videos) Lecturing, with live discussion during lecture time. For the former two, the instructor would meet with the students virtually online during the scheduled lecture times, with the instructors choosing either to record the meeting, for later review, or not. For the later, the instructor would pre-record the lecture and upload it for the students to review before they meet virtually online during the scheduled lecture time.

B. Survey Structure and Conduction Methodology

At the end of each semester, and just before final exams, the students were asked voluntarily to participate in this survey, provided to them through Qualtrics®. Human subjects approval (PRO18060710) was secured for these various forms of assessment. The survey questions are shown in Table I, where they were designed to capture the student perspective on the three online lecture delivery methods they experienced.

Amid Spring 2020, the school hosting this study had to switch to online learning mid-semester, where neither parties involved had enough time to prepare for this transition. However, during Summer and Fall 2020, the instructors and the students had adequate time to prepare for a full online semester. Consequently, an extra question was presented in the surveys conducted in these two semesters, asking the students about their fair opinion in a well-prepared online learning setup, compared to any prior traditional in-person classroom experience. This question is presented in Table II.

III. RESULTS AND DISCUSSION

A. Online Lecture Delivery Methods

The results of question 1 in Table I is displayed in Fig. 1, which is discussing what the students think the corresponding online lecture delivery method helped them in achieving the learning objectives. Seventy two students had the synchronous method without meeting recording, while 257 students had the same method but with meeting recording. On the other hand, 74 students had the asynchronous method. The analysis show that, for each method, about 63% or higher of the students thought the corresponding method helped them achieve the required learning objectives. However, the number of students who thought this method is unhelpful is, at least, 40% less for the delivery methods with meeting recordings, compared to the one without meeting recordings. Consequently, although the majority of the students find that think that all the presented online lecture delivery methods serves the purpose for programming classes, the authors recommends to include meeting records to help struggling students who are in different times zones, or may not be able to attend the live meetings.

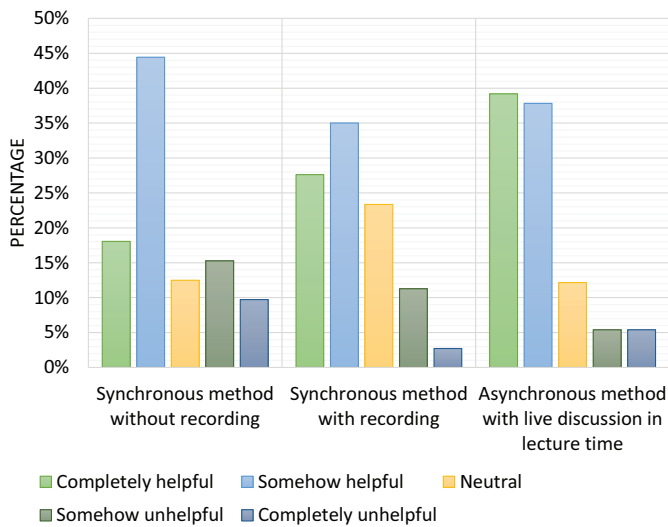


Fig. 1. Students' perspective on different online lecture delivery methods.

The results obtained from Fig. 1 are supported by those depicted in Fig. 2, which summarizes the students' overall satisfaction from the delivery methods. This question takes into consideration various factors that can contribute to the student's satisfaction, including, but not limited, convenience, engagement, reliability, and interactivity. At least 67% of the students are satisfied from the delivery methods that has the recording component, where this percentage drops down to 58% in case of the synchronous methods without meeting recording. The percentage of the students who are not satisfied from the lecturing methods with meeting recording is still about 40% less than that of the synchronous method without recording, which aligns with the result obtained from Fig. 1.

To further analyze the above responses, the students were presented with questions 3 in the survey, where they are asked to choose the factors that made them give their corresponding answers for question 1 and 2. Eleven choices of positive and negative factors were provided as "choose all that apply" answers for this question. Fig. 3a depicts the positive set of factors, grouped by the online lecture delivery method. The percentage of each factor is calculated by referencing the number of students who chose this factor, in a corresponding method, to the total number of students who chose the same factor across all methods. The synchronous method with meeting recording seemed to be the most appreciated by all students. The reason for that is that this method is the closest you can get to a traditional in-person classroom experience, in an online environment. Adding a recorded video component to the fully synchronous method allowed the student for more flexibility, by being able to watch the recorded meeting later, in case they had to miss the live meeting. Comparing the synchronous method with lecture recording to the asynchronous method, all the results seem to be intuitive, except for live lecture participation and activities and discussions being useful, which are interestingly higher in the former method. The authors revert this to the fact that,

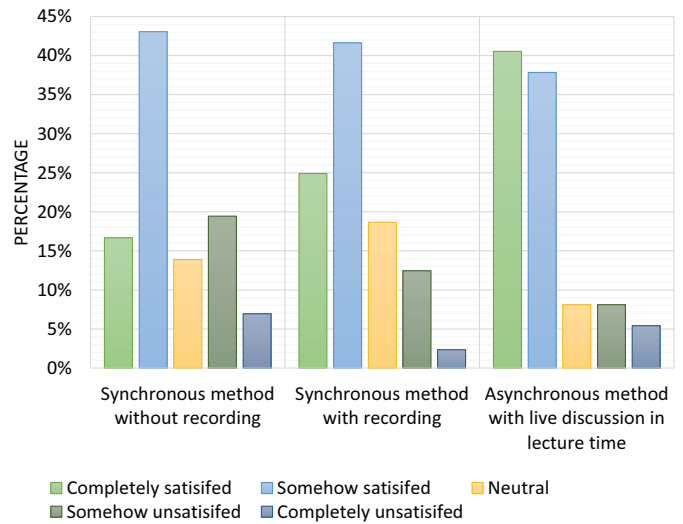
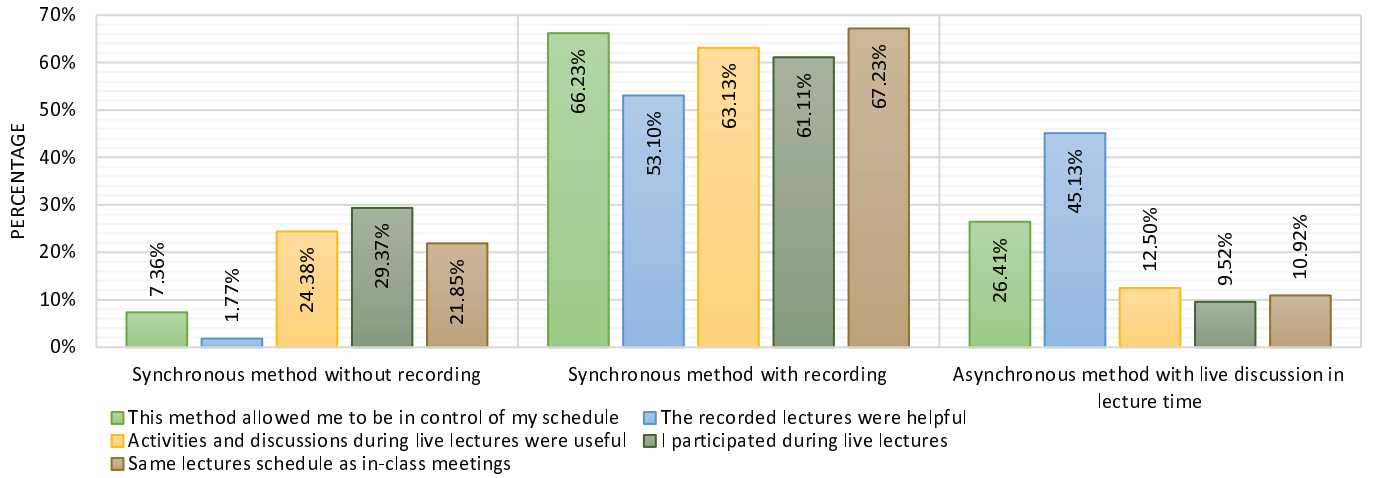


Fig. 2. Students' overall satisfaction from different online lecture delivery methods.

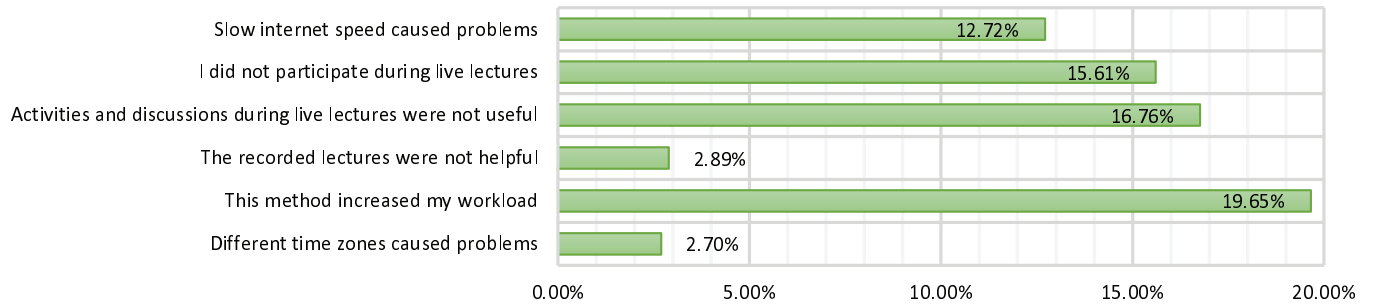
for synchronous method with no recording, students felt the need to actively participate during live meeting, as they had no other recorded components to refer to.

On the other hand, Fig. 3b shows the negative set of factors, where the percentages are calculated by referencing the number of students who chose a certain factor, across the three methods, to the total number of students in this study. Factors like "the recorded lectures were not helpful" and "Different time zones caused problems" had minimal impact on the students' satisfaction, where as "this method increased my workload" and "activities and discussions during live lectures were not helpful" are the main reasons of students' dissatisfaction. Surprisingly, slow internet connection is not a major source of dissatisfaction. It's worth mentioning here that the majority of the students who took these classes were present in the United States, and only a handful of them were in different countries. Moreover, not participating in live lectures and not benefiting from the discussions, combined together, form the most pain point for students. The authors think that one of the reasons that may lead to such a result is that the students feel disengaged and disconnected in an online setup, compared to a traditional in-person classroom.

Question 4 in the survey asked the students to choose a preferred online lecturing delivery method, giving the one they were presented with, and the results are summarized in the confusion matrix, depicted in Table III. The columns represent the provided method of delivery, while the rows represent the preferred one. The blue percentages in the last row and column are referenced to the total number of students (403), while the red percentages shown in each cell are referenced to the corresponding total at the end of each column. The green cells on the diagonal represent the students who preferred the lecture delivery method they were provided with, while the bold cells in each column represent the most preferred method, giving the corresponding provided method.



(a)



(b)

Fig. 3. The positive ((a)) and negative ((b)) factors correlated with the student satisfaction and dissatisfaction, respectively.

Analyzing the results show that the most preferred method is the synchronous method with meeting recording, leading by about 50% than it's runner-up (the asynchronous method). The authors think that one of the main reasons to contribute to this result is that the recording component this most preferred method gives flexibility of asynchronous method, and the live meetings in class schedule is as close as it can get to a traditional in-person experience. It comes at no surprise that the synchronous method without recording is be lowest of them all. The values on the diagonal represent the number of student who were presented with a given method, and ended up preferring it, which again confirms the superiority of the synchronous method with meeting recording.

B. Online vs. Traditional in-person Learning

During summer and fall 2020, an extra question has been included in the survey, shown in Table II. The students were asked to reflect on their previous traditional in-class experiences, in comparison to their online learning experience. By this time, they would have had at least two online learning experiences in two different courses. In these two semesters, 203 students were surveyed, where 158 (45) of them had the synchronous method with (without) meeting recording. Since the courses under investigation are of two types, the

TABLE III
COMPARISON BETWEEN THE METHOD THE STUDENTS WERE PROVIDED WITH (COLUMNS) AND PREFERRED (ROWS).

		Lecture delivery method provided			Total (%)
		Synchronous method without recording	Synchronous method with recording	Asynchronous method with live discussion in lecture time	
Lecture delivery method preferred	Synchronous method without recording	7 (9.72%)	6 (2.33%)	2 (2.70%)	15 (3.72%)
	Synchronous method with recording	47 (65.28%)	186 (72.37%)	25 (33.78%)	258 (64.02%)
	Asynchronous method with live discussion in lecture time	18 (25.00%)	65 (25.29%)	47 (63.51%)	130 (32.26%)
Total (%)		72 (17.87%)	257 (63.77%)	74 (18.36%)	403

authors split results by course type. Fig. 4a shows the results of the 98 students who had the pure programming classes, while Fig. 4b depicts those of the 105 students who had the online lab courses. The reason for this split is that, by nature, online labs have a hardware component, which may complicate its delivery in an online environment. As can be inferred from Fig. 4a, students still prefer in-person experience (44.9%), but they are not a majority. As a matter of fact, this percentage is less than the corresponding one for students who thought online learning is comparable or even better than in-person classes (46.94%). The authors find this outcome

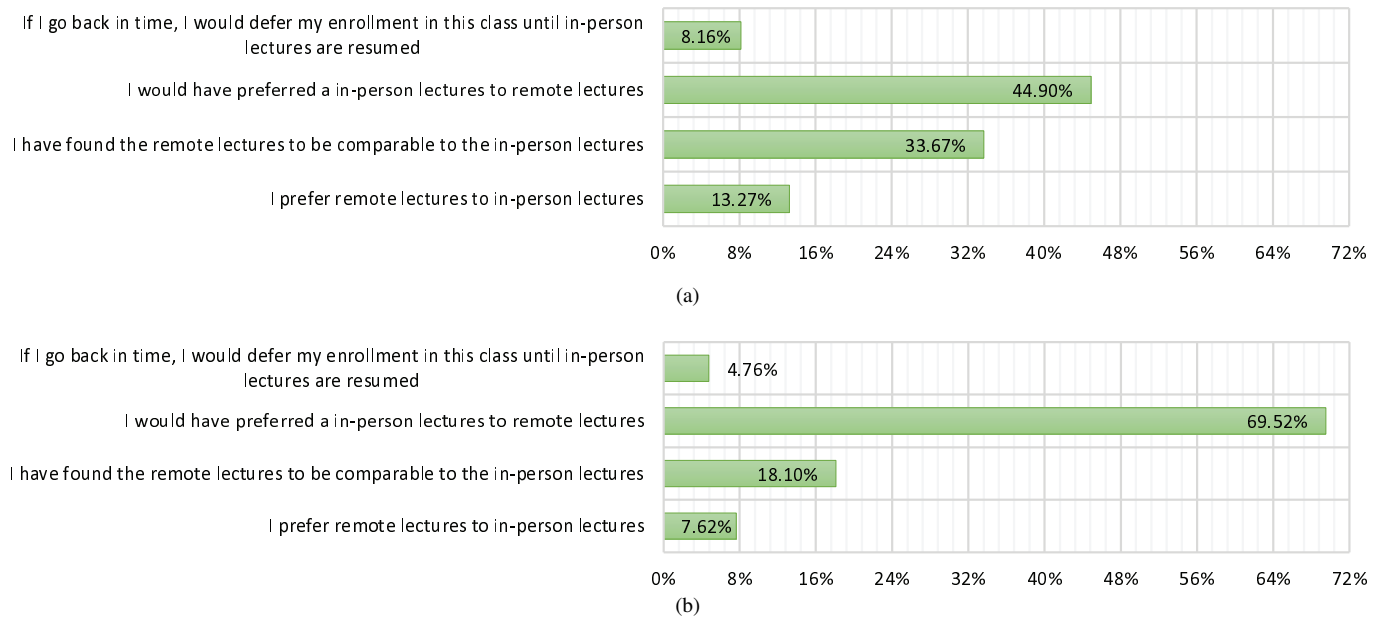


Fig. 4. Comparison between online and traditional learning for pure programming classes ((a)) and online labs ((b)).

to be important as, with few tweaks and refinements, online learning for pure programming classes might be even more preferred than traditional in-person ones. Some of the factors that the authors think contributed to this outcome are: 1) ease of access of the materials, resources, and the IDE used through the university servers; 2) having recorded materials to refer back; and 3) online office hours, held over the online meeting platform, utilized the screen sharing features, which helped significantly in debugging the students code. Simply put, the need for the instructor and the students to be physically present in the same room is almost eliminated.

On the other hand, Fig. 4b shows that, for online labs, the majority of the students still prefer in-person experience (69.52%), which are 2.7x more than the students who were at least neutral with online learning (25.72%). This result is intuitive, even though the instructors put a lot of effort in having a detailed walk-through tutorial on how to setup the take-home lab kits, not all the students were comfortable doing that all by themselves. Moreover, debugging any hardware bugs is not easy to be done remotely, compared to being in-person. Luckily, for both class types, a very small percentage of students wished to have deferred their enrollment in the corresponding class, when fully in-person classes resume.

IV. CONCLUSION AND FUTURE WORK

In this work, the authors present a survey study about the students' perspective on three different online lecturing delivery methods, adopted in programming courses. The study covered six pure programming and online lab courses, and 403 students participated in it, during spring, summer, and fall 2020. Based on the detailed analysis of the obtained data, the authors recommend to adopt the fully-synchronous online lecture delivery method with meeting recording, especially for pure programming classes. This method combines most of the

features of a traditional in-person programming class, with the added flexibility of having the meeting recorded for later review. For online labs, the majority of the student prefer the traditional in-person experience, because of all the logistics they have to go through setting up the take-home lab kits and hardware debugging.

As for future work, preliminary results in this study suggests that online lecturing for pure programming classes might be the future and even be more approached, compared to in-person classes. The authors are going to fine tune and tweak different aspects of the fully-synchronous lecturing method with meeting recording, with a goal set ahead to reach at least 70% of students' preferability.

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