

A Study of Students Perspectives on Different Pedagogical Practices for Remote Digital Signal Processing Courses

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Abstract—In this Research-to-Practice full paper, we study the perspectives of students on different pedagogical practices in signal processing classes during the pandemic. With the COVID-19 outbreak, universities transitioned to remote operation. While they were not trained for online teaching, instructors had different preferences and motivations of their teaching pedagogy and how to conduct their remote classes. However, only few instructors designed their approach based on their student perspectives. In this study, we survey the students, in signal processing classes, to investigate the different factors that affected their learning under different pedagogical approaches as well as their perspective on active learning and class flipping. Active learning helps maintaining the student motivation while studying from home. Traditional lecturing is the closest to what students are used to. On the other hand, flipped classroom, albeit requiring finishing pre-class activities, enables the students to come prepared and be able to engage more in class activities.

Index Terms—remote teaching, signal processing, traditional-lecturing, flipped-instructions, students perspective

I. INTRODUCTION

Online teaching requires a different pedagogy and set of skills from that of the in-person classroom [1], [2]. Instructors have to deal with emerging pedagogical issues regarding student interactions and communications, course content design and delivery, adopting new types of assignments and performance expectations, and different assessment and evaluation techniques [3]. Thus, as universities continue to offer online courses during the pandemic, educators can enrich online instructions if they are aware of current research on remote education and approaches that aligns with student learning.

In response to the widespread of the COVID-19 virus, most of the universities had to switch to online teaching mode. This new teaching environment urged decisions and adaptations to satisfy not only the expectations of students but also the requirements of course learning objectives and the settings in which schools had to operate [4], [5]. Instructors adopted different pedagogical methods to teach their classes. Additionally, the delivery methods varied; some courses were held synchronously, while others were conducted asynchronously. Most instructors were not well prepared to deliver their course contents remotely and made their decision on their teaching approach mainly based on their pedagogical preferences, the

nature of the subject being taught, and other factors that depend on the fact they are working remotely [6]. As a result, there were inconsistencies among instructors, teaching the same subject, on their choice of pedagogical and delivery methods (e.g., synchronous vs asynchronous). However, most of the teaching approaches fit under two main pedagogical paradigms: synchronous traditional lecturing and flipped classrooms with synchronous activities.

Traditional synchronous lecturing is the closest to the conventional in-person model [7]. In synchronous lectures, new concepts are presented during the online lecture time, and the students apply that learning through homework assignments. Thus, it is easier to manage and prepare for a synchronous classroom than a flipped classroom. However, working remotely challenged this traditional approach. Communication with students is not as easy as in-person settings and working from home affected students attention span [6].

On the other hand, flipped classrooms allow students to go through the course contents at their own pace then share their learnings during discussions encouraging higher engagement and exposing gaps in understanding [8], [9]. Previous research suggests that student learning is improved in the flipped compared to the traditional classroom, especially in signals courses [10]–[12].

Instructors motivations to pursue any of the aforementioned pedagogical approaches varied between personal preferences and class-driven factors [6]. However, only few instructors considered their students perspectives on which approaches might fit their learning goals and needs.

In this work, we investigate student perspectives on different pedagogical approaches for teaching signal processing classes. These classes were offered at the department of electrical and computer engineering (ECE) department at the University of Pittsburgh. The study considered three offerings of a junior-level signal processing class with varying styles of teaching, for the same instructor, over the summer semester of 2020 through the spring semester of 2021. The instructor adopted traditional synchronous, partially flipped, and fully flipped classrooms throughout the study. At the end of each semester and before the final exams, students were surveyed to gather

their perspectives and collect their feedback on the adopted pedagogical method, and the challenges they might have.

The survey data from 109 students are content-analyzed by two independent reviewers to understand the students needs for an efficient learning experience in signal-processing classes. The results indicate that higher percentage of students prefer a traditional form of teaching and find traditional teaching helpful in achieving their goals in remote classes. Also, the majority of the students in the flipped sections believe that the flipped approach helpful as it allowed them to review the concepts before coming to class, while the class-time was better utilized for discussions, simulations and problem-solving. We discuss the positive and negative factors that affected student learning in each section as well as their preferences in terms of what teaching method they prefer when studying signal processing. We also investigate their perspectives on being active in class and their opinion of the benefits and drawbacks of flipped instructions.

The rest of this paper is organized as follows. The different class activities, surveys, and data analysis, used in this study, are described in section II. In section III, we present and discuss students' perspectives and preferences of different teaching methods. Also, students' perspectives on active learning and on flipped style of instructions are discussed in sections III-C and III-D, respectively. Finally, the paper concludes along with recommendations and directions for future work in section IV.

II. METHODS

A. Class Activities and Instructions

In this study, three teaching styles were adopted for teaching junior-level signals classes offered at the ECE department hosting this study. Namely, fully flipped, traditional, and partially flipped instructions in Summer 2020, Fall 2020, and Spring 2021, respectively. At the beginning of each semester, during the period of this study, the instructor presented the pros and cons of the selected teaching approach and compared them to other approaches. The level of difficulty of the assignments and the exams were kept the same in all offerings. However, the class activities and discussions were varied depending on which teaching approach was adopted.

In the traditional sections, the materials were presented in the traditional lecturing fashion. However, simple active learning activities, e.g., think-pair-share and minute paper, were used. In the flipped sections, the students were asked to watch three to six videos before the class meetings. The videos were 10 to 20 minutes long. Students were also instructed to complete a short accountability quiz after finishing the videos. These quizzes were adopted to motivate the students to finish the video lectures before class time. During the class time, the instructor reviewed the materials from the videos and answered questions. Then, students worked with the instructor and their peers on demos, discussions, and problem-solving. Finally, irrespective of the teaching approach, all class meetings were recorded and uploaded on the course website

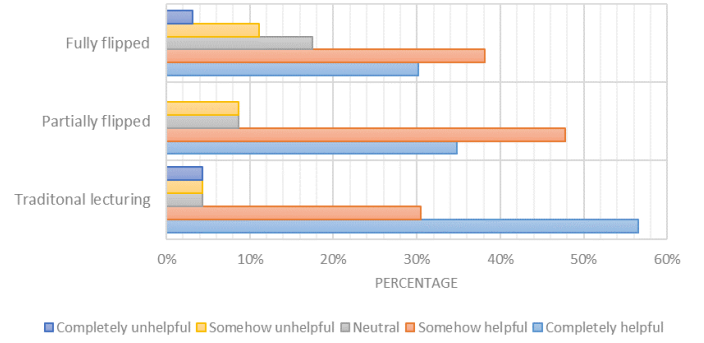


Fig. 1. Students' perspective on the teaching method chosen for their section.

to enable students to rewatch them again while reviewing the class materials.

B. Assessment of Students Perspectives

Over the period of this study and towards the end of each semester, students were asked to voluntarily complete a Qualtrics-based survey. Human subjects' approval (PRO18060710) was secured for these various forms of assessment. The survey aimed to understand how effective the selected teaching approach was for students and understand the challenges that they might have encountered. We adapted a survey similar to the one used in [7]. Also, we added two more open-ended questions (Table I) to study the students perception of active learning exercises used in each class (all semesters) and their perspective on class flipping (summer 2020 and spring 2021 only). To ensure reliability of the reported results, two independent analysts content analyzed the open-ended questions. In total, 134 students were invited to a complete a survey that captures their perspectives on the teaching approach. Out of the 134 invited students, 109 responded to the surveys. The 109 collected responses are securely stored in the university's cloud system. Table II shows the breakdown of collected responses per each semester.

III. RESULTS AND DISCUSSION

A. Teaching Method

Fig. 1 shows students' perspectives on how effective the teaching method for their section was and how it helped them to achieve their learning objectives. The majority of students in each section indicated that the teaching approach for that section was helpful. Compared to the other two sections, the traditional lecturing section has the largest percentage of students (87%) who indicated that the adopted lecturing style is helpful. Among the three sections, the fully flipped section has the least percentage of students (68%) who found that the adopted lecturing style is helpful in achieving their learning goals. Also, the largest percentage of students (14%) who found that the adopted lecturing style is unhelpful was in the fully flipped section.

TABLE I
EXTRA SURVEY QUESTIONS

In this class, the instructor asks you to complete activities, discuss items, and in general participate. Can you discuss the impact of this instructional style on your learning and development?

In this class, the instructor asked you to do some learning on your own outside of class and then come to class prepared for hands-on work. Discuss your thoughts on this instructional method relative to learning and satisfaction in a remote setup.

TABLE II
NUMBER OF SURVEYED STUDENTS PER SEMESTER

Semester	Teaching Method	# Students Invited	# Responses
Summer 2020	Fully Flipped	65	63
Fall 2020	Traditional	40	23
Spring 2021	Partially-Flipped	29	23
Total:		134	109

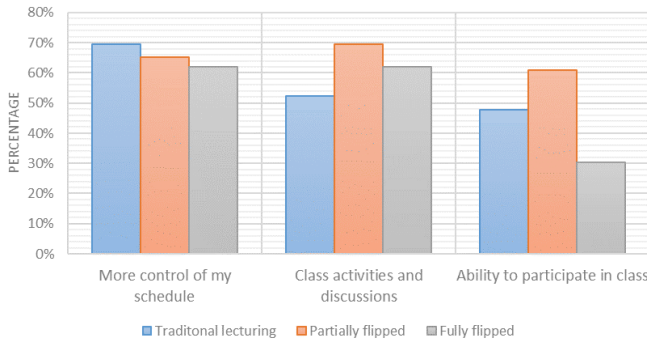


Fig. 2. Positive factors that affected student learning.

Fig. 2 shows the positive factors that affected the students' perception of the effectiveness of the adopted teaching approach in their section. The figure also shows percentage of student stated each factor for each teaching pedagogy. Class activities and discussions was the main factor that helped students in sections with flipped modules, either partial of full flipping, to achieve their learning goals. The flipped classroom approach allowed the students to review the concepts before coming to class, while the class-time was better utilized for discussions, simulations and problem-solving. They also had more chances to participate in class compared to traditional classes, especially in small class sizes. The ability to gain more control on their study schedule had higher contribution in traditional than other factors. Students in traditional lecturing section didn't have to watch videos or finish accountability assignments before coming to the class, therefore, there study schedule was slightly flexible compared to those in flipped sections.

Table III shows the negative factors that contributed to the students' perception of the effectiveness of the adopted teaching approach in their section. The sense of increased workload was the major factor that biased the students opinion in the fully-flipped section to perceive that class flipping is unhelpful. The most frequently stated complaints was related

TABLE III
NEGATIVE FACTORS THAT AFFECTED STUDENT LEARNING

	Traditional Lecturing	Partially Flipped	Fully Flipped
Increased workload	13.04%	17.39%	44.44%
Lack of motivation to participate	13.04%	13.04%	17.46%
Class activities were not helpful	4.34%	4.34%	4.67%
Different time-zone	0%	8.69%	3.17%
Internet problems	13.04%	8.69%	22.22%

to the requirement of watching lecture videos and completing accountability quizzes before class time. On the other-hand, the students in the partially-flipped section found that these pre-class assignments were to their advantage and they felt more prepared to engage in class activities compared to the traditional modules that they studies prior to the flipped modules. The percentage of students in the partially-flipped section (17.39%) who expressed a feeling of increased workload due to flipping is drastically less than those in the fully-flipped section (44.44%), and is slightly higher the corresponding percentage in the traditional teaching section (13.04%). The lack of motivation to participate in an online class was one of the main negative factors that affected student learning, specially in classes with large enrollment. Although it is challenging to keep students motivated in a remote setup, different active learning activities can help with increasing the students motivation. We discuss student perception of the use of the use of active learning in section III-C. Internet connectivity and technology issues was one of the factors that affected the students negatively. However, these factors vary from one student to another depending on the setup at their homes, and they are not directly related to the teaching pedagogy. Students were encouraged to use the university cloud computing resources in case they need extra computing resources.

B. Student Preference of Teaching Method

In each section, students were asked whether they prefer the adopted teaching method in their section or they would rather prefer a different teaching pedagogy to learn signal processing concepts. Table IV shows the student preference in each section. In total, 61.5% of the surveyed students indicated that traditional lecturing is what they prefer while studying signal processing. In the traditional lecturing section (fall 2020), the great majority of the students, 82.6%, reported that they prefer to continue learning in a traditional format rather than using a flipped style of instructions. This high percentage can be justified by the fact that traditional teaching has been the dominant teaching approach in most of the engineering schools

TABLE IV
STUDENT PREFERENCE OF TEACHING METHOD

		Student preference		Total
		Traditional Lecturing	Flipped Style	
Adopted	Traditional Lecturing	19	4	23
	Partially Flipped	15	8	23
	Fully Flipped	33	30	63
	Total	67	42	109

and all the students in this section did not experience a flipped format of instructions for signals classes and it is natural for them to resist flipped instructions out of the fear of an increased workload. On the other hand, the percentage of students who favor a traditional format of teaching has decreased to 65.2% in the section taught in a partially-flipped format, i.e., spring 2021. This reduction suggests that student resistance to flipped instruction is manageable if they had the opportunity to experience the benefits of a flipped classroom. This claim is supported by the results from the fully flipped section (summer 2020), where the percentage of the students who prefer a traditional form of teaching is reduced to 52.4%. Nonetheless, in all the three sections more than half of the class indicated that they still prefer a traditional form of teaching. This result is reasonable given the relative novelty of student-centered teaching methodologies like flipped classroom and the students fear of increased academic responsibilities. In section III-D, we assess the students perspective of flipped instructions and their perceived benefits and drawbacks of such teaching style. However, the percentage of students who prefer flipped style in this study, 38.5%, is encouraging and instructors who teach in a flipped model should continue using flipped teaching in their classes, but they need to carefully design their assignments to lean students' resistance to flipped instructions.

C. Student Perspectives on Active learning

Eighty-three students responded to the first question in table I. This question measures the students' prospectives on being active and participatory during class activities. Based on the analysis of the collected responses, the majority of students had a positive experience participating in class activities, with only five students indicating that class participation was a negative experience for them. The two frequently stated aspects of this positive experience were: (i) the in-class problem solving, practice, and application (45 students); and (ii) the aid in clarifying difficult materials (39 students). Twenty students noted that class participation helped them to a feedback on their understanding either from the instructor or from their peers. Finally, 18 students indicated the ability to being engaged and communicate with other students and/or the instructor during class as a positive experience. While these results are encouraging, further analyses, that measure the student performance in remote classroom in correlation to class activities, should be conducted to understand the impact of class participation on students' attainment of course objectives.

TABLE V
SUMMARY OF SURVEY RESPONSES RELATED TO FLIPPED INSTRUCTION

Total number of Responses	52
Benefits discussed	
Alternative use of class time	10
Preparation, engagement & professional behaviors	22
Enhanced learning or learning processes	10
Convenience & flexibility	13
Drawbacks/Suggestions discussed	
Don't use/prefer flipped instruction	4
How class time was used	2
Increased time, work, or stressors	5
Challenges with video-based learning	5

On the other hand, 32 students mentioned that they did not participate in class activities because of logistic problems (2 students), social fear (18 students), or their desire not to participate in class (12 students). We believe that student advisors may be a key to motivate their students to participate in remote class discussions as it may be challenging to be focused in the remote class setups as indicated in [6].

D. Assessment of Student Perspectives on Flipped Style of Instruction

Table V presents the content analysis of the benefits and drawbacks discussed in response to the second question in I. Besides the factors discussed in section III-A, this analysis of the collected 52 responses aims to understand students' perception of different aspects of the flipped style of instructions. The most frequently-stated benefit to the flipped style was the preparation, engagement, and professional behavior. Flipped instructions is a student-centered approach. Students are responsible of watching the video and completing quizzes before coming to the class. This responsibility aids the professional behaviors development in our students character. Then, they come to class prepared with questions and ready to engage with their peers and instructors in different class activities. Convenience and flexibility of learning was stated by 13 students. This included having more control over their schedule, the ability to reference the videos and learn at their own pace, and the ability to learn from a different time-zone. Roughly, 20% of the responses discussed enhanced learning or learning processes associated with flipped instruction. Similar percentage of students referred to the benefit of the alternative use of class-time. Alternative use of class time included in-class problem solving, active learning, asking questions, one-on-one instructor support, and teamwork.

The number of students discussed the drawbacks were significantly less than those who discussed the benefits. Four student indicated that flipped instruction is not their preferred method of learning and two students mentioned that the class time or activities was not utilized in an efficient way in their opinion. Challenges with video-based learning outside of classroom and the sense of increased time, workload, or stressors were the most frequently mentioned drawbacks. The

challenges varied over logistic factors (e.g., internet speeds vs. streamed video quality) and motivations to focus while studying from home and not able to ask immediate questions to instructors. The later is understandable given the nature of the signals classes that relies on heavy math background and analysis. Working from home while having to access to campus' study resources (e.g., library space and study rooms) contributed to the stressors on the students who needed time to focus on the completion of the pre-class activities.

IV. CONCLUSIONS

The pandemic has affected the different elements of teaching and learning. Instructors and students had to adapt to changes in the way classes are conducted and had to deal with different factors and distractors that resulted from working at home. In this survey-based study, we studied the students' perspective on different teaching pedagogy in three signals classes in the ECE department hosting this study. The different negative and positive factors that affected student learning under different pedagogy in a remote classroom have been discussed. The majority of students find the traditional lecturing is the preferred and most helpful approach as it allows them to ask immediate questions and require less work prior to class meeting. Because of the relative novelty of student-centered learning for many students who transitioned to remote learning, resistance to the flipped classroom may still occur, relying on a belief that the course is disorganized and/or increased feelings of stress to complete the work. However, there still a good percentage of students who prefers a flipped style of instructions and find that the flipped style of instructions is helpful in achieving their learning goals. The students discussion of benefits associated with flipped instructions is positive and indicate that learning is improved with this mode of teaching. Thus, instructors should not be discouraged from adopting flipped instructions. Nonetheless, and as a direction for future work, more studies are needed to investigate the effectiveness of each teaching approach in enhancing student

performance in different remote classes. Finally, active learning and class participation are well perceived by the students, and we recommend the adoption of active learning exercises in remote classrooms, irrespective of the teaching style that an instructor may use. Our results suggest that active learning exercises kept students motivated and engaged in the remote classroom. The class activities increased class participation and helped in fostering student understanding of the presented materials.

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