Further Strategies to Increase Engagement in an Online/Hybrid Signals and Systems Course

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Further Strategies to Increase Engagement in an Online/Hybrid Signals and Systems Course

Abstract

This paper describes additional strategies taken to increase student-reported achievement of Learning Objectives of a sophomore-level "Signals and Systems" core course in the Bradley Department of Electrical and Computer Engineering at Virginia Polytechnic Institute & State University, a large mid-Atlantic institution. As described at 2023 ASEE Annual Meeting, we spent the past few years increasing the response rate to the end-of-course survey and aim in the longer term to increase the proportion of students who self-report their attainment of the course learning objectives as either "Good" or "Excellent." After reflecting upon these results and learning lessons from previous course offerings, we are now introducing strategies to increase student engagement further and attain department metrics for the course. Starting in Fall 2023, 13 activities were introduced to improve the course. The activities can be grouped into three categories: (A) Demonstrating the worth of the course to the students; (B) Making class fun; and (C) Removing obstacles to student learning. Results are promising. In Fall 2023, attendance was high; targets for the two department metrics were achieved; and students who completed the course passed the course with a grade of C or higher.

Introduction

This paper describes additional strategies to develop a sophomore level online/hybrid signals and systems course in an electrical and computer engineering department in Virginia Polytechnic Institute & State University (Virginia Tech), a large mid-Atlantic university. In our prior paper, we described strategies to develop an online/hybrid signals and signals course [1]. The course textbook is "Signals and Systems" by Oppenheim and Willsky [2]. These efforts focused on developing the course aspects devoted to online/hybrid delivery to increase student learning in today's enhanced learning environment. Virginia Tech is designated by the National Science Foundation as a minority serving institution.

Starting in Fall 2023, 13 activities were introduced to improve the Signals and Systems course in the Bradley Department of Electrical and Computer Engineering. The 13 initiatives introduced are: (1) Tracking attendance for assigned points starting on the first day of class; (2) mapping each exam problem and each quiz question to the corresponding course Learning Objective(s) [3]; (3) introducing a series of mini-Guest Speakers to talk with the students about how they use the concepts of signals and systems in their careers and jobs; (4) introducing Prize Day with a 'Prize bag' filled with items that students can select after achieving certain milestones in the course; (5) purchasing non-programmable calculators for anxious students who come to office hours and are worried about obtaining a non-programmable calculator that they can use in the course; (6) offering class participation bonus points for arriving early to class; (7) offering weekly recitations starting on the second week and focusing on prior exam problems; (8) working on white boards to solve problems in groups; (9) bringing sports equipment to class to encourage camaraderie and study group formation, prior to the home football games (including football, soccer ball, lacrosse balls,

baseball, tennis ball, golf ball); (10) an opportunity to write a signals-and-system-themed poem with up to 100 words and at least 5 technical words for class participation bonus points; (11) offering in-person lab demonstrations for lab bonus points; (12) bringing breakfast bars to class; and (13) promising office hours with GUEST approach (Greet, Understand, Explain, Share, Thank). These 13 activities can be grouped into three categories: Demonstrating the worth of the course to the students; Making class fun; and Removing obstacles to student learning. The 13 Activities are assigned to these categories, as shown in Table 1. In Fall 2023 there are 70 students, and in Spring 2024 there are 72 students.

Table 1. Activities added in Fall 2023 to develop a sophomore-level signals and systems course

Category	Topics	Activity
(A)	Demonstrating the worth of the course	(1) Tracking attendance for assigned points starting on the first day of class;
	Demonstrating the worth of the course	(2) mapping each exam problem and each quiz question to the corresponding course Learning Objective(s);
	Demonstrating the worth of the course	(3) introducing a series of mini-Guest Speakers to talk with the students about how they use the concepts of signals and systems in their careers and jobs;
	Demonstrating the worth of the course	(6) offering class participation bonus points for arriving early to class;
	Demonstrating the worth of the course	(7) offering weekly recitations starting on the second week and focusing on prior exam problems;
	Demonstrating the worth of the course	(11) offering in-person lab demonstrations for lab bonus points;
	Demonstrating the worth of the course	(13) promising office hours with GUEST approach (Greet, Understand, Explain, Share, Thank)
(B)	Making class fun	(4) introducing Prize Day with a 'Prize bag' filled with items that students can select after achieving certain milestones in the course;
	Making class fun	(8) working on white boards to solve problems in groups;
	Making class fun	(9) bringing sports equipment to class to encourage camaraderie and study group formation, prior to the home football games (including football, soccer ball, lacrosse balls, baseball, tennis ball, golf ball);
	Making class fun	(10) an opportunity to write a signals-and-system-themed poem with up to 100 words and at least 5 technical words for class participation bonus points;
(C)	Removing obstacles to student learning	(5) purchasing non-programmable calculators for anxious students who come to office hours and are worried about obtaining a non-programmable calculator that they can use in the course;
	Removing obstacles to student learning	(12) bringing breakfast bars to class.

The course has five Learning Objectives (LOs) listed in Table 2. The learning objectives are now listed by number and written in full at the start of the weekly Quizzes and on exam cover sheets.

Table 2. Learning Objectives for Course

LO #	Name	Learning Objectives
1	LO 1	"Describe a given system using a block-level description and identify the input/output signals".
2	LO 2	"Mathematically model continuous and discrete linear, time-invariant systems using differential and difference equations, respectively".
3	LO 3	"Analyze the use of filters and their interpretation in the time and frequency domains and implement standard filters in hardware and/or software".
4	LO 4	"Apply computations of the four fundamental Fourier transforms to the analysis and design of linear systems".
5	LO 5	"Demonstrate professional communication through formal documents that communicate solutions to problems and document projects within the domain of signals and systems".

The GUEST approach toward offering office hours (Greet, Understand, Explain, Share, Thank) is promised to students in the welcome slides shown on the first day of class (Figure 1). This model is adapted from the GUEST model used, for example, in hospitality operations [1]. In our GUEST model, we Greet the student by name and use their preferred pronouns; we Understand the student's question and where the student is stuck; ask the student Explain their steps starting with the key equations on the ECE2714 equation sheet; we Share course concepts that can be helpful, and we work through the rest of the problem; and finally at the end of office hours, we Thank the student for attending office hours.

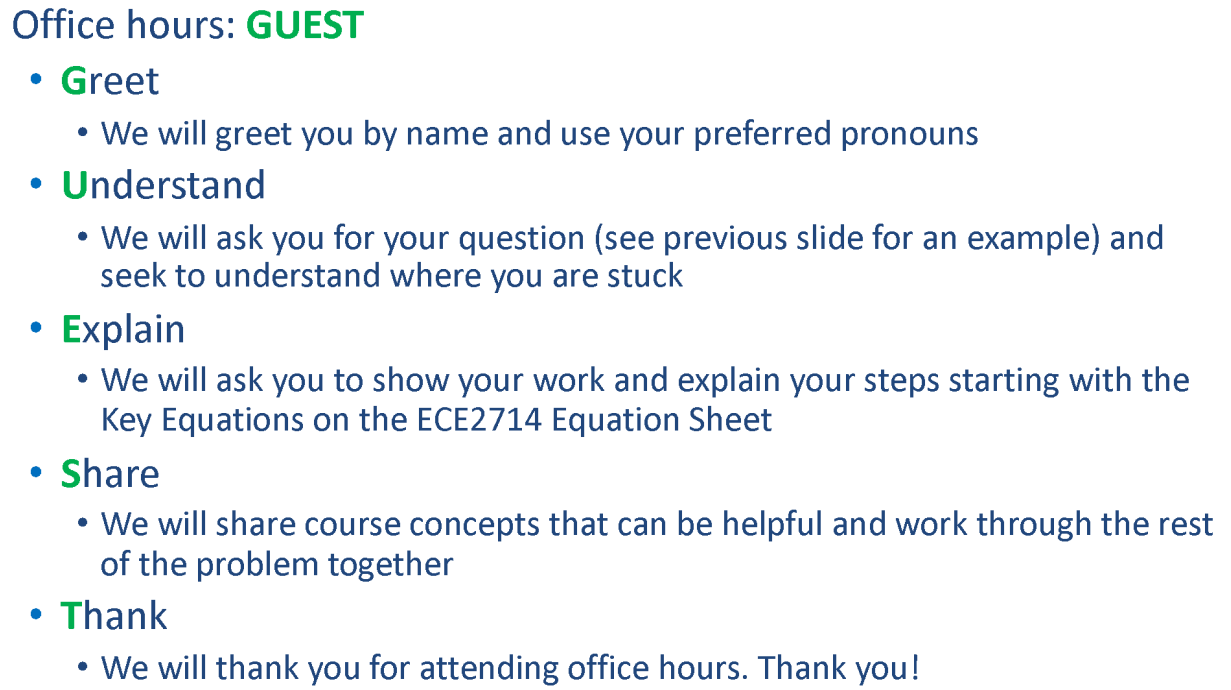

Figure 1. Welcome slide explaining GUEST approach in this course (Greet, Understand, Explain, Share, Thank) adapted from the hospitality area [4].

In Fall 2023, for the first time in teaching this section of the course, all students who completed the course passed the course with a grade of C or higher. High attendance was achieved: The average attendance in the first 10 classes and Review session is 88.3%. Attendance in the first five classes is 94.3%, 92.9%, 94.3%, 94.3%, and 94.3%, respectively. In the first 10 classes, 4, 3, 4, 3, 4, 8, 13, 17, 15, and 13 students missed class which corresponds to 94.3%, 95.7%, 94.3%, 95.7%, 94.3%, 88.6%, 81.4%, 75.7%, 78.6%, 81.4% attendance rates, respectively. Only six students missed the review sessions prior to Exam 1 (91.4% attendance). Only 5 students missed 4 (or more) out of 10 classes. All 70 students took the first MidTerm Exam. After the first MidTerm Exam, 92.9% of the class had passing grade of C or higher (at least 74%). The percentage of students who respond to the online course-end student survey tended to increase from 38% (Spring 2021), 45% (Fall 2021), 54% (Spring 2022), 57% (Fall 2022), 62% (Spring 2023), and 58% (Fall 2023).

Background and Overview

At the conclusion of the course each semester, students are asked in a "SPOT" survey ("Student Perception of Teaching") about how the student rates their ability to achieve each of the course learning objectives [5]. The results are shown in Figure 2 which shows the student self-reported achievement of ECE2714 learning objectives in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023. Results in the figure show that the 70% target (blue horizontal line) is exceeded in Fall 2023 semester for all five learning objectives.

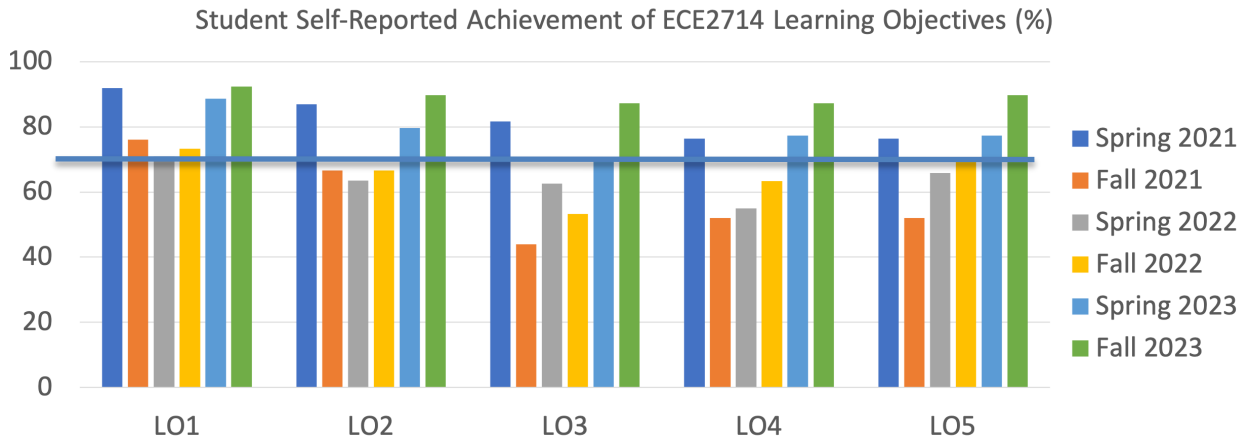

Figure 2. Student self-reported achievement of ECE2714 learning objectives

Figure 3 shows the student response rate to end-of-semester surveys in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023.

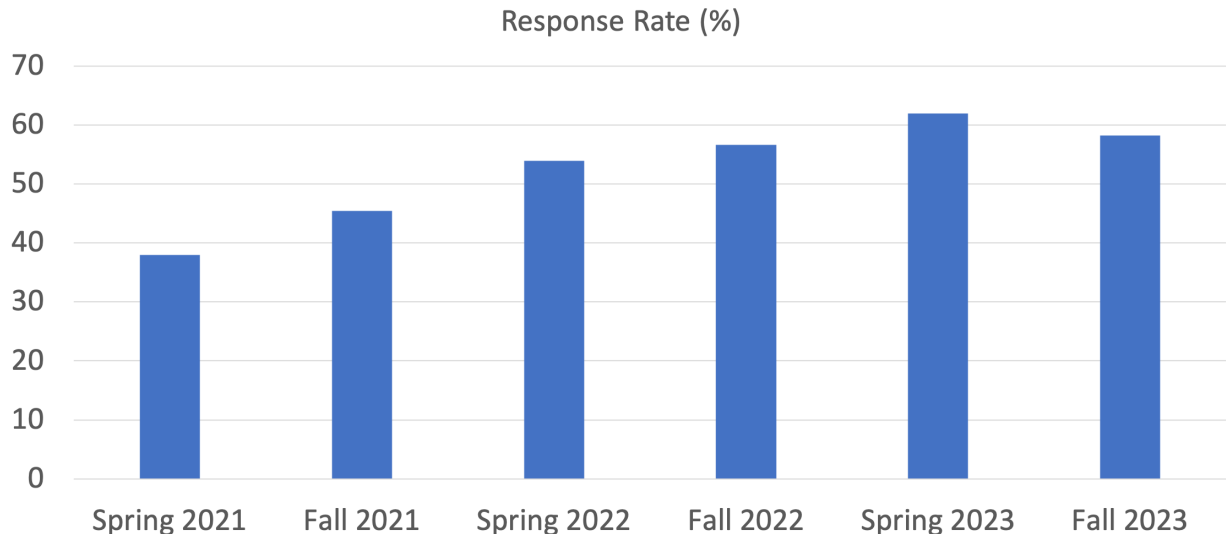

Figure 3. Response rate to end-of-semester student surveys.

In Fall 2023, all students who completed the course passed the course with a grade of C or higher. Figure 4 shows the grade distribution in Signal and Systems in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023 semesters.

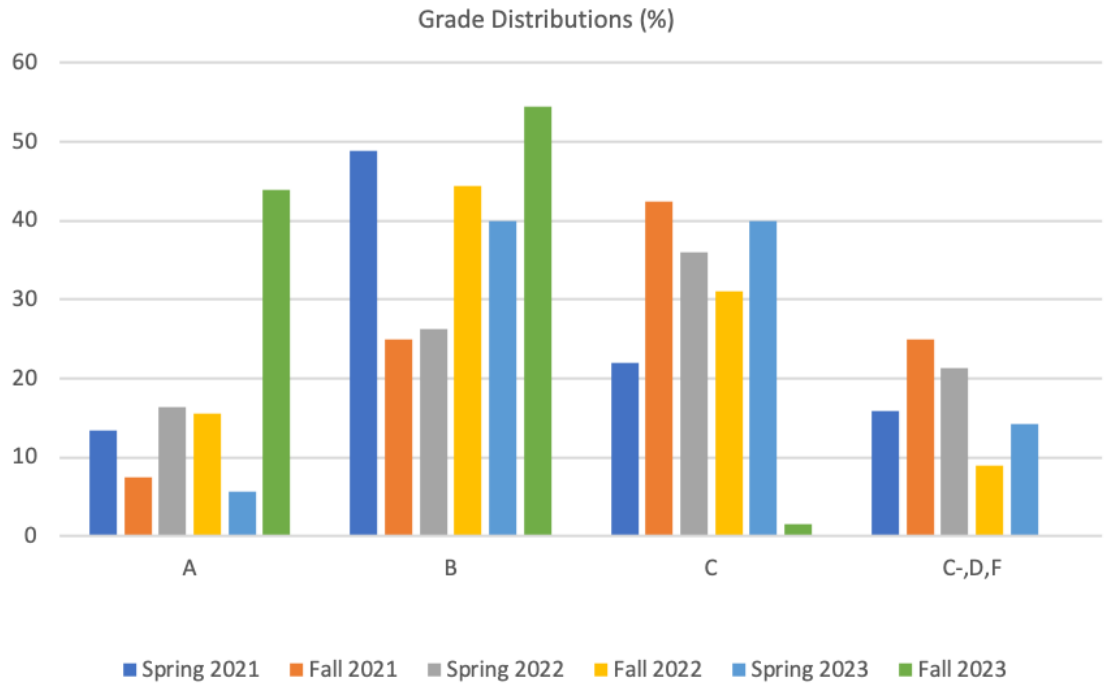

Figure 4. Grade distributions in Signals and Systems in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023 semesters

Figure 5 shows the percentage of honor code violations in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, Fall 2023. This effort described in this paper and published in our prior paper at 2023 ASEE to develop the online/hybrid signals and systems course started as an effort to improve the course while at the same time introducing strategies to develop the course.

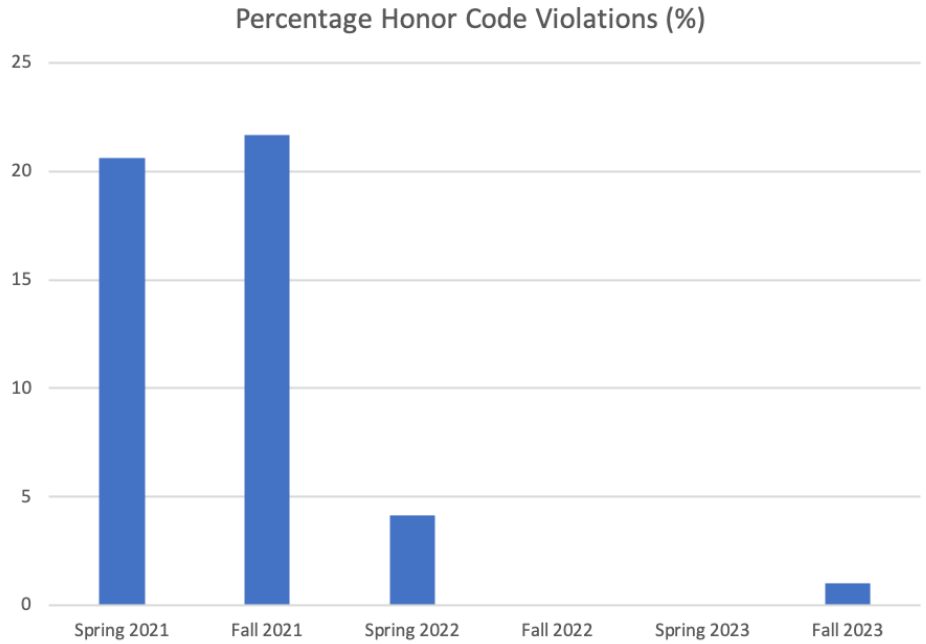

Figure 5. Honor Code violations in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, Fall 2023

Instructional Approach and Course Elements

As discussed in our previous paper at 2023 ASEE [1], the course instructional approach consists of learner-centered teaching techniques assigned in four categories: (A) Course setup, (B) Course delivery, (C) Formative assessment, and (D) Summative assessment. These categories implement the principles of "Constructive Alignment", "Practice and Feedback", and "Balance" that guide the instructional design approach [6]-[22]. The same concept map is used as in prior semesters to "preview material to be covered in class and/or summarize what was covered and put it in a broader context" [9], [11]. The Virginia Tech Center for Teaching and Learning provides mid-semester feedback during the course [12].

The 13 new activities are added in Fall 2023 to develop the course. These new activities are highlighted in blue in Table 3.

Table 3. Course elements

	Element	SP21	FA21	SP22	FA22	SP23	FA23	SP24
(A) Course Setup	Graphic organizer (concept map) [9, 11]	X	X	X	X	X	X	X
	Learning objectives	X	X	X	X	X	X	X
	(2) mapping each exam problem and each quiz question to the corresponding course Learning Objective [3]							
(B) Course Delivery	Online (live) Zoom lectures	X	X	X				
	In-person lectures with "small group classroom" with whiteboards, dual screen projection, and wall displays				X	X	X	X
	Active Reading Worksheets (in Excel/Canvas) [14, 17]	Excel	Excel	Canvas	Canvas	Canvas	Canvas	Canvas
	Lectures with Circuit Examples	X	X	X	X	X	X	X
	Engagement Questions (in Excel/Canvas) [15, 18]	Excel	Excel	Canvas	Canvas	Canvas	Canvas	Canvas
	Breakout Sessions (Zoom)	X	X	X				
	Mapping topic learning objectives to exam problems [3]	X	X	X	X	X	X	X
	Meme Competition [15, 16]	X	X	X	X	X	X	X
	Signals and Systems Song Contest							**X**
	Monthly visits to Blacksburg	X	X	X				
	Students offered choice in some assessments		X	X	X	X	X	X
	Tent cards for student names (in class)				X	X	X	X
	Equation Sheet			X (Final)	X	X	X	X
	Weekly Modules in course Learning Management System with 'before class', 'during class', 'after class' topics, learning objectives, assignments	X	X	X	X	X	X	X
	Evening review sessions for Exam 1, Exam 2, Final Exam				X	X	X	X
	(1) Tracking attendance for assigned points starting on the first day of class						X	X
	(3) introducing a series of mini-Guest Speakers to talk with the students about how they use the concepts of signals and systems in their careers and jobs;						X	X
	(4) introducing Prize Day with a 'Prize bag' filled with items that students can select after achieving certain milestones in the course;						X	X
	(5) purchasing non-programmable calculators for anxious students who come to office hours and are worried about obtaining a non-programmable calculator that they can use in the course;						X	X
	(6) offering class participation bonus points for arriving early to class;						X	X
	(7) offering weekly recitations starting on the second week and focusing on prior exam problems;						X	X
	(8) working on white boards to solve problems in groups;						X	X
	(9) bringing sports equipment to class to encourage camaraderie and study group formation, prior to the home football games (including football, soccer ball, lacrosse balls, baseball, tennis ball, golf ball);						X	X
	(10) an opportunity to write a signals-and-system-themed poem with up to 100 words and at least 5 technical words for class participation bonus points;						X	X
	(11) offering in-person lab demonstrations for lab bonus points;						X	X
	(12) bringing breakfast bars to class.						X	X
	(13) offering office hours with GUEST approach (Greet, Understand, Explain, Share, Thank) approach						X	X
(C) Formative Assessment	Course check-in surveys	X	X	X				
	MidSemester Feedback [12]				X	X	X	X
	Reaching out to students who missed graded events with individual emails requested by the department			X	X	X	X	X
	Reaching out to students who missed each class with individual emails requested by the department (after attendance was tracked)				X	X	X	X
	Homework (for credit)	X						
	Homework (extra credit)		X	X	X	X	X	X
	Quizzes		X	X	X	X	X	X
	Quizzes with podcasts				X	X	X	X
(D) Summative Assessment	Mid-Term Exam 1 Online	X	X					
	Mid-Term Exam 1 in person			X	X	X	X	X
	Mid-Term Exam 2 Online	X						
	Mid-Term Exam 2 in person		X	X	X	X	X	X
	Final Exam online	X						
	Final Exam in person		X	X	X	X	X	X

Results: Student Participation in low stakes graded events

This course integrates low stakes graded events with the two midterm exams and final exam. Figures 6-9 discuss participation in low-stakes assessments that are integrated into this instructor's section of the course. Published work in the literature discusses the importance of low-stakes assessments and mentions that "Studies have shown that balancing the use of low stakes and high stakes assignments and assessments in determining a course grade tends to improve the performance of all students while also specifically promoting the success of historically under-represented/underserved students in such a way as to reduce course-level equity gaps" [13]. One published study describes the use of bi-weekly assignments (BWAs) instead of high-stakes exams in a large introductory programming course [14]. Here, we evaluate the extent to which participation in the low-stakes assessments are related to the student performance in the course.

Figures 6-9 show student participation in daily activities including Active Reading Worksheets (ARWs), Engagement Questions (EQs), Quizzes, and Attendance. These activities are assigned points to give students low stakes assignments with low point values. These activities are graded within a few hours of the due dates. With timely feedback, these are intended to help keep the students on track throughout the week. The high stakes assignments are three exams [17,18].

The instructor grades the assignments on the course Learning Management System (LMS) within a few hours after the assignment is due and before the next assignment is due, so that students have speedy feedback. An ARW is due each class morning, and an EQ is due each class evening. For example, ARWs are due by 8:00am on class day. The instructor grades the ARWs right after class. EQs are due by 11:59pm on class day. The instructor grades the EQs the following day (the day before the next class). The instructor grades Quizzes on Sundays and Mondays (the day before the first class of the week). The instructor grades attendance and posts attendance grades after class.

Figure 6 shows the percentage participation in active reading worksheets each semester. In Spring 2021, students were given until the end of the semester to submit ARWs. This increased student participation in active reading worksheets. Participation can decrease if students forget to complete ARWs before class. Future work will find out why student participation tends to decrease.

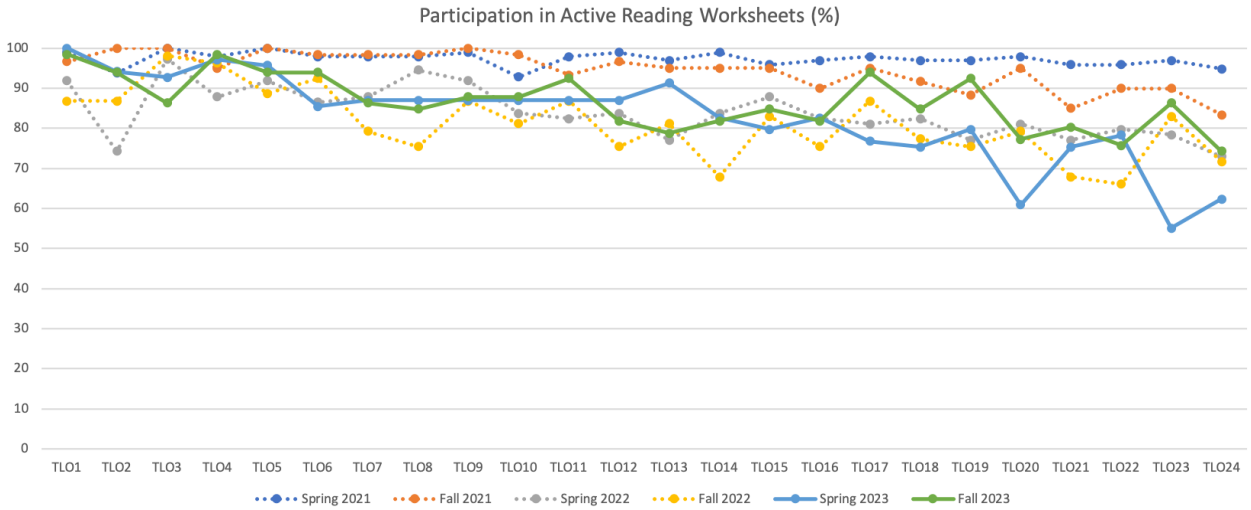

Figure 6. Participation in Active Reading Worksheets

Figure 7 shows participation in engagement questions in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023. In Spring 2021, students were given until the end of the semester to submit engagement questions. This increased student participation in engagement questions. In future semesters, students had until the end of the class day at 11:59pm to complete engagement questions which can decrease the participation in engagement questions if students forget to complete the engagement questions in time. Future work will find out why student participation in EQs tends to decrease.

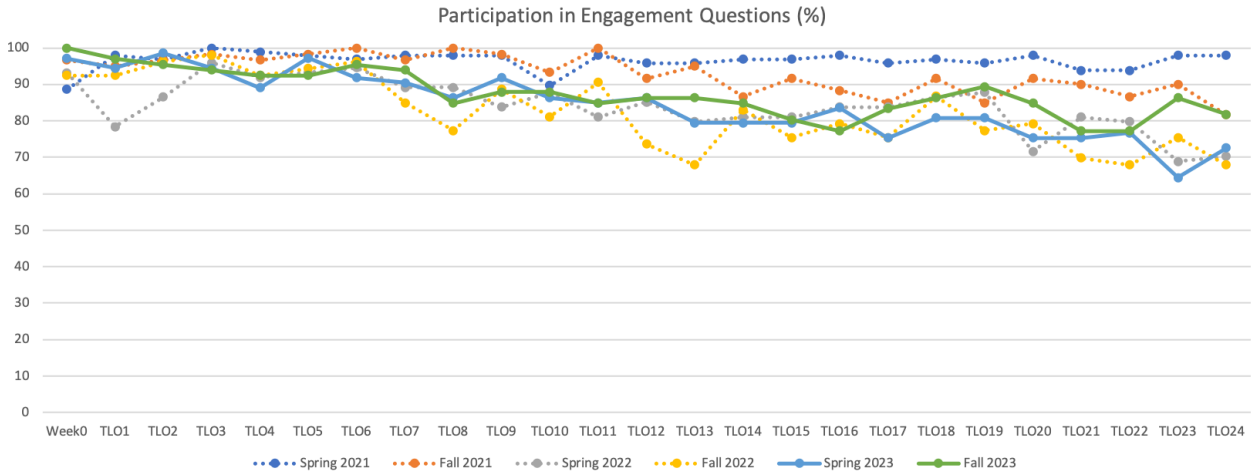

Figure 7. Participation in Engagement Questions

Figure 8 shows participation in quizzes in Spring 2022, Fall 2022, Spring 2023, and Fall 2023. Starting in Spring 2023, students receive full credit for submitting their work in the even-numbered quizzes (e.g., Quizzes 2, 4, …., 24) and for submitting a 2-minute podcast and their work in the odd-numbered quizzes (e.g., Quizzes 1, 3, 5, …, 25).

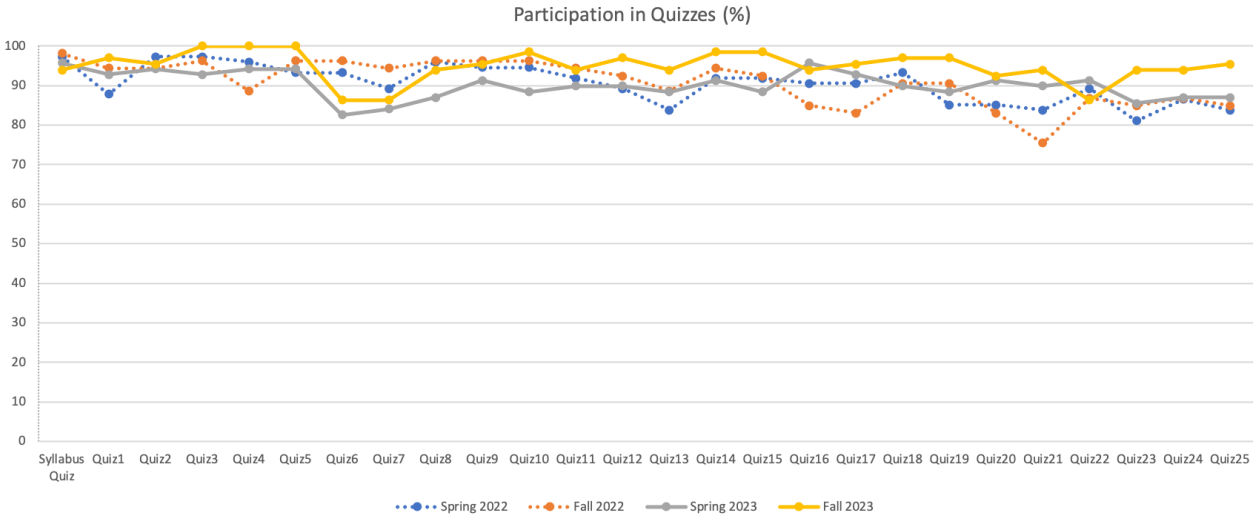

Figure 8. Participation in Quizzes

Figure 9 shows the attendance in Fall 2022, Spring 2023, and Fall 2023. Future work will find out why student attendance tends to decrease over time.

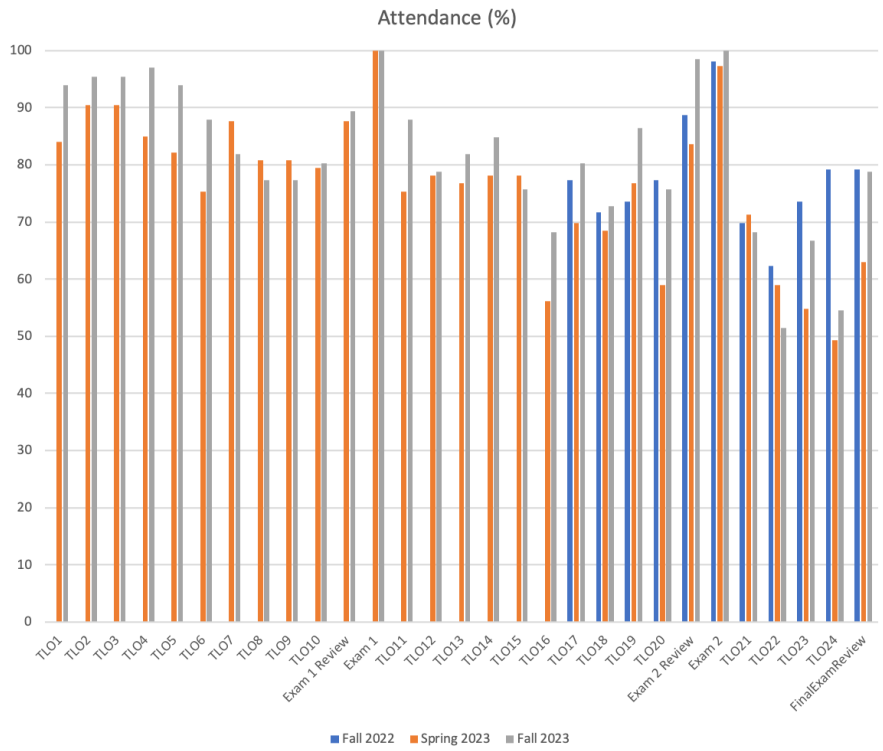

Figure 9. Attendance in Fall 2022, Spring 2023, Fall 2023 (Attendance was not tracked in Spring 2021, Fall 2021, Spring 2022)

Results: Two Department Metrics

Figure 10 shows the concurrence scores in the Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023 semesters. The results in the figure show that the concurrence scores in Fall 2023 exceed the department target of 0.70 (blue horizontal line).

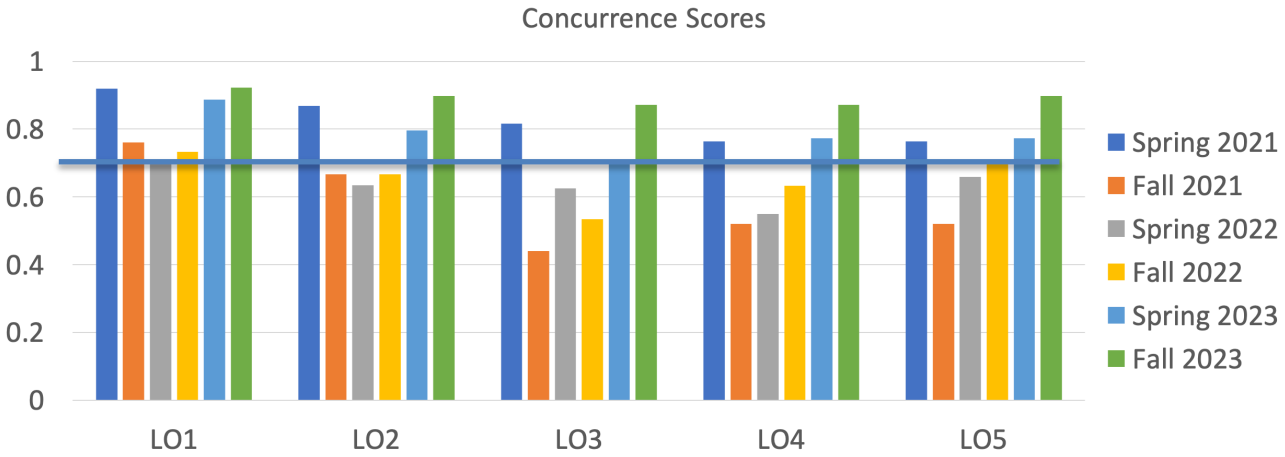

Figure 10. Concurrence scores in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023 semesters. The department target of 0.7 is shown in the blue horizontal line

Figure 11 shows mean opinion score (MOS) calculated from student end-of-semester surveys in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023. The department target is 2.7 for each learning objective.

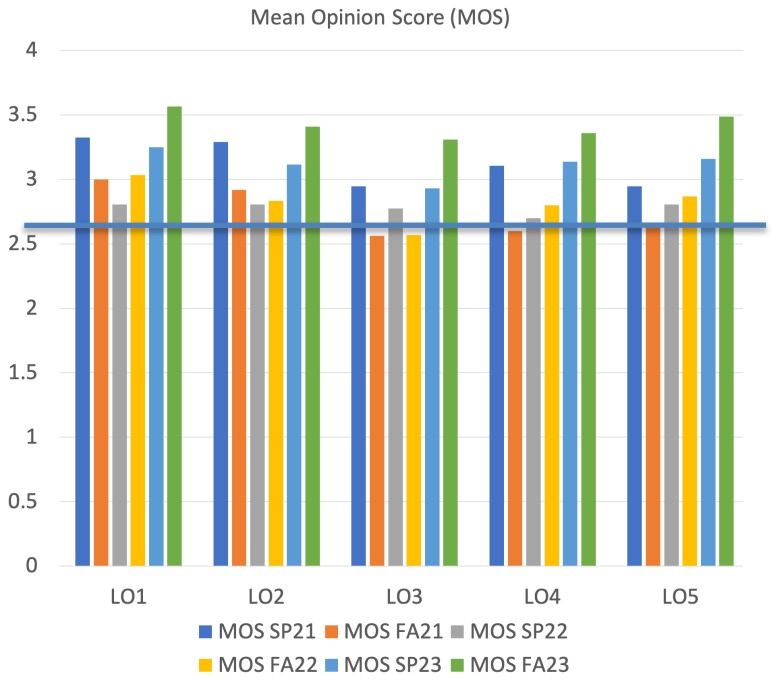

Figure 11. Mean opinion score (MOS) calculated from responses to end-of-semester surveys

Results: Student participation in graded events: Labs, Lab Demonstrations, and Exams

Figure 12 shows participation in Labs each semester.

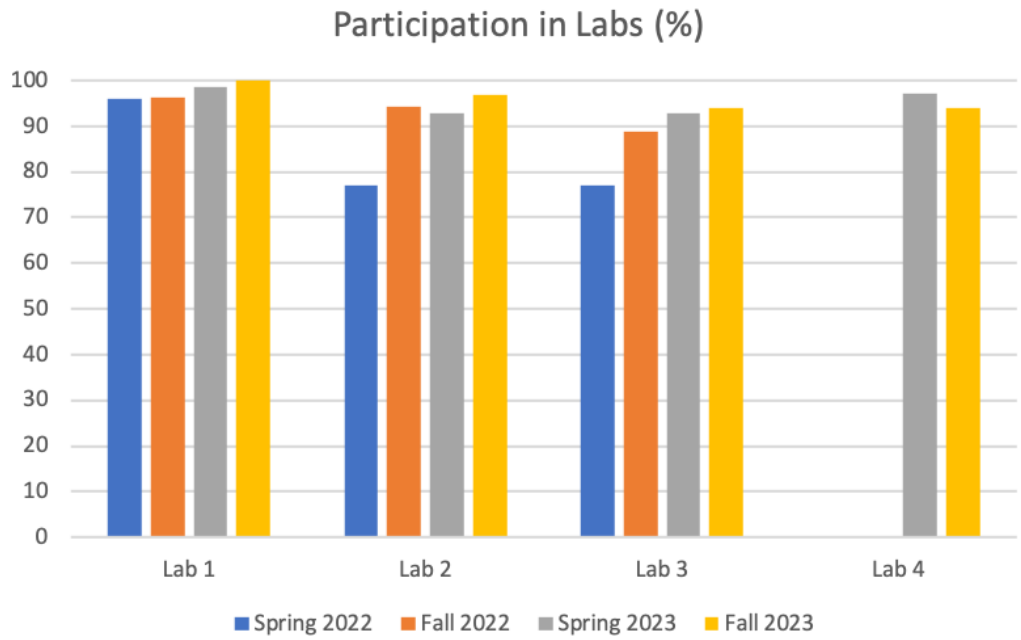

Figure 12. Participation in Labs

In Fall 2023, students had additional opportunities to bring lab circuit demos and code demos and receive lab bonus points. Labs 1, 2, and 3 are circuit labs, and Lab 4 is a programming lab. Figure 13 shows participation in the lab circuit demos in Fall 2023. Students were offered the opportunity to bring their lab circuits to demo to the instructors starting with Lab 3. After many students brought the Lab 3 circuits, additional opportunities were offered for the remaining labs – Labs 1, 2, 3, 4 – through the rest of the semester. In Spring 2024, we also offer circuit reviews for labs.

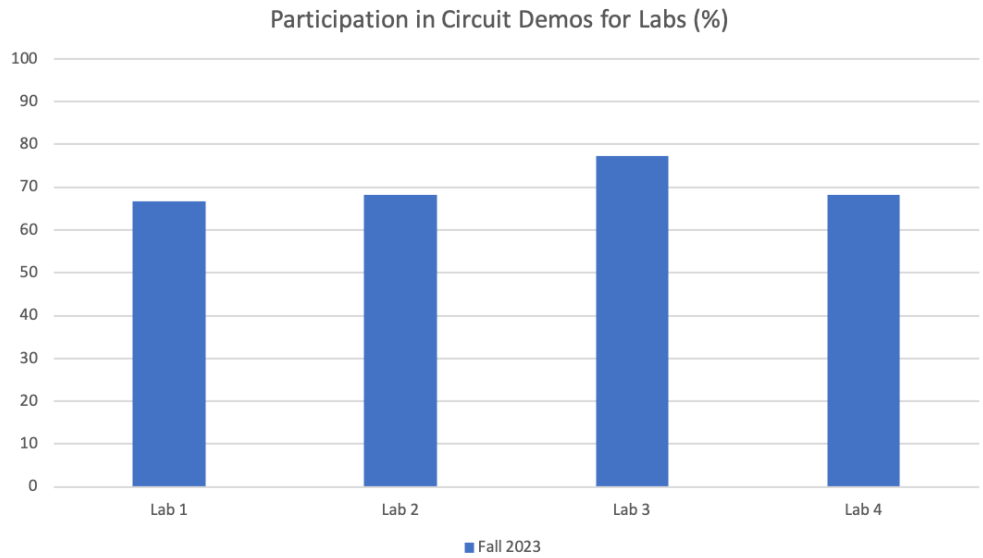

Figure 13. Participation in Lab Demos in Fall 2023

Figure 14 shows participation in Exams in Spring 2021, Fall 2021, Spring 2022, Fall 2022, Spring 2023, and Fall 2023.

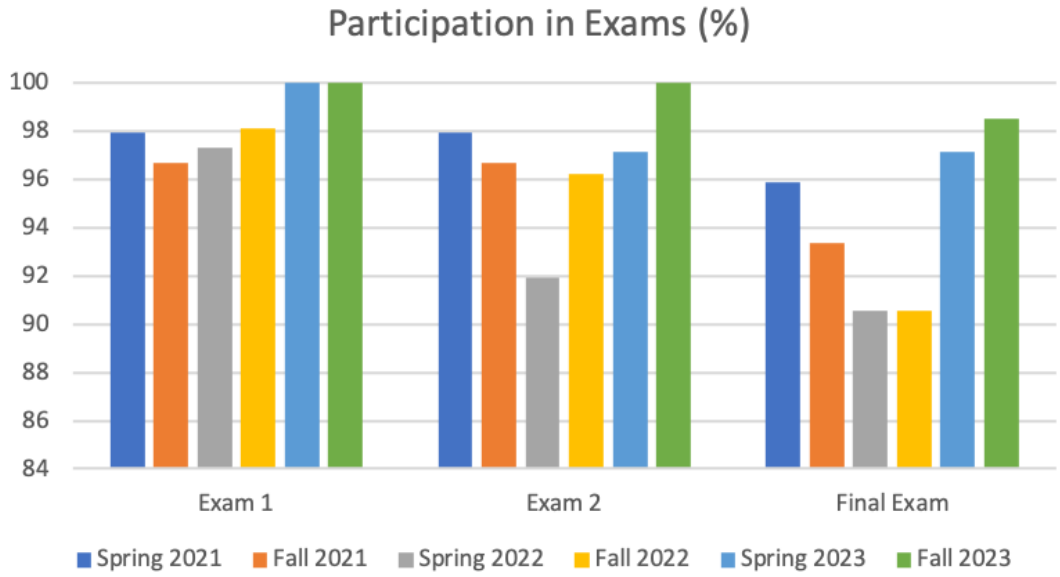

Figure 14. Participation in Exams

Results: Student self-reported feedback

The activities introduced in Fall 2023 receive positive feedback from the students. Table 4 shows examples of student self-reported feedback in Fall 2023 [5].

Table 4. Examples of anonymous student comments in end-of-semester Student Perceptions of Teaching (SPOT) Survey in Fall 2023 [5]

	Student Comments
Fall 2023	"I think doing example problems and having recitation that went over previous exam problems really helped. There were also a lot of resources on canvas to help me."
	"she offered many out of class resources, such as office hours, recitation, and exam review sessions."
	"LOTS of resources and incredibly empathetic to students. She also has us evaluate her teaching in the middle of the semester and started implementing any feedback we had for her almost immediately (the next class)"
	"Dr. Lanzerotti was very helpful in office hours and with offering extra credit, she also asked for and listened to student feedback which was very nice since not many professors do that."
	"The learning environment Professor Lanzerotti created made it very easy to understand what was supposed to be done and how to do it, any questions that were asked had answers available to students and students were communicated very clearly where to find those answers, whether that be office hours or recitations or other resources."
	"Splitting up the notes by TLOs, breakfast bars, effective lectures."
	"Professor Lanzerotti has a lot of office hour times available to help students, and holds weekly recitation sessions herself instead of having a TA do it. All of the extra time and effort she puts in outside of class hours is very helpful and is very much appreciated. She is truly one of the best professors I've had, and genuinely cares about her students."
	"The bonus point incentives are fun, and were actually really helpful for motivating me to come to class early and attend office hours."
	"She did a very good job of keeping attendance high and the classroom was nice."

Discussion

This work investigates student perceptions of learning and presents a variety of data to assess student perceptions of learning.

A major limitation of this work is that we are asking for student perceptions of learning.

Interactions with students by email was tracked during each semester since Spring 2022, as described in the companion paper at 2024 ASEE entitled "Interactions with Undergraduate Academic and Career Advisors in a Signals and Systems Base Course" [23].

Conclusions

The students continue to take charge of their learning in the signals-and-systems course which is wonderful to see. While it is difficult to surmise which of the specific course elements had a positive impact, we can see that the variety of materials provided for course setup, course delivery, formative feedback, and feedback provide students with opportunities to learn the concepts related to signals and systems and to achieve the course Learning Objectives.

Future Work

Future work will continue to improve the course and include assessment of the student learning of the course topics in addition to assessment of student perception of student learning. One technique is the Instant Feedback Assessment Test (IF-AT) by Epstein Enterprises [24,25].

Future work will also investigate why the student attendance, student participation in engagement questions and Quizzes tends to decline over time throughout the semesters. The long-term goal of this work is to develop the online/hybrid signals and systems course so that all students succeed in the course.

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Glossary

ARW Active Reading Worksheet
CETL Center for Excellence in Teaching and Learning
CT Continuous time
DT Discrete time
ECE Electrical and Computer Engineering
EQ Engagement Question
LO Learning Objective
MOS Mean Opinion Score
SPOT Student Perception of Teaching
TLO Topic Learning Objective

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