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Student-designed assessments in electronic systems and signal processing courses

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Paul Andreas Hadjipieris

Student-designed assessments in electronic systems and signal processing courses

Abstract

Designing assessments that could improve student learning in addition to assessing their understanding of the course material is of great interest in many disciplines, including electrical and computer engineering. One such assessment method is requiring students to contribute to the design of their exam questions. The method established a closed-loop between learning the material and answering the exam questions by providing an opportunity to actively refine and deepen student learning while working on the exam questions to improve the exam score and hence improve mastery of the materials. This method is in sharp contrast to the traditional exams through which usually the learning process ends when students start the exam.

In this paper, we investigate an assessment type that could improve student learning in addition to assessing their understanding of the course material. Three variations of the student-designed assessments were implemented in signal processing and electronic systems courses at the University of California, San Diego. In the first variation, students created and solved student-generated questions each week of the course. In the subsequent two course variations, a comparison of treatment groups occurred between those participating in creating exam questions (group 1), those creating exam questions and peer reviewing (group 2), and those participating in neither activity (group 3/control). In each of the later two course variations, different requirements, level of difficulty, for the students in their design of the questions was implemented. The peer review process utilized an instructor-created rubric; students graded the submissions of three of their classmates and encouraged peer feedback. Anonymous end-of-term feedback surveys were used to seek students' perceptions of the effect of this assessment method and the peer-review activity on their learning. The survey results showed most of the students found the students-designed assessments and the peer review activity helpful to their learning. There was no statistically significant difference between how helpful students found the peer-review activity in two different student-designed assessment variations. Students who participated in the assessment for which more guidance and restrictions on the selection of the assessment questions were provided found these assessments more helpful to their learning compared to students who participated in assessments with fewer restrictions. In addition, students who were given more restrictions on the student-designed assessments found the preparation of these assessments a more challenging task than the other students.

Introduction

The focus of this study is to assess the efficacy of student-designed assessments in two electrical and computer engineering courses. In one of these courses, electrical engineering students are introduced to practical analog circuits and in designing such circuits students learn about the time and frequency domain characterization of analog filters and implementing such filters using passive and active elements. They analyze several operational amplifier-based functional circuits with positive or negative feedback. They also learn about the stability theory and how it is used to design stable circuits and oscillators. In the other course, students learn about the introductory signal processing topics such as Fourier series, Fourier transform, Laplace transform, and

sampling. They also learn how to use such tools to analyze continuous and discrete-time systems analytically and using MATLAB. This study builds off previous work that introduced student-designed assessments into the curriculum in these courses and encouraged students to design and submit their problems each week and receive feedback on their progress. Further, students had to reflect upon the difficulty of the problems and align them with the cognitive levels of Bloom's Taxonomy [1]. The course instructor created the opportunity for students to design and administer their course assessments to achieve the desired level of knowledge and comprehension needed for content mastery. Aligned with the recommendations within the educational literature on student-constructed assessment, students were encouraged to challenge themselves and create more complex problems each week. The instructor and instructional team (Teaching Assistants) set up short meetings each week to support the construction and delivery of the student-design assessments. Building on previous work the instructor and research team saw the efficacy of this teaching and learning approach and continued to improve the teaching methods and measure the strategy's efficacy for electrical engineering students at UC San Diego. The instructor of the course worked in consultation with an Educational Specialist at the university to think through the connection between assessments, active learning experiences, alignment with the course learning outcomes, and the lessons learned from previous course iterations were all incorporated with the goal of supporting an increase in student learning.

Literature Review

This literature review will examine this current study's connection of student-designed assessments and student learning, through a review of scholarship on self-directed learning, student-designed assessment, and student peer-to-peer teaching.

Self-Directed Learning

Self-directed learning (SDL) is an approach educators incorporate into their curriculum to teach lifelong learning skills. This pedagogical technique provides the opportunity for students to take ownership over their learning and have a significant role in assessing not only what they learned but how they learned [2], [3]. Specifically, SDL allows students to create their learning goals, diagnose resources required to meet those goals, and finally self-assess against the goals they created [4]. Seminal studies on SDL suggest the importance of the instructor to design learning environments in which students can choose their path in a safe and supported space [5], [6]. Further, the intentional design of these environments is essential for students to develop their SDL skills and self-efficacy in the college classroom [7], [8]. The SDL research reveals when students apply SDL techniques they can apply their learning strategies to gain a deeper conceptual comprehension of the problems they are trying to solve and create new innovative solutions to solve these problems [3], [9]. Results indicate when students can reflect upon how they learned, share with others their learning patterns, and are open to peer feedback. This process has a cumulative effect on student knowledge and comprehension of the material [10], [11], [12].

Self-Directed Learning as an Assessment

Recommendations illuminated in the literature posit a significant component of self-directed learning is for students to develop the skills to self-assess their work. Data shows successful self-assessment correlates with instructor formative and summative assessment results of their

mastery skills. Therefore, suggestions for educators center on building self-assessment into the curriculum and incorporating it into their everyday learning [12], [13]. Scholars who have offered definitions to support educators create learning experiences for the student to self-assess their work break down the self-assessment process into two distinct parts: s*elf-appraisal* and *self-management*. Self-appraisal supports students to evaluate their abilities while self-management helps regulate student behaviors. These findings point to when students have more "time on task" they become more efficient at self-appraisal and self-management. These two SDL strategies allow multiple dimensions of performance to be assessed by the educator and the student now demonstrates how to ask and receive feedback significantly better than students without SDL learning opportunities [13], [14]. Correspondingly, encouraging students to design their assessments has encouraged autonomy, self-efficacy, and motivation and is connected to a positive outcome on their learning goals as well as summative course assessments [15], [16], [17].

Student-Designed Assessments

Research clearly shows active student learning through inquiry-driven learning is the best way to improve student learning in STEM, which includes engineering courses [18]. This knowledge has allowed instruction in engineering, to focus on interactive teaching styles to improve student mastery of content. One interactive teaching style is to have students generate their own exam questions thereby creating a student-led formative assessment. The sheer act of crafting these questions enhances understanding and promotes deep learning for the student [19]. Research suggests multiple potential benefits from students asking and generating possible exam questions includes performance on summative assessments and overall course grades [20]–[25], these questions function as a useful study aid [22], [36], encourages higher-order cognitive skills through peer review and discussion of questions [21], [25], [27], [28], and increases student engagement in the process of assessment, as well as the course in general [20], [17]. Multiple studies examining student-generated exam questions primarily focused on using the questions to generate peer to peer conversations to critique and solve each other's work with some attention to the complexity of the questions being discussed [20], [21], [27], [29]. In this present study, students fully created and solved questions on their own personal exams, consequently benefiting from the learning [30], [31]. Additionally, this study differed from other study approaches by including an individual follow-up meeting with instructional staff, the Professor, or the Teaching Assistant (TA), to discuss the student generated exam questions and their solutions. These types of meetings allow the student to receive feedback on exam performance which research shows increases student learning when compared with traditional correct/not correct grading practices [32]. Finally, these personalized meetings with faculty benefit the student's learning, motivation [33], [34] and support a sense of belonging [35].

Peer to Peer Teaching

Peer-to-peer teaching, sometimes referred to as peer-to-peer review, has gained popularity in the research literature as a pedagogical approach due to its importance in improving student understanding of course content [36], [37]. Multiple definitions of the term, peer to peer teaching or review, is available but for the purpose of this study, the definition refers to students teaching and learning from each other without immediate direct intervention from the professor [38]. Research shows students engaged in peer dialogue, written or in person, contributes to increases in core content knowledge, and the development of transferable skills, such as communication,

collaboration, and self-directed learning [39],[40]. Specifically, in STEM education literature, a variety of peer learning modalities improve the academic performance of students in higher education settings [41]. Research further exposes the benefit of peer-to-peer interactions to enhance understanding but most interesting is this interaction does not require any member of the team to know or understand the correct answer for the discussion to enhance understanding [42]. In this current study, the researcher utilized both peer-to-peer teaching, as well as Teaching Assistants serving as mentors to fully develop a new method of assessment in engineering courses. Research shows that having an experienced Teaching Assistant (TA) working with students as a mentor provides increased access to information and knowledge to increase student progress toward mastery. Overall, this study sought to build on prior work by combining the benefits of evidence-based inquiry-driven learning, student generated exam questions, and the further understanding of a new model of assessment in engineering education to improve student understanding and mastery.

Methods

Utilizing practical action research in its design, this study, supported by an approval from the Institute of Review Board (IRB), builds on prior work to increase student achievement in engineering courses. This design was chosen because it allows the researcher to gather information, improve teaching practices through reflection, and impact student learning within engineering courses [43]. Three courses in the Electrical and Computer Engineering Department at the University of California, San Diego were included in this study. Table 1 shows the enrollment and the student's year of study related to each one. First, a pilot study was conducted utilizing a single course selected for implementing the student-designed assessments, ECE 101, an introductory signal processing course, taught in Summer 2020. The summer course was offered four days a week for 90 minutes with a duration of five weeks. In the pilot ECE 101-Summer 2020 course, students were instructed to design a set of questions related to the engineering topics covered each week and provide the solutions to their designed questions. Students submitted a total of four question sets, student-designed assessments, in five weeks. Every question set had 5 to 10 problems along with the solutions to those problems. In this pilot stage, students were given minimal restrictions in selecting and designing their problems. They were allowed to use the practice problems in the lecture notes or the textbook problems after modifying such problems to form new questions. Students were also asked to label their problems, designating them with the appropriate topic-level Learning Outcome posted in the syllabus, and to rate the level of difficulty of each of their problems based on the cognitive levels in Bloom's Taxonomy [1]. Even though the cognitive level of their designed problems didn't affect their grades, they were encouraged to challenge themselves and select more complex problems. Each week, after submitting this assignment, students attended a 10-minute one-on-one meeting with the course instructional team, either the Teaching Assistant (TA) or Professor, to explain their designed problems and their solutions to those problems. The instructional team provided feedback to students in these meetings and corrected mistakes in the submitted solutions. During the five weeks of the course, the students designed four question sets that replaced the midterm exam and were worth 25% of the total course grade. The final exam counted for 35% of the total course grade.

Using the lessons learned from this pilot study of a single engineering course, modified versions of the student-designed assessment were used in the Winter 2021 offering of the same course and Summer 2021 offering a different circuit course. Similar to the pilot study course, ECE 101 - Winter 2021 and ECE 100 - Summer 2021, each lecture in the course was 80 minutes long; however, the lectures in ECE 101 - Winter 2021 and ECE 100 - Summer 2021 were offered twice per week for 10 weeks. Due to the COVID- 19 pandemic, all three courses were offered remotely through Zoom, and all exams were in the format of take-home tests. The same instructor taught the pilot course as well as the courses in this current study.

In the new version, the instructor provided more restrictions to students on selecting and designing their problems. For example, instead of asking students to design a question related to discrete-time unit impulse signals, periodicity of signals, and Fourier series, as used in the Summer 2020 class; the Winter 2021 students were asked specific questions such as "create a periodic discrete-time signal that consists of an infinite sum of two impulse signals and find the Fourier series coefficients of the selected signal." In ECE 101 - Winter 2021, the student-designed assessment was integrated into the course as an optional extra credit activity and not used to replace the midterm as in Summer 2020. An additional difference from the students in Summer 2020 was that Winter 2021 students were asked to participate in a peer review activity after submitting their designed question set and their solutions. Since these student generated questions were used as extra credit in this course, the students could earn a total possible extra credit of 10%, 7% for designing the questions and correctly answering those questions, and 3% for completing the peer review activity. The peer review process utilized an instructor-created rubric; students graded the submissions of three of their classmates and encouraged feedback. The Teaching Assistants also graded everyone's submission and students' final grades were the ones determined by the Teaching Assistants. During the peer review process, students were encouraged to leave a comment about the mistakes they noticed in submissions and to leave encouraging remarks if they saw an interesting question or an interesting solution to a question.

Out of 120 enrolled students, 90 submitted the student-designed assessments, treatment group 1, and 81 participated in the peer-review activity, treatment group 2. Five out of 120 enrolled students didn't submit either the midterm or final exam. The rest, 25 students, were included in the control group. The Winter 2021 course had a midterm and final exam that counted for 30% and 40% respectively of the total course grade.

After receiving positive results on the effectiveness of the student-designed assessments in student learning, the instructor investigated the feasibility of using such assessments in circuits courses. ECE 100, a course about the time and frequency analysis of operational amplifier circuits, was selected for this purpose. In the summer 2021 offering of ECE 100, the student-designed questions were integrated into the midterm exam questions in this course making it a requirement for all students. Out of five midterm exam questions, two questions instructed students to design their own problems that would assess understanding of certain topics covered in the course. They were required to submit their designed questions and the solutions to those questions as part of their midterm exam submission. Students had the option of including a circuit simulation component in their designed question in addition to asking for an analytical solution for their problem. The other three instructor-designed questions required either simulation or analytical solutions, or both. All students were required to complete a peer-review

activity after submitting their midterm exam solutions. For this activity, students graded three midterm exam solution files submitted by their peers. In addition to two student-designed questions that were unique in each submission, the answers to one of the other three midterm exam questions, designed by the instructor, were also different in each submission as students selected the parameters of the filter in that question themselves. Thus, by participating in the peer-review activity, students were exposed to different problem types allowing for additional opportunities to analyze corresponding solutions. Similar to the peer-review activity in ECE 100 - Winter 2021, students were given an instructor-created rubric to grade their classmates' midterm exam question submissions and were encouraged to leave a comment for their peers if they see a mistake in the solutions or encounter an interesting problem or solution. The Teaching Assistants (TAs) graded all the submissions including the student-designed questions and their answers, and the final midterm exam grades were the ones assigned by the TAs. Since ECE 100 is a lab course, 50% of the course grade was based on the lab reports, while the midterm, and final exams counted for 18% and 30% of the total course grade, respectively. The last 2% was for completing the peer-review activity. Overall, 2% of the total course grade was based on the student-designed questions and the correctness of their answers, and 2% was based on participation in the peer-review activity. Table 2 summarizes the student-designed assessment configurations as implemented in each of the three courses under study.

Table 1. Enrollment and demographics of students enrolled in each of the three courses under study.

Course title and term	Total enrollment	1st year	2nd year	3rd year	4th+ year
ECE 101 - Summer 2020	57	0	2	6	49
ECE 101 - Winter 2021	120*	0	2	35	85
ECE 100 - Summer 2021	31	0	0	1	30

* In ECE 101 - Winter 2021, 115 students were included in the study. Five out of 120 enrolled students did not submit the midterm or final or both of these tests so they were not included in this study.

Table 2. A summary of the student-designed assessment configurations in the courses under study.

Course title	Require/ Optional	Peer review	1-1 meeting with IA(s)	Guidance on the selected questions	Frequency	Integration to the course and grade weight
ECE 101 - Summer 2020	Required for all students	No	Yes, all students participated (10 minutes)	minimal	4 sets with 5-10 questions in each set	Replaced the midterm exam, worth 25% of total grade
ECE 101 - Winter 2021	Optional	Yes	No	structured	Once (an individual assignment)	Extra credit (max 10%), 7%: the questions and the correctness of solutions, 3%: completion of peer review
ECE 100 - Summer 2021	Required for all students	Yes	No	structured	Once (as part of the midterm)	Part of the midterm exam, Out of the total course grade, 2%: the questions and correctness of solutions 2%: completion of peer review

The standard Course And Professor Evaluation (CAPE) surveys administered by the university were used in all ECE 101 - Summer 2020 and Winter 2021 courses to gather feedback from students. In addition, in ECE 101 - Summer 2020, and ECE 100 - Summer 2021, separate Google forms were created by the instructor and sent to students at the end of the quarter to receive feedback about the new intervention. In ECE 101 - Winter 2021, custom-designed questions related to the intervention were integrated into the CAPE survey.

Results

In ECE 101 - Summer 2020, students provided feedback about the course and the new student-designed assessment through a standard university administered survey (CAPE), and an instructor designed survey. In the free-response sections of these surveys, students reported that the student-designed assessment helped them identify and focus on the course topics that they were confused about. They also found the one-on-one follow-up meetings with the TA (Teaching Assistant) and the instructor helpful in clarifying the confusion and getting feedback about their understanding of the course content. When students were asked about the areas of improvement on the student-designed assessments, a few mentioned preparing these assessments was time-consuming and some pointed out that the open structure of these assessments made selecting easier questions tempting, resulting in some students not challenging themselves.

In ECE 101 - Winter 2021, to receive feedback from students about the new student-designed assessment and peer review activity, custom questions created by the instructor were added to the standard CAPE survey questionnaire. Likert scale questions such as, “To what extent do you agree or disagree that completing the students-designed assessment helped you improve your learning of the course materials?”, “To what extent do you agree or disagree that designing questions/choosing the parameters of questions and then solving them helps achieve mastery of

the materials?", "To what extent do you agree or disagree that reviewing /grading other students' assignments was helpful to your learning?", and "To what extent do you agree or disagree that an assignment consisting of designing questions and then solving them is challenging?" were added to the CAPE survey. Figures 1 to 5 show the student responses to these questions. Among the students who completed the student-designed assessment and responded to the survey question, 92% agreed or strongly agreed the assessment helped improve their learning of the course materials. 72 students who had completed the peer review activity responded to the survey question about the effectiveness of the peer review activity on improving their learning and 71% agreed or strongly agreed that the activity was helpful to their learning. When asked if they found completing the student-designed assessment a challenging task, 91% of the respondents agreed or strongly agreed that the task was challenging.

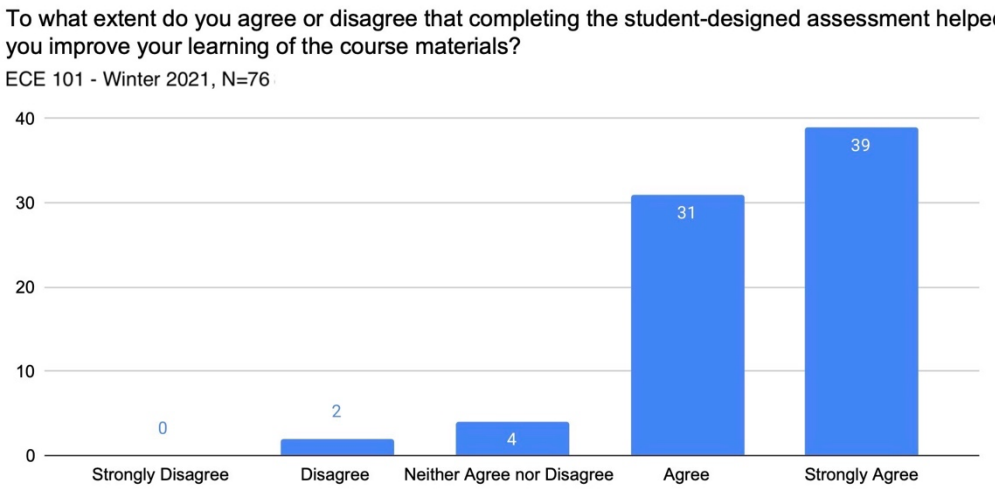

Figure 1. Students' responses to the ECE 101 - Winter 2021 CAPE survey question about the effectiveness of the student-designed assessment on student learning.

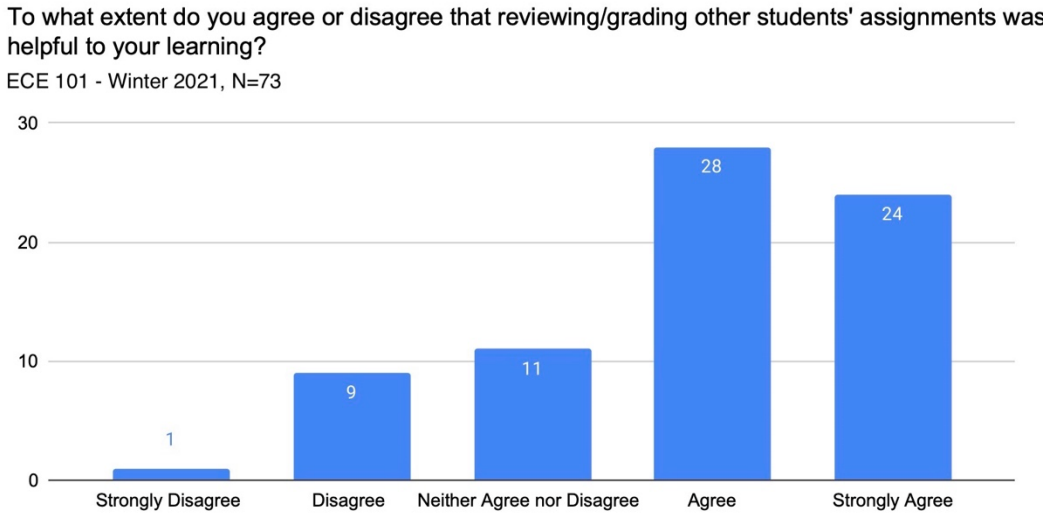

Figure 2. Students' responses to the ECE 101 - Winter 2021 CAPE survey question about the effectiveness of the peer review activity on student learning.

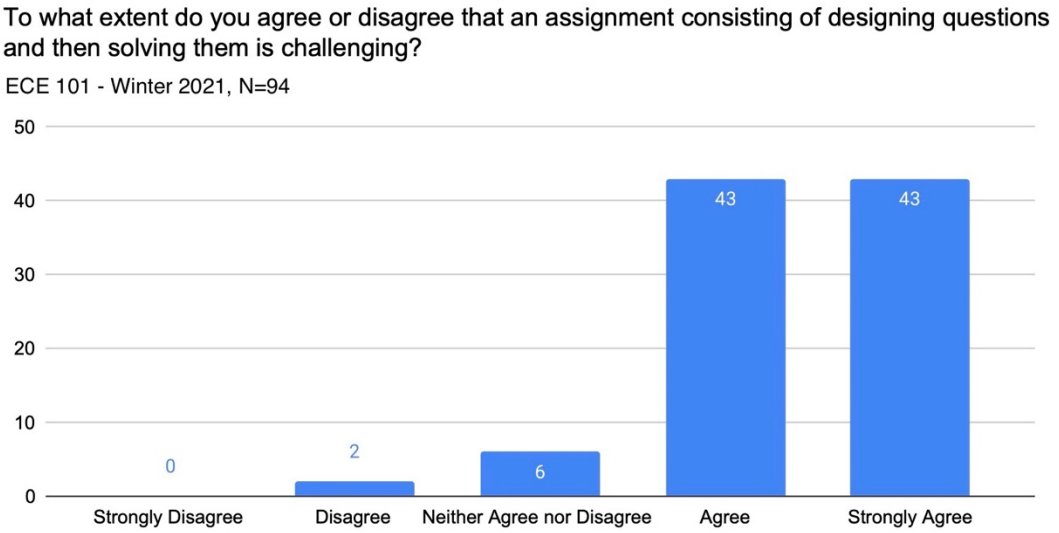

Figure 3. Student responses to the ECE 101 - Winter 2021 CAPE survey question about whether or not they found the new assessment challenging.

In this study, the midterm and final exam grades of students in two treatment groups and one control group are included. The two treatment groups consisted of students who completed the student-designed assessment and the peer review activity and the students who only completed the student-designed assessment. Only students who submitted the student-designed assessment were allowed to participate in the peer-review activity. The control group included the students who did not complete the student-designed assessment. Table 3 lists a summary of the midterm and final exam grade statistics as well as the positive or negative change on the final exam grades compared to the midterm exam in each group.

Table 3. A summary of the midterm and final exam grade statistics for students in ECE 101 - Winter 2021. * Five students had minor participation in the course, so they were removed from the study. They either didn't submit midterm or final exams or none of them.

Group	# of students	Average final exam	STDV final exam	Final exam median	Average midterm	STDV midterm	Total grade change midterm to final
All students in the study	~~120~~ 115*	57.6%	20.5%	55.5%	69.2%	20.8%	-11.6%
Treatment - student-designed assessment activity + peer review	81	57.6%	19.7%	55.5%	66.8%	20.6%	-9.2%
Treatment - student-designed assessment activity	90	57.2%	19.5%	55.5%	66.2%	20.5%	-9%
Control	25	60.2%	21.7%	57.8%	79.5%	19.2%	-20.4%

Out of the total 115 students, 28 students received a better grade percentage on the final exam compared to their midterm exam. Of these 28 students, 26 were from the treatment group and two were from the control group. In other words, 29% of the students in the treatment group were able to improve their learning and get a better grade on the final exam, while 8% of the students in the control group received better results on their final exam compared to the midterm exam. If we only include the students who completed both the student-designed assessments and the peer review activity (81 students), then the percentage of them who did better on the final exam is 32%.

The final exam was a relatively challenging test, and the class average was 57.6% on this exam. The control group had slightly higher average scores on the final exam. Comparing the final exam grades of the control group with the ones in either one of the treatment groups using a Welch t-test showed that with a confidence level of 95%, the differences between the final exam grades of the control and treatment groups were not statistically significant.

The average grade changes from the midterm to the final exam in the treatment groups were -9.2% and -9%. This change was -20.4% for the control group. This result is of particular significance as the median final exam score is close to the average score on this test in all three groups.

In ECE 100 - Summer 2021, an instructor designed survey questionnaire was sent to students at the end of the term to gather students' impressions about the effectiveness of the student-designed assessment and peer review activity on improving their learning. 16 out of 26 students agreed or strongly agreed that designing questions and answering those questions were helpful to their learning. 21 out of 26 students found the peer review activity helpful to their learning of the course materials. In the free response section of the survey, students mentioned grading other students' work required them to review the materials thoroughly. The students also noticed different ways their classmates solved problems and found it helpful for their learning. Out of 26 students, 18 agreed or strongly agreed that designing and solving questions is a challenging task. Figures 4 to 6 show the results of the student responses to three selected survey questions.

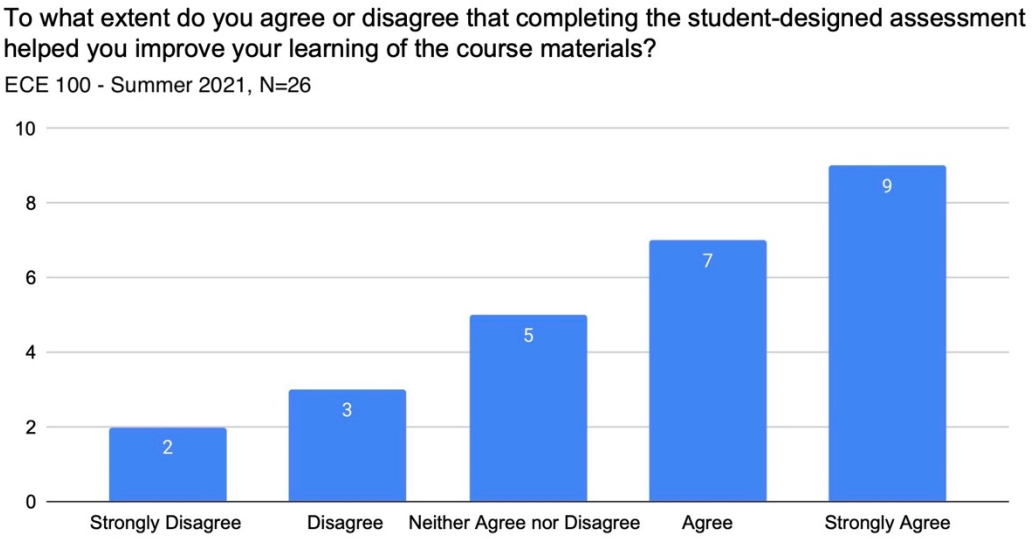

Figure 4. ECE 100 - Summer 2021 survey question about the extent to which students agree that student-designed assessment was helpful to their learning.

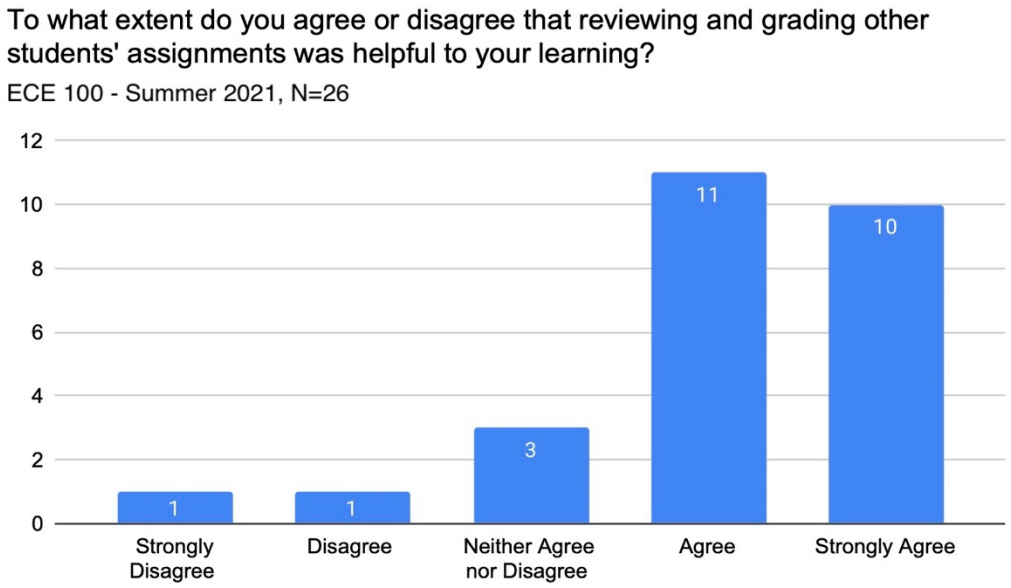

Figure 5. ECE 100 - Summer 2021 survey question about students' impressions on the effectiveness of the peer review activity on their learning.

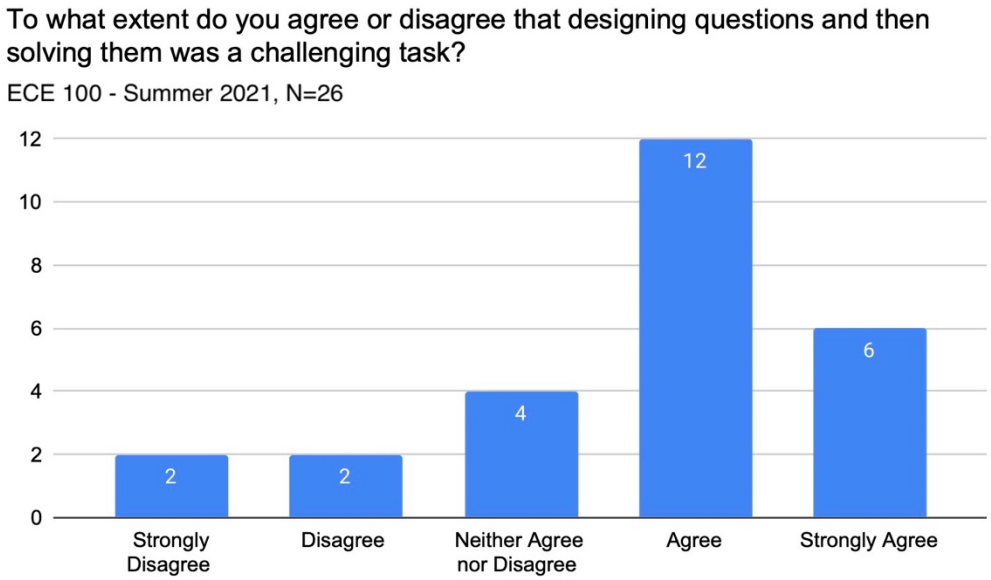

Figure 6. ECE 100 - Summer 2021 survey question about whether or not students found the task of designing questions and answering them a challenging one.

The ECE 101 - Winter 2021 and ECE 100- Summer 2021 student responses on the effectiveness of the student-designed assessments and the peer review activity on their learning and the extent to which they found creating such assessment a challenging task were compared using a Mann-Whitney U test. For this purpose, scores of 1 to 5 were assigned to each one of the five options, "strongly disagree" to "strongly agree", in the Likert questions. The results showed that while there was no statistically significant difference between student responses to the effectiveness of the peer review activity on their learning between two courses, the differences in their responses to the student-designed assessment and the task being a challenging one were statistically significant. With a confidence level of 95%, students in ECE 101- Winter 2021 found the student-designed assessment more useful to their learning and completing this assessment a challenging task compared to the students in ECE 100 - Summer 2021.

Discussion

In the pilot stage of this study, the student-designed assessments were integrated into the summer 2020 offering of ECE 101, an introductory signal processing course. Students were asked to design questions related to the course topics to assess their understanding of those topics. Minimal restrictions were given to students on the selection of their questions, though they were required to link their questions to the topic-level Learning Outcomes of the course. Students submitted a question set every week during the five weeks of the summer term. To keep the time commitment for the summer course within the usual average, one component of the course, the midterm exam, was removed from the course, and replaced by the grades of student-designed assessments. In the feedback survey, students reported that the activity was helpful to their learning as it helped them identify the areas of confusion. They focused more on those areas in preparation for the final exam. They also found the one-on-one meetings with the instructor and

the Teaching Assistant useful as they received timely feedback on their understanding of the course materials during those meetings. As the drawbacks of the activity, students cited the time constraints for preparing such assessments, and the tendency of some students to select easier questions when there are no particular restrictions on the complexity of the designed questions.

To improve students' experience with the student-designed assessments and enhance their effectiveness, in the next offering of ECE 101, the instructor limited the frequency of such assessments to only one submission and added some restricting criteria to the selection of each question to ensure the questions students designed for assessing a particular topic have included certain elements. This provided consistency in the level of the complexity of the problems students selected. Since it was the first time integrating such an assessment with the proposed criteria into a course, the instructor made the assessment optional and for extra credit. The student-designed assessment in this course, ECE 101 - Winter 2021, was assigned to students at the halfway point between the midterm and final exams. The average final exam grade among the students in the control group was slightly higher than the average grade among students in each of the treatment groups. However, the results of a Welch t-test showed the differences in final exam grades between the control and treatment groups were not statistically significant. Overall, the final exam was challenging, and the average class grade was not high. Of the 28 students who received a better grade on the final exam compared to their midterm exam, 93% were from the group who completed the student-designed assessment, and 7% were from the group who didn't participate in the activity. In addition, when the average grade change from the midterm to the final exam was compared within these same two groups, the negative change was much smaller in the group who completed the student-designed assessment. These results suggest the student-designed assessment could have a positive impact on student learning. The students' feedback about the effectiveness of the student-designed assessment showed more than 90% of the students found the activity helpful for their learning and reported it to be a challenging task. In addition, 71% of the students found grading their classmates' submissions helpful to their learning.

After receiving positive results in the selected signal processing course, the idea of using the student-designed assessments in a different course within the electrical and computer engineering curriculum was investigated. An upper-division course about designing operational amplifier circuits and their analysis in the time and frequency domain, ECE 100, was selected for this purpose. Since a vast majority of the ECE 101 - Winter 2021 students found completion of the student-designed assessment helpful to their learning, in ECE 100, the instructor integrated the new assessment into the midterm exam, thus making the participation required for all students. Students submitted their designed questions and their corresponding solutions as part of their midterm exam submission file. Because the assessment was being tested in a new course for the first time, a small percentage of the total course grade was allotted to the student-designed questions. After submitting the midterm exam solutions, all students were required to review and grade the submissions of three other students. End of the quarter instructor generated survey forms were sent to students to gather their feedback on the effectiveness of the new assessment and the follow-up peer review activity. Based on the survey results, 61% of the students found the completion of student-designed assessment helpful to their learning. In addition, 81% rated the peer-review task a useful activity in improving their learning.

The student responses to the Likert scale questions about the effectiveness of the student-designed questions and the peer review activity on their learning in ECE 101 - Winter 2021 and ECE 100 - Summer 2021 were compared to each other using Mann-Whitney U tests. Their responses to how challenging they found the completion of these assessments were also compared using a Mann-Whitney U test. According to the results, there was no statistically significant difference between how students ranked the effectiveness of the peer review activity in these two courses. However, students in ECE 101 - Winter 2021 ranked the effectiveness of these assessments higher than students in ECE 100 - Summer 2021. Moreover, students in ECE 101 - Winter 2021 found the task more challenging than the students in ECE 100 - Summer 2021. One possible reason for this difference could be that in ECE 101 - Winter 2021 the student-designed assessment had a higher weight, 7% extra credit added to the total course grade, compared to the contribution, 2% of the total course grade, of such assessment in ECE 100 - Summer 2021. Students in ECE 101 might have put more effort into the assessment because of its greater grade contribution and thus benefitted more. The other possible explanation could be that in ECE 101 - Winter 2021, the assessment was offered as an individual component in one of the weeks between midterm and final exam and students might have perceived the assessment as an opportunity to improve their learning and get better grades on the final exam. In contrast, in ECE 100 - Summer 2021 the student-designed assessment was integrated into the midterm exam and students might have perceived it as an additional assessment element and not much of a learning opportunity. In addition to the two possible explanations outlined above, the differences in the content and scope of these two courses might have played a role in the observed differences. These hypotheses will be investigated in the future using targeted survey questions.

Overall, the results of our study show that the student-designed assessments and their followed-up peer review activity have a great potential in improving students' learning outcomes and these activities are perceived positively by students.

Further Work

Based on the positive results we received from implementing the new student-designed assessments in the circuits and signal processing courses, we plan to integrate these assessments into other courses within the electrical and computer engineering curriculum. We will extend the study to further review the feasibility and effectiveness of using this assessment strategy in the new courses. Revised survey forms will be sent to students to gather information about why students select a particular level of agreement on the effectiveness of the student-designed assessments on their learning. In the pilot study, ECE 101 - Summer 2020, students provided positive feedback on the one-on-one follow-up meetings that they had with the Teaching Assistant and the Professor after submitting their student-designed assessment. In future research, follow-up meetings in lieu of the peer review activity or along with the peer review activity will be compared to determine if a better learning gain is achieved for students. In addition, a separate study will be conducted to compare the effect of the students-designed assessments with the effect of one-on-one meetings with the instructional team members on students' learning gains.

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