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Redesigning Soil Mechanics as an Inclusive Course

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Abstract

In its quest to become an inclusive department that uses a strengths-based approach toward neurodiversity to personalize the learning experience for all students, the Civil and Environmental Engineering (CEE) department at the University of Connecticut has implemented changes to several core courses within the project "Beyond Accommodation: Leveraging Neurodiversity for Engineering Innovation" (abbreviated as INCLUDE), funded through the Revolutionizing Engineering Departments program of the National Science Foundation. One of the objectives of the program is to develop redesigned courses, known as "I-Courses" in the department, that aim to incorporate inclusive teaching practices for an improved educational experience for all students, taking into account the experiences, strengths, and needs of neurodivergent learners.

As a part of the program, the Soil Mechanics course was redesigned as an I-Course in the summer of 2021. Soil Mechanics is a required course in the civil engineering curriculum, that is primarily taken by students in their junior or senior year. It is offered every year in the fall semester and typically has a large enrollment (80 ~ 110 students). The redesigned course was offered in the Fall 2021 semester with an enrollment of 82.

This paper delineates the four different stages of the redesign process: preparation, redesign, implementation, and findings. In the preparation stage, the instructor attended a series of workshops/meetings to get familiarized with the different strengths and challenges of neurodivergent students in undergraduate engineering programs. The course redesign process centered around the use of an I-Course Standards Framework - a set of course design guidelines rooted in the Universal Design for Learning (UDL) framework and the strengths-based approach. Instructors tailor design elements to the course to meet each I-standard and undergo a peer review process. Under the 'implementation' section, the paper outlines the changes that were made to implement a strengths-based approach to neurodiversity within the course context and increase the accessibility of the course content for a wide range of learners. The 'findings' section discusses the effectiveness of the redesigned course based on the student feedback on the mid-semester survey and the annual Student Evaluation of Teaching (SET) survey as well as the lessons learned along the way.

1. Introduction and background

The present study is a part of a project funded by a National Science Foundation (NSF) IUSE/PFE RED grant through the Division of Engineering and Education Centers. One goal of the project is to radically transform the way courses are taught in the Civil and Environmental Engineering Department at the University of Connecticut. The program aims to create a more inclusive learning environment that not only enhances the learning outcomes for all students, but also provides flexibility and choices to allow all types of learners to personalize their educational experience. These changes are reflected in redesigned courses, designated in the department as I-Courses. It is anticipated that incorporating flexibility within engineering courses while also adopting a strengths-based approach to neurodiversity may increase the participation of neurodivergent students in engineering and contribute to a more diverse engineering workforce.

This paper documents the redesign of the Soil Mechanics course as an I-Course, a description of the context within which the redesign occurred, the team structure, and the standards guiding the redesign process. The paper will also present details related to the various stages of the process, from preparation to implementation, along with the student experiences and perceptions of the changes implemented within the redesigned course. It is anticipated that these findings will increase the understanding of how students perceive the changes implemented within this course and contribute to current understandings of the best practices for building a more inclusive learning environment.

1.1 Neurodiversity

While the term neurodiversity originated as a part of the autism activism that emerged in the 1990s [1], within the context of this paper neurodiversity is more broadly defined as the neurological variations present in human populations that may be related to sociability, learning, attention, mood, or other mental functions. A few examples of the variations that fall under the neurodiversity umbrella are attention deficit hyperactivity disorder (ADHD), autism (ASD), generalized anxiety disorder (GAD), depression, and dyslexia. A growing body of literature suggests that neurodivergent individuals often possess unique strengths that may be assets in engineering. For example, ADHD has been associated with divergent thinking and risk-taking [2]-[4]; dyslexia has been associated with strong 3-dimensional visualization skills [5]-[7]; and autism has been associated with a tendency toward systems thinking and pattern identification [8]-[11]. Yet, despite the high potential for neurodivergent individuals to contribute to unique approaches and innovative solutions in engineering fields, they remain highly underrepresented in undergraduate (UG) engineering programs [12]-[14]. Those who do enroll in UG engineering programs are significantly less likely to complete their programs. For example, students with ADHD have lower GPAs overall and are more than twice as likely to leave their programs than their peers without ADHD [15].

1.2 Strengths-based approach

The work of the project is anchored by a strengths-based approach toward teaching and learning in general, and neurodiversity in particular. The literature related to strengths-based education suggests that incorporation of student strengths into the learning environment may enhance student engagement and motivation [16], [17]. For neurodivergent students, such as those with ADHD, who may struggle to maintain interest and motivation within the traditional classroom, a strengths-based approach may be particularly impactful. Schreiner [18] writes that “strengths-oriented teaching recognizes the talents students bring to the learning environment and uses those talents as the foundation for further learning – and for addressing academic challenges” (p. 88).

One way in which the strengths-based approach is communicated to students is through a brief presentation at the start of the course that provides positive messaging related to neurodiversity and how different ways of thinking, learning, and expression may be an asset within engineering fields. Instructors of redesigned courses also provide an inclusion statement as part of their syllabus that reinforces the idea that the course is aiming to provide an inclusive learning environment that cultivates the strengths of all types of learners. This messaging is a key component in providing an atmosphere that acknowledges the strengths of neurodivergent students. Every instructor drafts their own unique inclusion statement. An example of an inclusion statement is provided below:

> I hope to create an inclusive learning environment in which all students can thrive. Emphasis is given to providing a strength-based approach to education that encourages students to identify, develop, and leverage their unique abilities to address complex engineering problems. This course was designed to address the diverse ways of thinking and learning that neurodiverse students possess. Several pedagogical innovations will be implemented in this course including, but not limited to peer-learning, alternative examination modalities, project-based learning, etc.

While one of the goals of the redesigned course is to help students personalize their learning, within the context of large engineering courses, it is often not feasible for the instructor to tailor activities and assessments within the course based on their knowledge of individual student strengths. Rather than attempting to profile student strengths and matching students with certain activities and assessments, instructors in such large courses encourage students to develop self-awareness by reflecting on their own strengths, challenges, and performance, and then to use that awareness to navigate their educational landscape. Thus, building flexibility and choice into the course learning activities and assessments is also a key part of the strengths-based approach.

Within I-Courses, students are encouraged to make choices about their learning based on their own understanding of their areas of strengths and challenges. As in the Universal Design for Learning (UDL) framework, students are provided with multiple means of “engagement, representation, and action and expression” [19] to support their access to and engagement with course material. The incorporation of flexibility and choices within each course may allow students to personalize their learning activities and assessments based on their own differences in social behavior, thinking, attention, or mood. Students may be given multiple formats from which to learn course material. Instructors may provide an e-textbook, recorded and captioned lectures, and supplementary YouTube videos that allow students to access information in alternate ways. Likewise, instructors may offer multiple ways for students to demonstrate their learning. For example, a student with intense anxiety and high creativity might opt to complete a project that allows them to use their creative strengths while minimizing the stress and anxiety caused by a timed exam or an oral presentation. A student with strong 3D visualization skills, who struggles to express themselves in writing, might opt for a design-based project rather than a written report.

1.3 Development of I-Standards

The redesign of this Soil Mechanics course was guided by a set of inclusive teaching standards created by the first cohort of department faculty participating in project activities related to teaching and learning [20]. These standards, known as I-Standards within the project team, are a part of a living document that has undergone multiple iterations to reflect the team's understanding of current best practices for inclusive teaching. The standards were developed within the context of a summer institute during year one of the project in which the faculty team worked together to launch the portion of the project related to teaching and learning.

The version of the I-Standards used in this course redesign focused on four main areas: 1) incorporation of a strengths-based approach into teaching and learning, 2) building a culture of inclusion, 3) incorporation of inclusive teaching practices, and 4) improving communication with and supports for students.

Specifically, the standards related to a strengths-based approach encouraged instructors to enhance student motivation and engagement [16], [17] by providing a variety of modes for activities and assessments and provide students with the opportunity to make choices and apply their strengths within the context of these learning activities and assessments. The standards related to building a culture of inclusion encouraged instructors to a) include a personalized inclusion statement in the course syllabus that goes beyond the required accessibility statement related to access and accommodations, b) to participate in development activities related to neurodiversity, and c) to adopt inclusive teaching practices that are appropriate for their course. The teaching and learning standards were based primarily on UDL [19] and other best practices for teaching and learning that are found in the literature. Some of these standards were related to instructional design (such as alignment of course components), accessibility of course materials, personalization via choice and flexibility, and incorporation of active learning and real-world applications in regular class activities. Finally, the standards related to communication and supports encouraged instructors to build in mechanisms to receive and provide feedback in multiple modes, build in supports for underperforming students, and building connections with students within and outside of the classroom.

2. Preparation stage

In January of each year, the I-Team welcomes a new cohort of between three and five faculty members who are new to the redesign process. Soil Mechanics was redesigned as a part of the second cohort of faculty. Faculty volunteer to participate in the I-Team. For their additional efforts, they are offered a reduced teaching load during the spring semester and receive a stipend for their summer work.

During the preparation stage, I-Team members attended a two-day kickoff meeting that included a panel of neurodivergent students who shared their own educational experiences with the team and a panel discussion with the first cohort of faculty, who highlighted some of their experiences with the redesign process. In subsequent meetings, the new cohort engaged in reflections about their courses, brainstormed about ways they would incorporate the standards into their courses, and attended a variety of sessions presented by faculty and staff in the university center for teaching and learning, the center for students with disabilities, and the school of education. Some of the topics of these sessions include neurodivergent student experiences, UDL guidelines, creating accessible content, and the strengths-based approach. Faculty were also invited to attend community-building events, such as a virtual discussion series with invited speakers who spoke about the unique strengths and challenges of neurodivergent individuals. The discussion series included topics related to student experiences with ADHD, dyslexia, and autism.

3. Redesign stage

During the summer of 2021, the I-Team continued to meet as they entered the active redesign stage. Summer meetings included a morning presentation from a guest presenter, time to work independently on a task related to the presented topic, and then a second meeting in the afternoon to share about progress made and reflect on the topic. These sessions were aimed at giving faculty time to apply the presented information with a peer group able to provide feedback and brainstorm solutions to challenging tasks. The summer meetings included development sessions intended to deepen faculty understanding about key topics such as UDL, accessibility, instructional design, design and alignment of assessments, taking a strengths-based approach within the context of engineering courses, a broad range of inclusive teaching practices, and incorporation of active learning into the course activities.

Instructors were encouraged to engage with these topics in a way that worked for them and their own strengths as a teacher. So, just as students are encouraged to use their strengths in their coursework, instructors are encouraged to leverage their own strengths and areas of interest as they complete the redesign process. For this reason, no two I-Courses are exactly alike in their offerings, but rather, share certain key elements, such as flexibility of assessments, strengths-based messaging about neurodiversity, built in supports for students, and increased communication between instructors and students.

4. Implementation stage

The redesigned Soil Mechanics course was offered in the Fall 2021 semester. Within the I-Standards framework based on the strengths-based approach, the instructor provided the students with a variety of modes for activities and assessments and the opportunity to make choices and apply their strengths within the context of these learning activities and assessments. While several changes were made to the course as a part of the redesign process, this section will focus on the implementation of four major aspects of the course such as the course design, the choices given to the students in terms of assignments/assessments, incorporation of different active learning techniques, and an opportunity to connect outside the classroom via the online discussion board.

4.1 Course design

In the redesigned course, students were provided with the course learning objectives at the start of the semester. Thereafter, at the start of each module, the module level objectives were provided. The homework assignments and the Term Project were designed to allow students to develop the required skills to meet those objectives. The assessments (module quizzes and exams) were then administered to assess those skills. The students were offered choices to choose the assessment based on their perceived strengths. The choices are described in section 4.2 below.

4.2 Assessment choices

The students had an opportunity to make the following choices:

a. They had the option to choose the mode of the final deliverable of the Term Project assignment – either a written report or an oral video presentation. The flexibility built into the Term Project assignment allowed students to make a choice about which mode would allow them to best express their learning (either written or oral/video mode). This choice is important for neurodiverse learners who may have relative strengths in written or oral expression, strong visual or creative abilities, or anxiety related to one or the other mode. By allowing students to navigate this choice, they are able to better personalize their learning experience in a way that addresses their unique strengths and challenges.

b. The final exam was made optional. If the students were satisfied with their performance on the mid-term exams, then they had the option to forgo the final exam. However, if they opted to take the final exam, then the higher of the 'lowest mid-term exam grade' and the 'final exam grade' would be counted toward their final course grade. The instructor wanted to assess all the course objectives through exams in addition to homework assignments and quizzes. Since the final exam was made optional, a third mid-term exam was introduced to assess the objectives of the last two modules (module 7 and module 8). 55 students out of total 82 (67%) chose to forgo the final exam.

4.3 Active learning activities

Freeman et al. [21] showed that students in science, engineering, and mathematics with traditional mode of lecturing were 1.5 times more likely to fail than students in classes where the mode of teaching was based on active learning. In order to better engage the students, the redesigned course included regularly planned opportunities for in-class active learning. Clicker questions and problem-solving activities were primarily used to engage the students, along with think-pair-share activities and open-ended discussion questions in which students made joint contributions using a Google doc/word cloud. The said active learning activities are described below.

4.3.1 Clicker questions

In each class session, after a topic had been discussed, the students were asked to use their clicker remotes or the clicker app to answer anonymously one or more conceptual questions presented on the lecture slides. The questions were designed to test the students' understanding of the materials covered. If more than 20% of the students got the answers wrong, then the instructor explained the topic again briefly and discuss the correct answers. The clicker course site was integrated into the Learning Management System (LMS) course site for grading purposes. The answers to the clicker questions were graded automatically based on participation rather than correctness. In some cases, after the students finished answering the questions individually, the instructor asked them to discuss their answers with their neighbors instead of revealing the correct answer. After the peer discussion, the same question was asked again to evaluate whether the students answered differently after discussing with their peers. This method promoted learner-to-learner interaction in the classroom.

4.3.2 Problem-solving

After the basic concepts behind a particular topic were covered, one or two basic problems related to those concepts were introduced to the class. Once the students acquired the basic problem-solving skills on a particular topic, they were given more challenging problems to solve within a certain time. After that time, the instructor went over the solutions so that the students followed the thought process to solve the problem and have a chance to compare their solutions. In all problem-solving sessions, students were encouraged to discuss their solutions with their peers to promote learner-to-learner interaction.

4.3.3 Think-pair-share

During a think-pair-share activity, students were first asked to think of the probable answer to a given question individually in one minute. Then, they paired up with their immediate neighbor and discussed their answers for another minute. After the peer discussion, a member from two or three groups each shared their answer with the class. Others were encouraged to ask follow-up questions or provide counterarguments.

4.3.4 Open-ended discussion questions

Since many students used clicker remotes, which cannot be used for open-ended questions, a Google doc was created and shared with the class at the beginning of the semester. From time to time, students were asked to write their answers to open-ended questions in the Google doc, which allowed simultaneous editing by more than one person. Once the time was over, the instructor generated a word cloud using a web service and showed it to the class.

4.4 Online discussion board

An online discussion board built in the LMS was used to provide the students with a forum to interact with each other, as well as with the instructor and the TAs on the course content outside the classroom. For each module, the students initiated the discussion by responding to a prompt given by the instructor. The prompt also encouraged them to comment on their peers' posts to carry the discussion forward.

5. Findings

This section discusses the students' feedback on different aspects of the course.

5.1 Feedback on the strengths-based approach

Since the present study is anchored to a strengths-based approach, it was important to get feedback from the students on the effectiveness of the interventions in implementing the approach. Out of the different assessment methods used, one representative assignment (Term Project) and one representative assessment (Mid-Term I exam) were selected for this purpose. Twice in the semester (once after the Mid-Term I exam and again toward the end of the Term Project), students were asked to rate their agreement or disagreement to the following statement: "This assignment/assessment allowed me to use my strengths/talents." The findings are presented in Figure 5.1. That figure shows that all of the respondents agreed that both the Mid-

Term I exam and the Term Project allowed them to use their strengths/talents. However, it should be noted here that only 9% (N = 7) of the students responded to the Term Project survey as opposed to the 70% response rate (N = 57) for the Mid-Term I survey. Hence, the Term Project data with such a low response rate should be interpreted with caution as they may not be representative of students in the class (who completed that assignment).

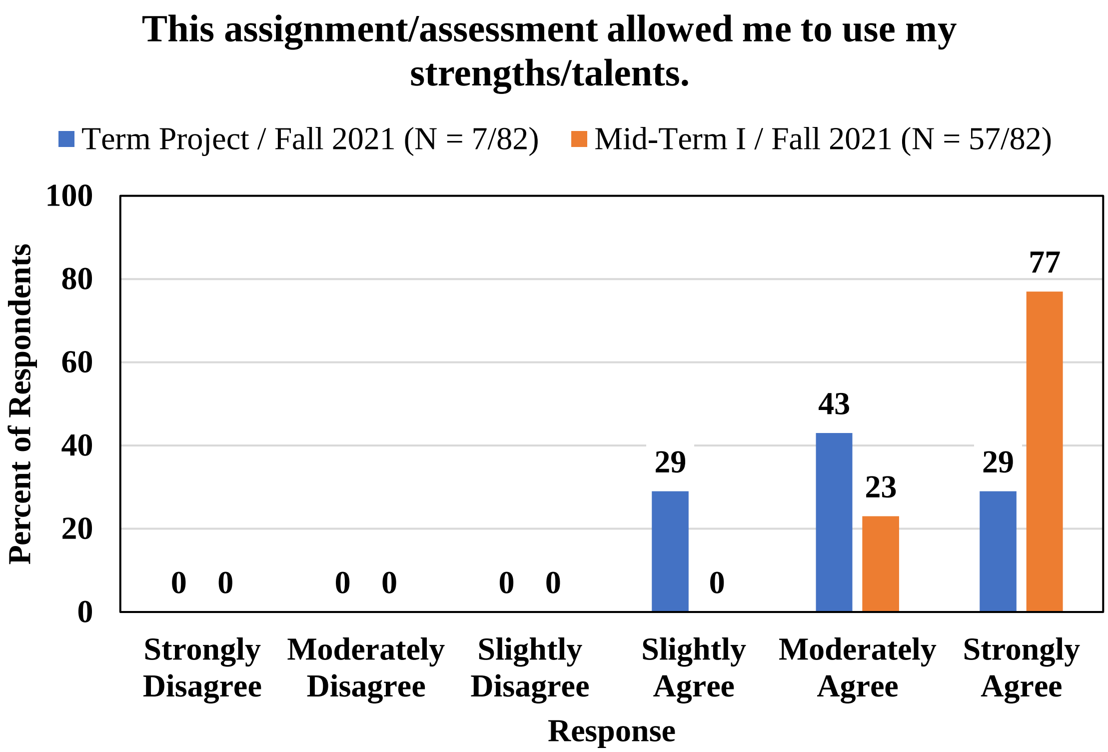

Figure 5.1 Student feedback on the strengths-based approach

In the aforesaid surveys, students were also asked to give their feedback on whether they learned course ideas or developed skills while doing the Term Project and whether they could demonstrate their knowledge and/or skills in the Mid-Term I exam. The findings are shown in Figure 5.2 and Figure 5.3, respectively. While all the respondents agreed that the Mid-Term I exam helped them demonstrate their knowledge and/or skills, 14% of the respondents (one student out of seven) disagreed that the Term Project helped them learn course ideas and/or develop skills. The same caution (low response rate) for the Term Project data (as mentioned before) applies here, as well. Overall, it is evident from Figures 5.1, 5.2, and 5.3 that the strengths-based approach was perceived by the students to be effective in this course.

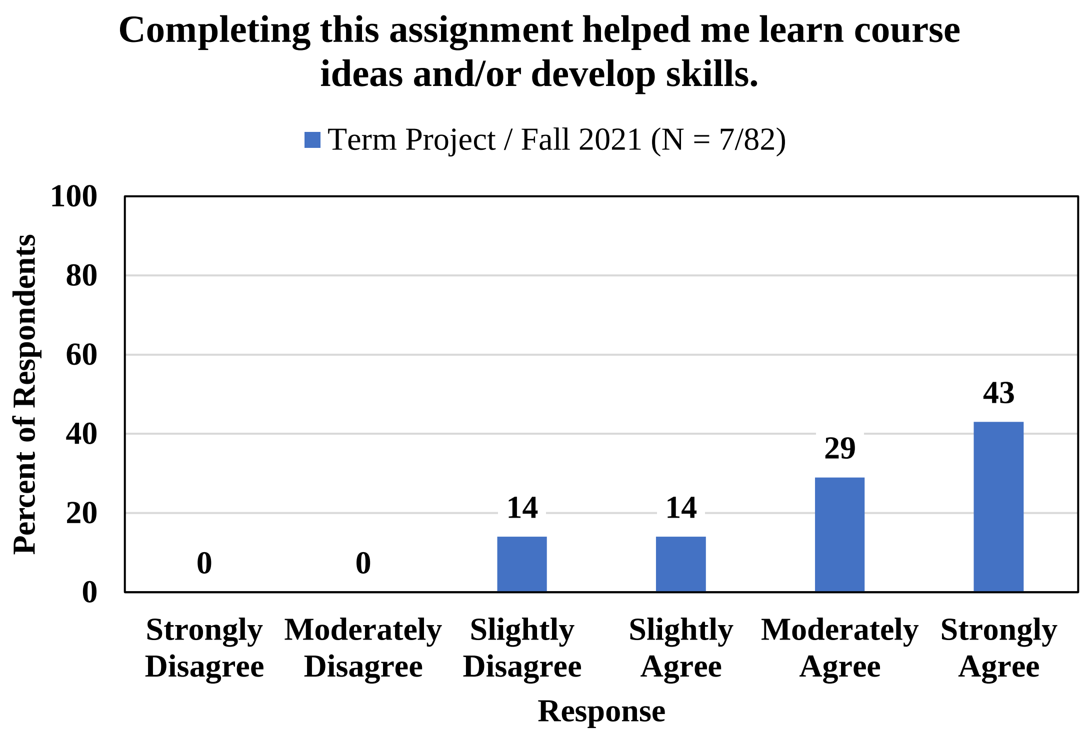

Figure 5.2 Student feedback on developing skills (Term Project)

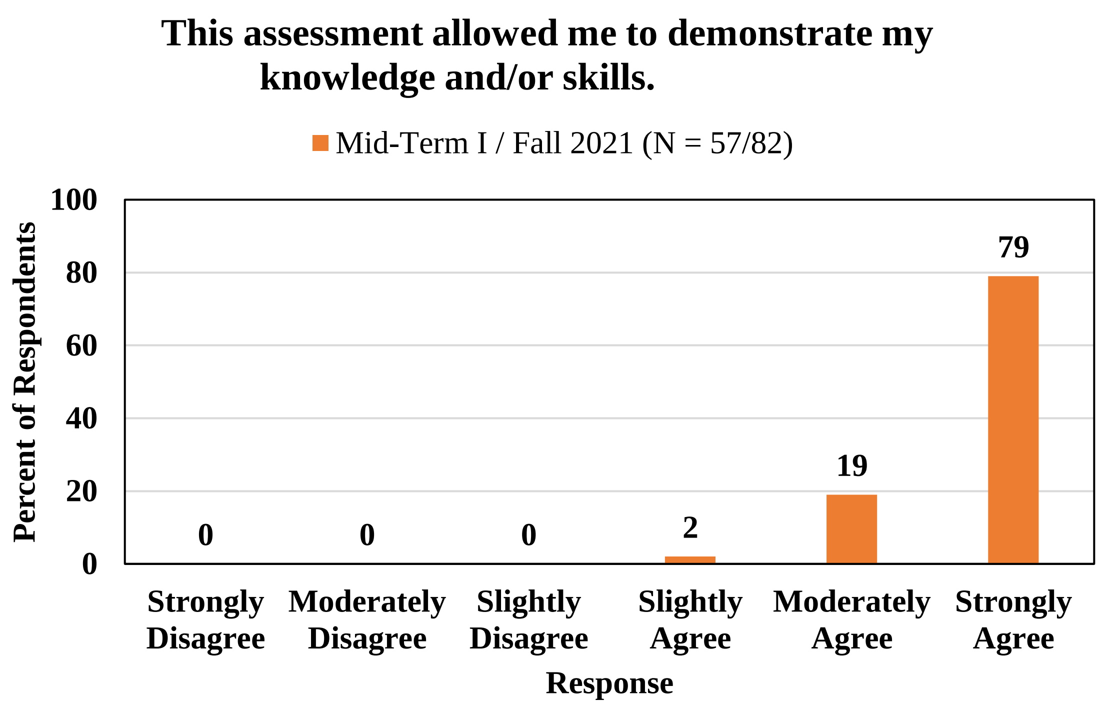

Figure 5.3 Student feedback on demonstrating skills (Mid-Term I)

5.2 Feedback on choices given

Out of the many different choices given to the students, perhaps the most important one from the students' perspective was the final exam being optional. Hence, in the formative mid-semester survey, the students were asked to rate their agreement or disagreement to the following statement: "It is helpful that the final exam has been made optional instead of mandatory." 54% of the students (N = 44) responded to that survey. Figure 5.4 presents their response. As per that figure, 89% of the respondents strongly agreed that the choice to take the final exam was helpful.

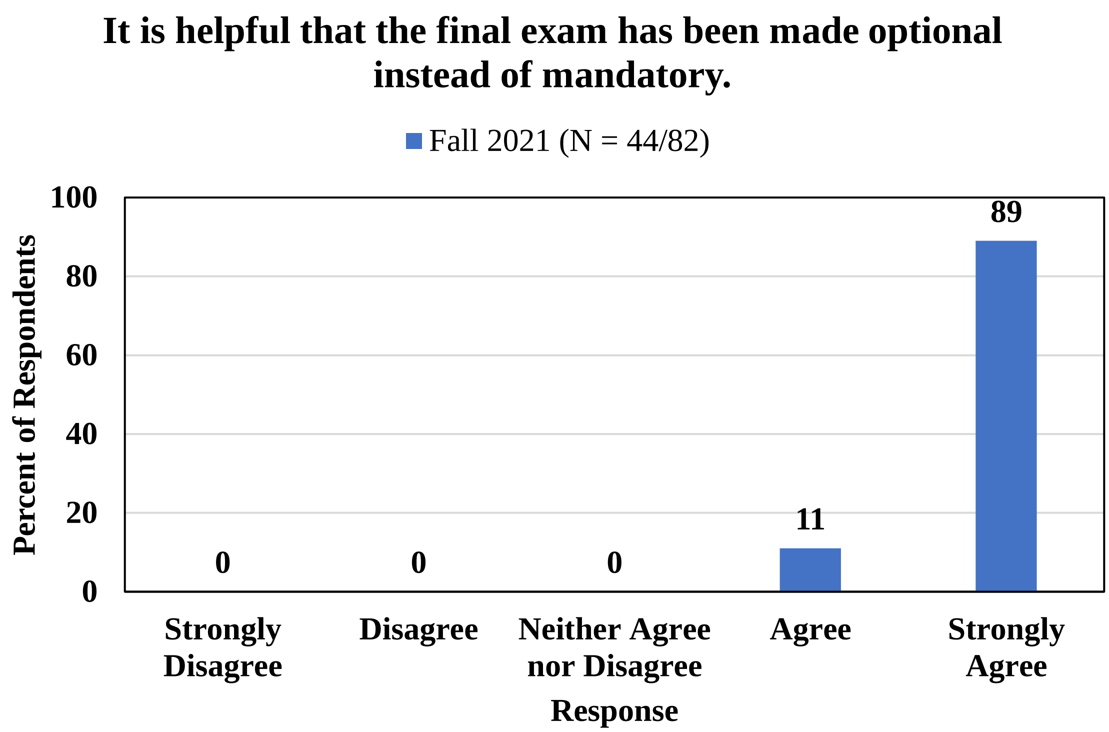

Figure 5.4 Student feedback on the choice of exam

5.3 Feedback on active learning/engagement

Figure 5.5 and Figure 5.6 show the student feedback on the effectiveness of two different active learning techniques employed in the course, viz., in-class problem-solving activities (Figure 5.5) and in-class clicker questions (Figure 5.6). 54% of the students (N = 44) responded to that survey. 100% of the respondents agreed that the in-class problem-solving activities were beneficial to their learning (Figure 5.5), and 89% of the respondents agreed that the in-class clicker questions helped reinforce the concepts (Figure 5.6). Figure 5.6 further shows that 2% of the respondents strongly disagreed with the statement and 9% of the respondents neither agreed nor disagreed. From these two figures, it is evident that the active learning techniques employed in the course were overall conducive to student learning.

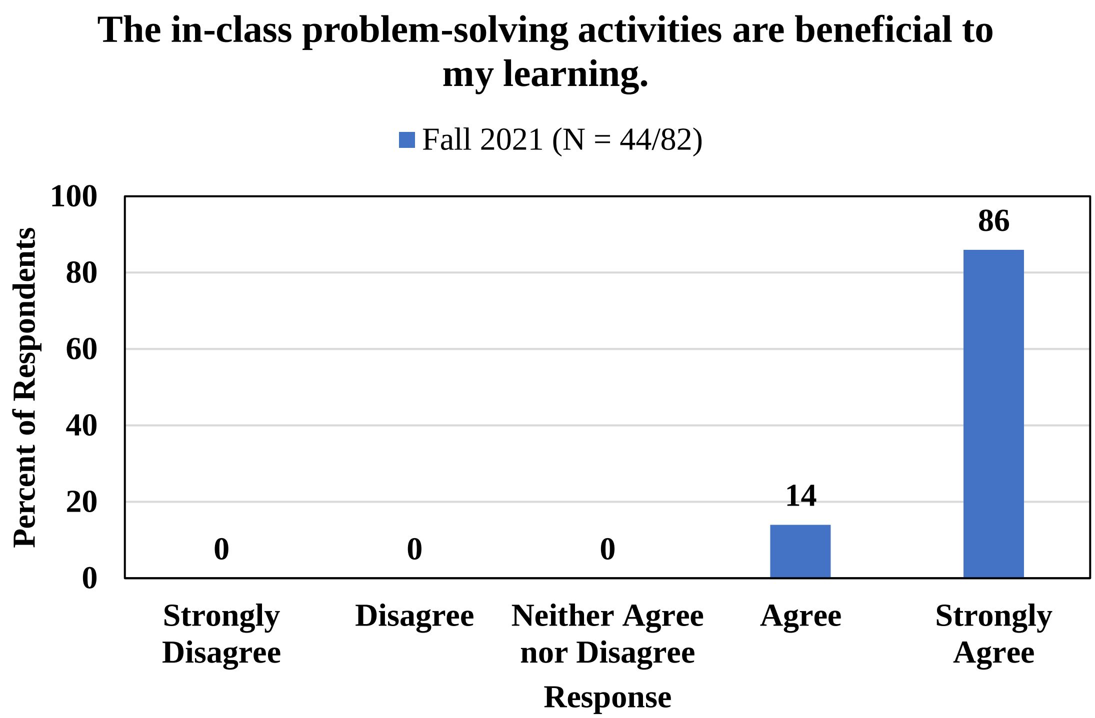

Figure 5.5 Student feedback on in-class problem-solving activities

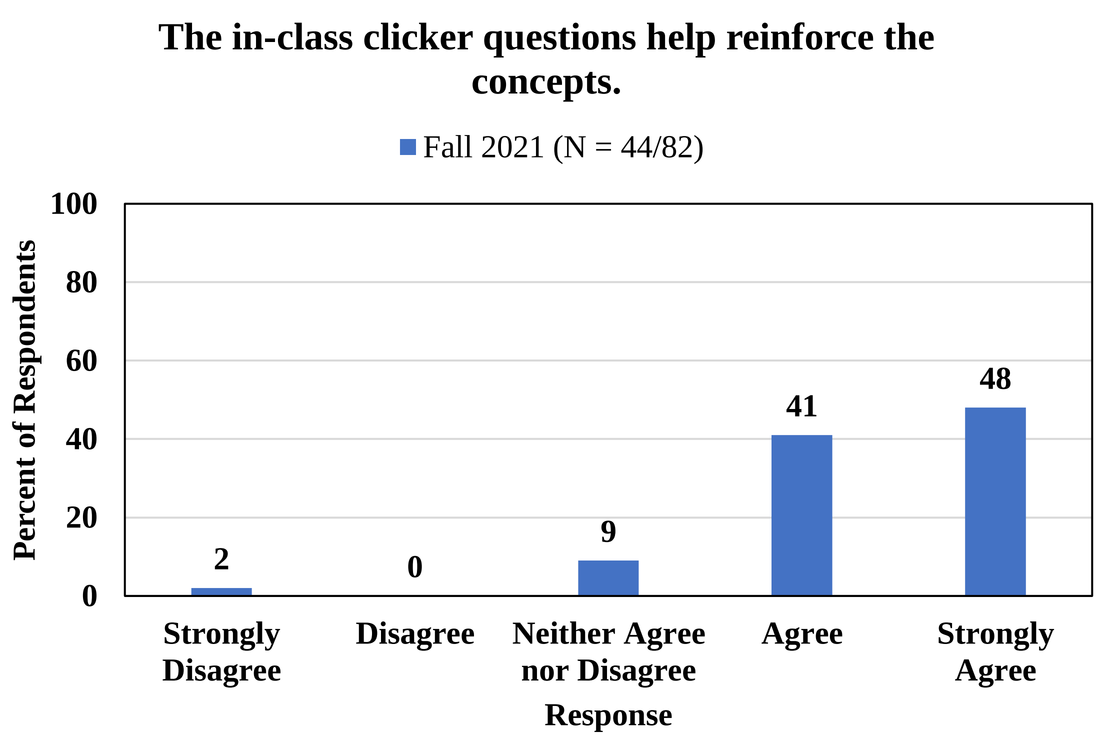

Figure 5.6 Student feedback on in-class clicker questions

5.4 Feedback on the course

In the summative SET survey conducted during the last two weeks of classes, students provided their feedback on different aspects of the course. Figures 5.7 through 5.12 show the student feedback on the respective questions. Since the same course was taught by the same instructor in the Fall 2020 semester, the results from that semester are also included for the purpose of comparison. The title of each figure shows the question asked in that particular case. It is evident from those figures that the students gave overwhelmingly positive feedback about the course in both the semesters, although the percentage of students agreed strongly to the questions was higher in the Fall 2021 semester when the course was delivered as an inclusive course.

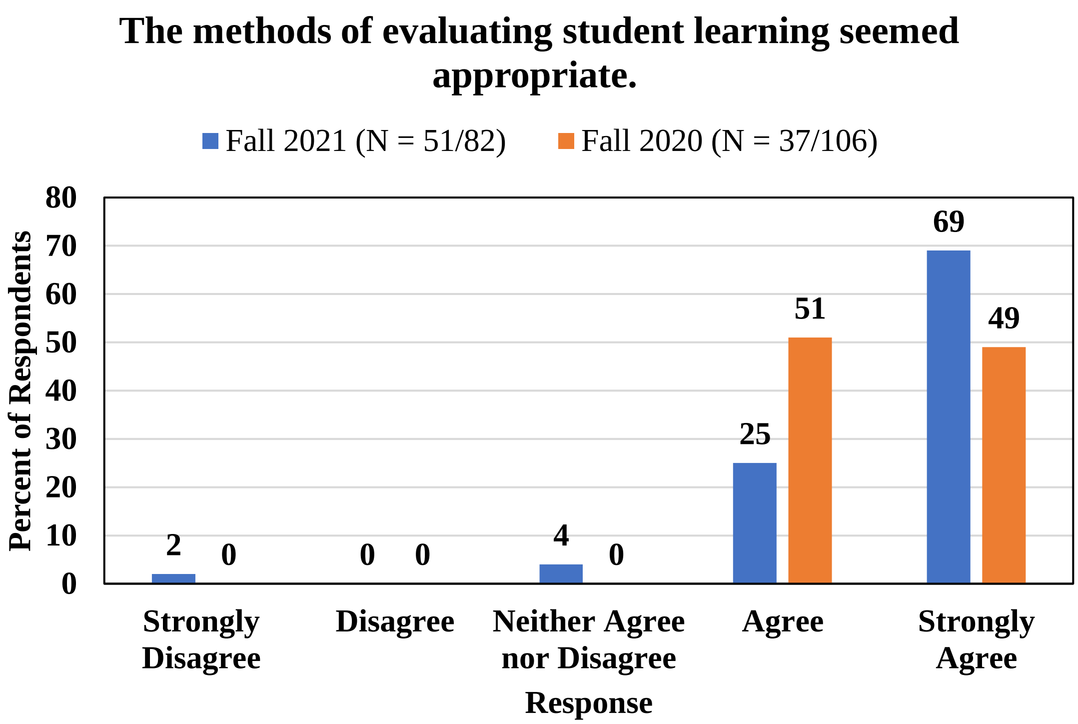

Figure 5.7 Feedback on the evaluation methods of student learning

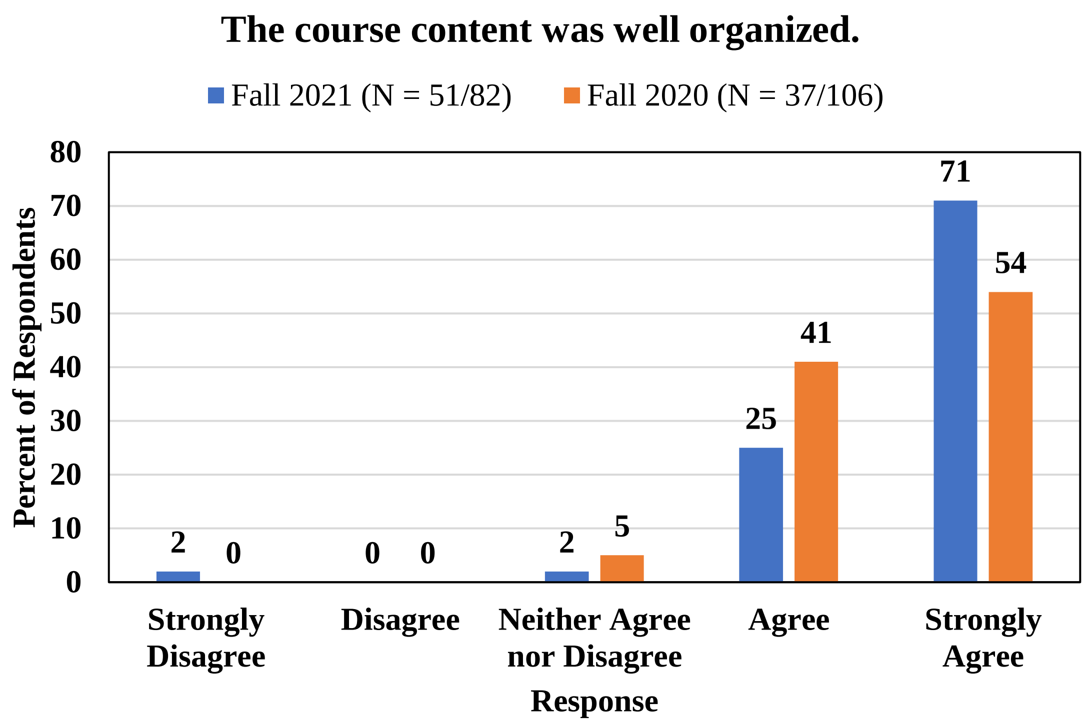

Figure 5.8 Feedback on the organization of the course content

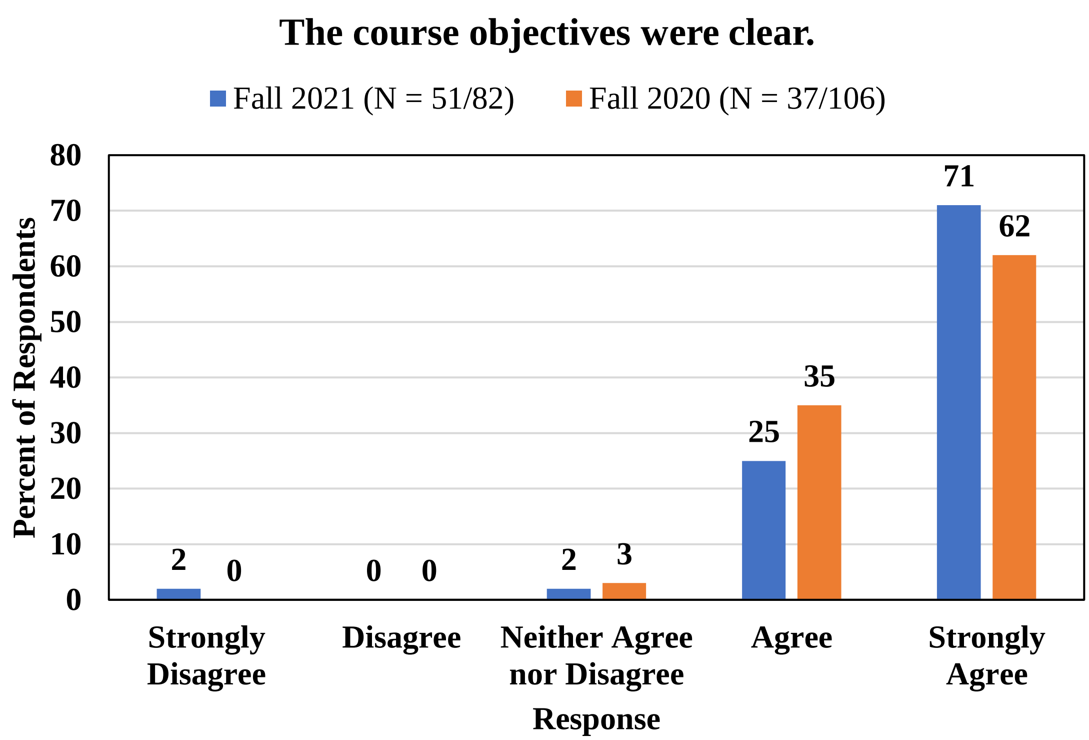

Figure 5.9 Feedback on the clarity of course objectives

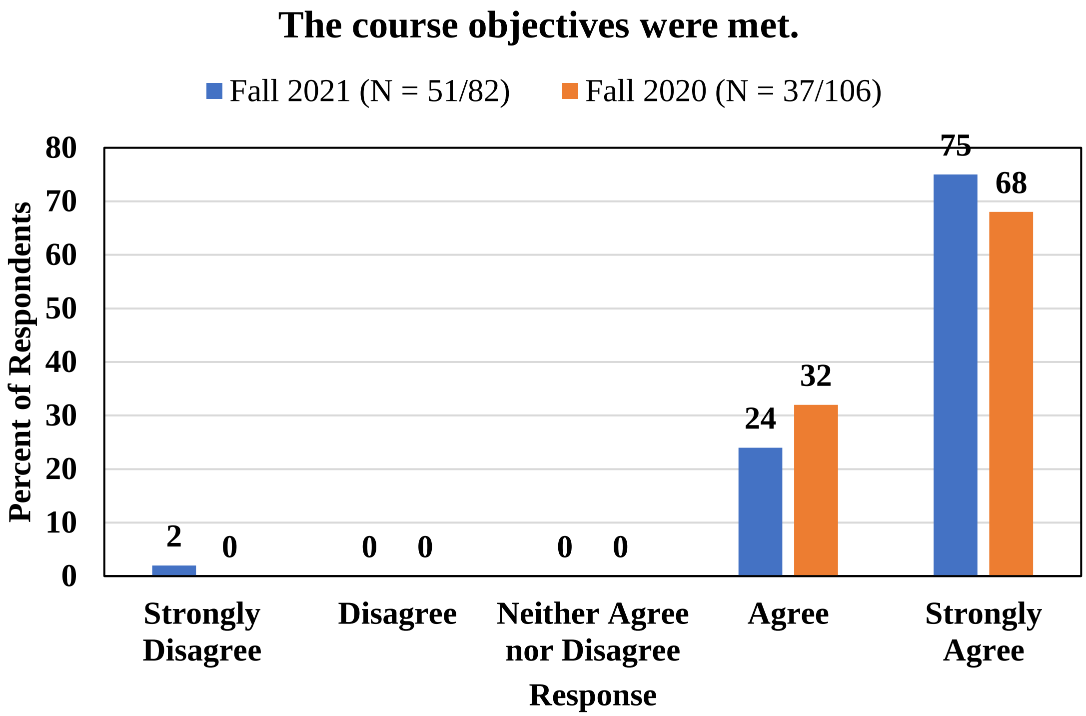

Figure 5.10 Feedback on the accomplishment of course objectives

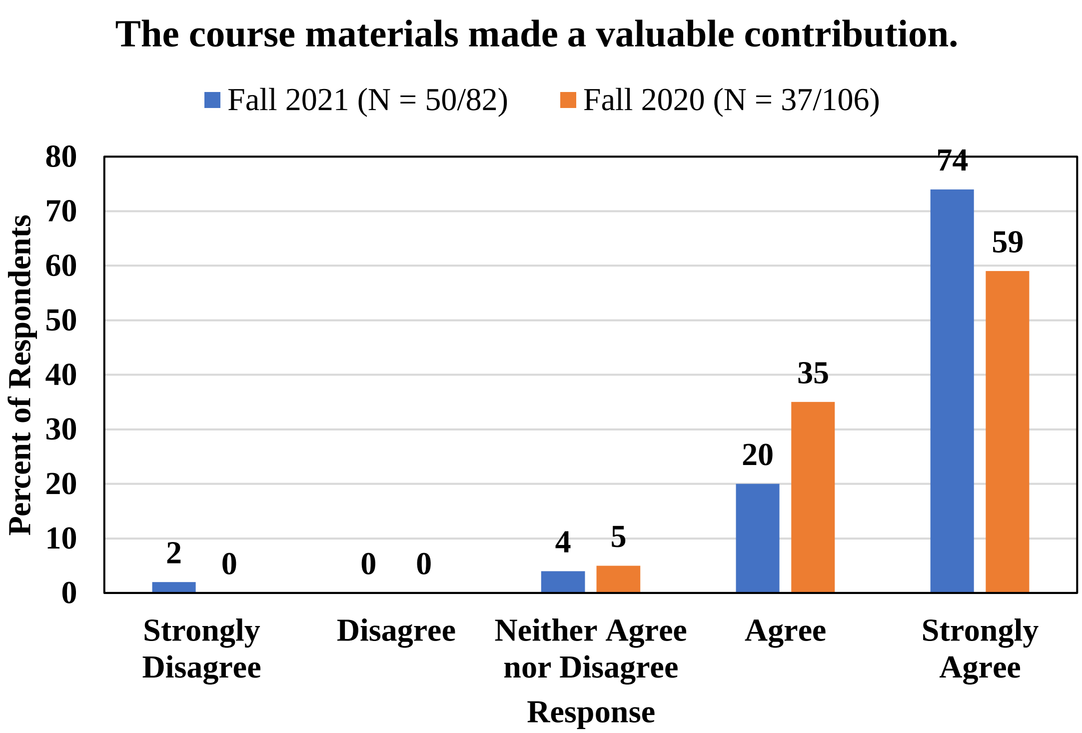

Figure 5.11 Feedback on the contribution of course materials

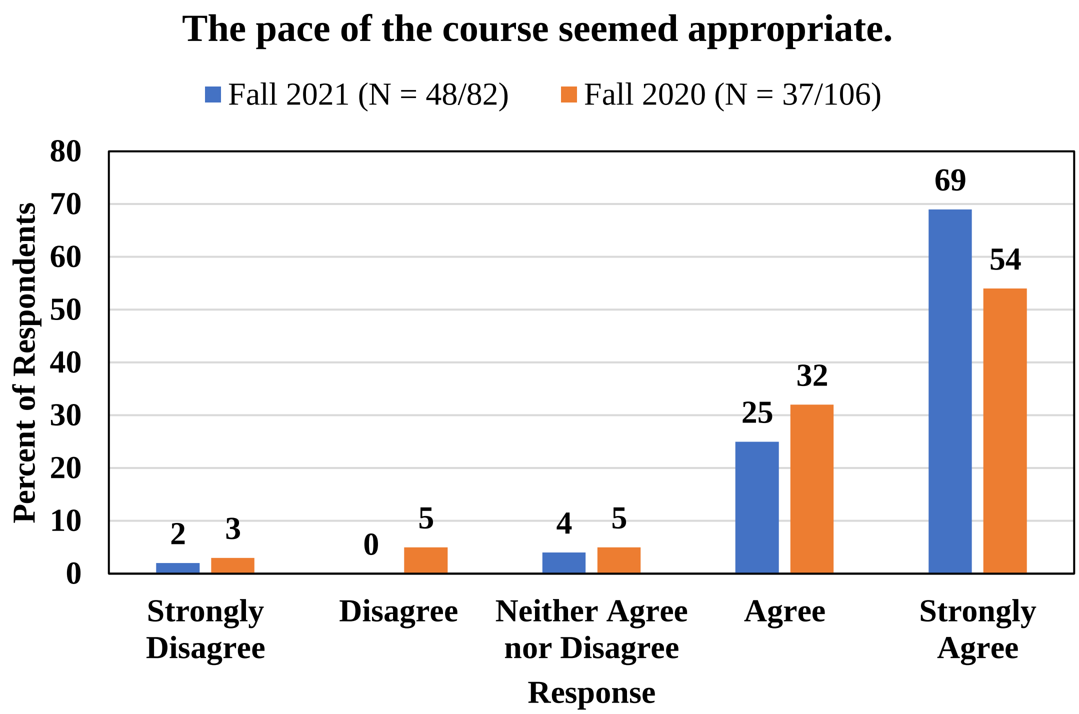

Figure 5.12 Feedback on the course pace

5.5 Overall feedback

In the same SET survey, the students were also asked to give overall feedback on their perceived learning in the course as well as their rating of the course. Figure 5.13 shows that 88% of the respondents (N = 51) felt that they had learned more than/much more than most courses and 12% of the respondents felt that they had learned about the same as most courses. Figure 5.14 depicts the students' overall rating of the course. 64% of the respondents (N = 50) gave an 'excellent' rating for the course and 20% gave it a 'very good' rating. From these two figures, it can be inferred that the course was effective in providing the students with an improved learning experience. Furthermore, both the figures show that the perception of learning and the overall rating was higher in the Fall 2021 semester in comparison with that of the Fall 2020 semester.

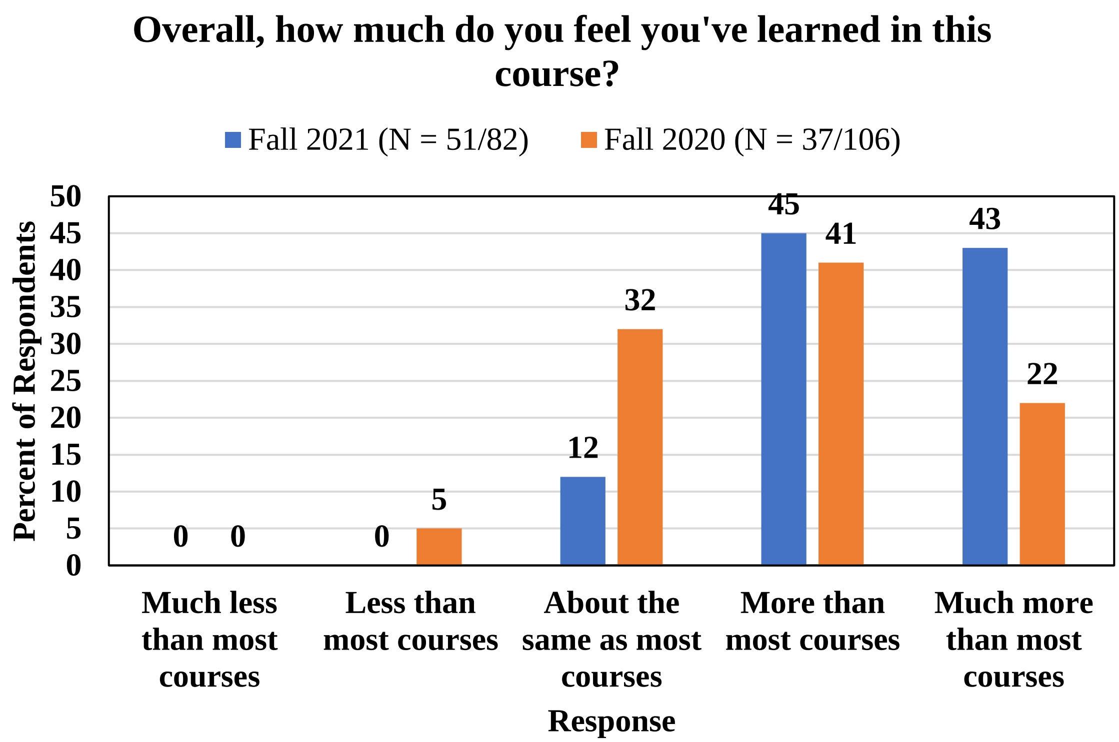

Figure 5.13 Student feedback on perceived learning

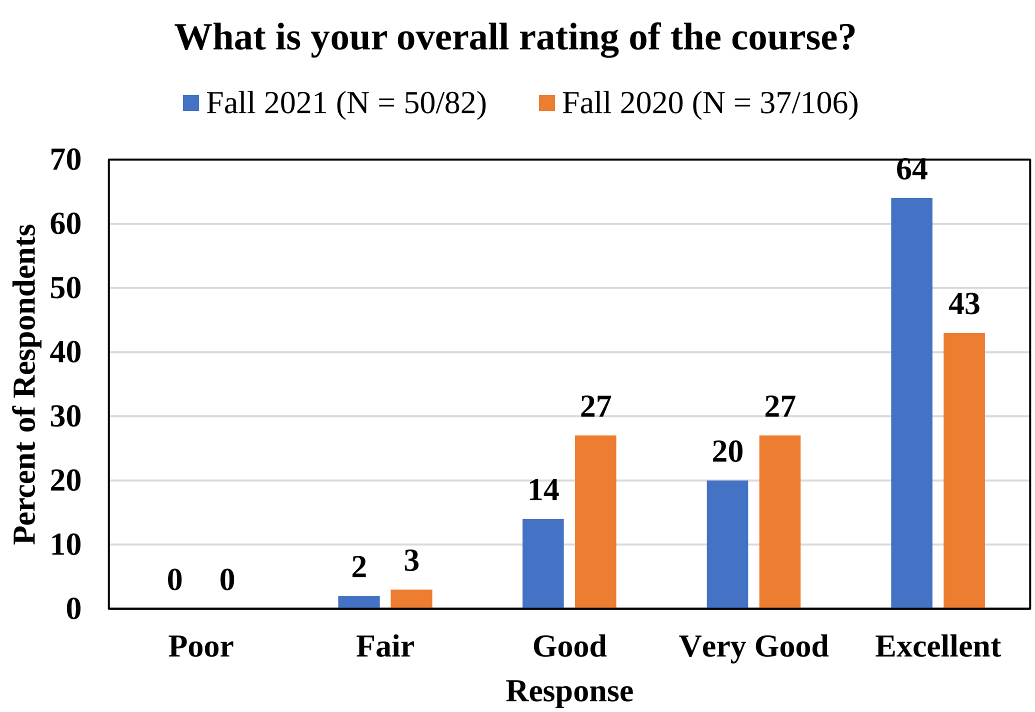

Figure 5.14 Overall course rating by the students

5.6 Participation in the online discussion board

Figure 5.15 shows the participation rate in each learning module in the online discussion board. Although over 50% of the students participated in the discussion on the Introduction module (Module 0) [Fall 2021 – Inclusive course], the number of participants decreased gradually as the semester progressed with no participants for the last couple of modules. Since the participation in the discussion board was not mandatory, it is likely that the students lost the motivation to participate as the semester got busier. A similar trend was observed in the Fall 2020 semester, which was taught in a hybrid setting (about 53% of the enrolled students attended the lectures in person and the rest joined remotely). The data indicates that the online discussion board in-built in the LMS may not be an effective medium to promote learner-to-learner interaction as well as learner-to-instructor interaction outside the class unless it is made mandatory. Student response to a custom SET question ("What could I have done to have more students take part in discussion with their peers using the Discussion Board in HuskyCT?") pointed to requirement or extra credit assignment as incentives to participate. Based on the student feedback, the online discussion board could be made mandatory in future and included in the course grade.

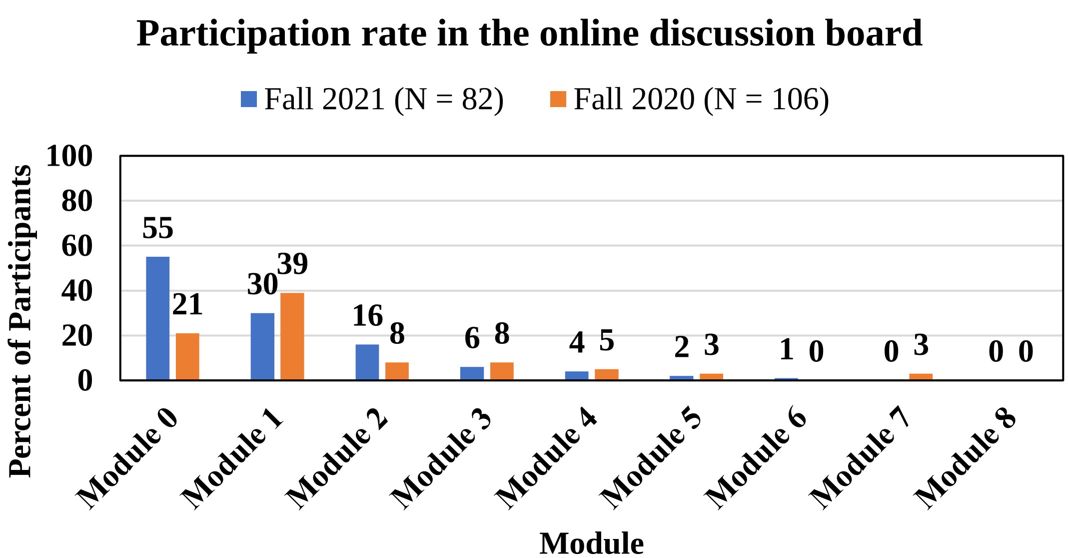

Figure 5.15 Participation rate in the online discussion board

6. Conclusions

As a part of the project "Beyond Accommodation: Leveraging Neurodiversity for Engineering Innovation", the Soil Mechanics course in the Department of Civil and Environmental Engineering at the University of Connecticut was redesigned using a strengths-based approach and UDL guidelines. The goal of the redesign process was to incorporate inclusive teaching practices for an improved educational experience for all students, keeping in mind the experience and needs of neurodivergent learners.

The student response to the different interventions made to the course was overwhelmingly positive across all questions posed in the informal course surveys and the formal Student Evaluation of Teaching surveys. Students perceived the assessments to offer them the opportunity to demonstrate their skills; interestingly, this was primarily the case for the traditional midterm exam and less so for the term project. Offering choices in the exams was perceived to be very positive by 90% of the students and so were the in-class problem solving activities.

Furthermore, compared to the Fall 2020 delivery of the same course, the redesigned course (Fall 2021) was found to be more effective in providing the students with an improved learning experience. An ongoing research study in the department is investigating the differential effect of inclusive teaching strategies on neurodivergent learners versus all learners across I-Courses.

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