Implementation of Weekly Active Learning Days in a Junior Level Aerospace Engineering Lecture Course

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Abstract

Aerospace Structures 1 is a required junior level lecture course taken by approximately 80 students each academic year. Traditionally, this course has consisted of three 50-minute lecture sections per week, and students were assigned grades based on homework and exam scores. Beginning in Fall 2022, this course was re-designed to eliminate graded homework and replace this graded component with participation in a required active learning day each week. The lecture material was condensed to be covered in two lecture periods each week (Monday and Wednesday) and the Friday lecture was replaced with an active learning day, where students were able to practice problems related to the week's lecture content. While analysis of the impact of this change is still in progress, initial results indicate improved student performance. In spring semester 2022, the percentage of students earning final grades of D or F was 15.8%. Since making this change the following semester, all students who have stayed enrolled in the course past the initial two week drop deadline have passed the course with a C or better. Work is ongoing to evaluate student performance in the subsequent Aerospace Structures 2 course and to adapt and improve the active learning activities for future semesters.

Keywords

Active learning, aerospace engineering

Introduction

Aerospace Structures 1 is a fundamental course in the Aerospace Engineering program that introduces students to basic structural analysis techniques for aircraft and spacecraft. Students enrolled in this course are typically in their junior year, and they have the option of taking the course in the fall or spring semester. Approximately 80 students per year enroll in Aerospace Structures 1, with a fall semester enrollment of around 25 students and a spring semester enrollment of around 55 students. This course meets three times per week, Monday, Wednesday, and Friday, for 50 minutes each day. Historically, this course has been purely lecture-based, and grades were assigned based on exams (80%) and homework (20%). While the majority of students submitted the weekly assignments, there was little correlation between homework scores and exam scores, similar to the findings of several other studies evaluating the effectiveness of graded homework in engineering education [1, 2]. In the case of Aerospace Structures 1 specifically, it was suspected that students were sharing solutions both in person and digitally through sites such as GroupMe, which made it easy for some to submit homework solutions without spending much time trying the problems themselves. Many students who earned high grades on the weekly homework assignments were not performing well on exams covering the same topic.

To address this issue, the course format was restructured to include one active learning day each week. Ample research has shown the benefit of incorporating active learning techniques, including the flipped classroom method, in STEM education and many studies support replacing traditional lectures with active learning time [3-7]. Previously this author has worked on developing and evaluating a library of active learning strategies in a variety of engineering lecture courses [8], and in this re-design of Aerospace Structures 1, these activities were implemented in a more structured and rigorous manner. In the re-designed course, participation in the weekly active learning day was a required component of the course grade and replaced the graded weekly homework assignments. The goal of this change was to eliminate the temptation to copy homework solutions and encourage students to attend class and spend time each week engaging with the course material by solving difficult problems. The weekly active learning sessions were designed to better prepare students to work through problems independently outside of class and study effectively. It was anticipated that this change would improve student performance compared to the traditional lecture course.

Methods

Table 1 shows a comparison of the course formats before and after the change in fall semester 2022.

Table 1: Comparison of course format before and after incorporation of active learning days

	Spring 2022 and Earlier	*Fall 2022 and Later*
Lectures	150 minutes per week	100 minutes per week
Active learning	None formally, occasional activities within lectures	50 minutes per week
Grade components	Exams (80%), Homework (20%)	Exams (80%), Active learning (20%)
Attendance	Not taken or required	Taken on Fridays (active learning days)
Problem Sets	Assigned on a weekly basis, turned in digitally for a grade	Assigned on a weekly basis, not turned in or graded

Active learning days took place on Fridays, of which there were fourteen each semester. Students were required to attend and participate in ten Friday active learning sessions to earn full points for the active learning component of the course. Allowing each student to miss four active learning sessions seemed to be sufficient to accommodate for illness, athletics and design team participation, and personal travel. Each additional absence beyond the allowed four absences resulted in a 2% reduction in a student's course grade. Although weekly problem sets were still assigned after the format change, these were no longer collected and scored. Students were told that instructors would be happy to review their work and provide feedback, but it was not

required to turn in these problems. On average, there were five problems on each problem set, and the active learning days got students started on 2-3 of these problems, so they were well-positioned to complete the rest of the problem set on their own. Problem sets were posted each Wednesday, with solutions posted on Friday after the active learning sessions were complete.

To keep things interesting, active learning days took on a variety of formats including both individual and group work. Some examples of activities are detailed in Table 2.

Activity Name	*Activity Description*	*Group or Individual?*
Kahoot Quiz Game	Students work through problems and submit answers via their phones or other devices and compete with their classmates on a leaderboard	Options for both team and individual play
Gallery Walk	Students work through problems in a small group and write out their solutions on giant sticky notes around the room. After a set amount of time, students rotate to the next group's paper and make corrections or comments as they go.	Group
Escape Room	Students work through problems to get the numbers needed to unlock various combination locks and "escape" class	Group
Guided Problem Solving	For particularly difficult problems, students are given scaffolded worksheets to help identify the solution steps	Individual

Regardless of the format, instructors aimed to keep the environment casual and encourage discussion and interaction between students and their peers and students and the instructors. While attendance was required, full points were awarded for showing up and participating in the activity, without any requirement of turning in correct answers. This kept the pressure low and allowed students to make mistakes and learn from them without penalty to their grade.

Results

Analysis of the impact of this change in course format is ongoing, but initial results are promising. Prior to making the change, the percentage of students earning D and F grades had been steadily increasing, possibly due to challenges associated with deploying the course in a hybrid format due to COVID restrictions as well as disruptions to the prerequisite courses. In Spring 2022, 15.8% of students earned a D or F in the course. Anecdotally, even after a full return to on-campus learning was achieved, the attendance and participation of students in this course was still not back to pre-pandemic levels. By requiring attendance on Fridays for the active learning days, attendance did increase, not only on Fridays, but on other days of the week as well as students saw the value in coming to class to improve their understanding of the material. In the three semesters of running the course in the new format, 91% of students have earned full credit for participating in the active learning days, meaning they missed four or fewer Friday classes.

While changes in the overall exam and course grade averages were not significant, since making the change in course format, all students who have remained enrolled in the course past the initial two-week drop deadline have passed the course with a C or better. While some of this improvement may be attributed to the increased passage of time since the COVID learning disruption, the sharp reduction in D and F grades from Spring 2022 to Fall 2023 suggests that at least some of the improvement is due to the change in course format. Continued efforts will focus on studying the impact of this format change on students' performance in the subsequent Aerospace Structures 2 course and identifying if particular active learning activities have greater impact than others. Additional efforts will focus on improving the deployment of these activities in the larger spring semester course, where it is more challenging to engage all students to participate fully. Enrollment in the aerospace degree program has been steadily increasing, so it is important that these activities can be utilized in large enrollment courses in the future.

Summary

This paper details the incorporation of a weekly active learning day in a required junior level Aerospace Structures 1 course to improve student engagement with the material. Attendance at the weekly active learning class sessions was required, and the grade for this participation replaced graded weekly homework. While evaluation of this change is still ongoing, initial results suggest that this was an effective method to reduce the number students earning D or F grades and needing to repeat the course to proceed in their degree program. Future work will focus on studying the long-term impact of this change as students proceed through the aerospace degree program and refining the activities to work well for larger class sizes.

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