BOARD # 180: Implementing Mini Modules in Core Mechanical Engineering Courses to Enhance Student Engagement

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Abstract

Active learning promotes student engagement by emphasizing their active role in the learning process, contrasting with traditional lecture-based teaching. This study explores the implementation of four active learning strategies in a senior-level Mechanical Engineering course (Heat Transfer) at Western New England University: peer discussions, weekly self-assessed quizzes, flexible assignment deadlines, and self-selected team formation for collaborative projects. These strategies were designed to be easy to adopt without compromising lecture time or content coverage. Surveys and feedback help to understand the students' perspective when it comes to implementation, to further promote engagement, intrinsic motivation, and peer collaboration. The study also identified logistical challenges, such as balancing flexible due dates with procrastination. The results demonstrate the potential of small, structured interventions to improve student outcomes in engineering education, providing practical insights for integrating active learning across various courses. Future work aims to expand these strategies across the Mechanical Engineering curriculum to further evaluate their impact on student engagement and learning.

Introduction

Active learning promotes strategies that engage the students during the learning process. In contrast to the traditional classroom teaching, which focuses on the instructor's delivery and considers the students merely the receiving end of the knowledge, active learning emphasize the students' role in the process, and encourages them to think and learn actively, instead of just listening. Bonwell and Eison in 1991 [1] defined that instructional activities involving students in doing things and thinking about what they are doing as techniques to promote active learning. A broad range of activities can be considered active learning techniques under this definition [2]. Some are simple and easy implement. For instance, the students may engage in ”think-pair-share” [3], where the instructor raises a question, ask the students to think about it, and then they are paired with peers to discuss their thoughts and answers. A single think-pair-share session can be as short as five minutes, depending on the difficult level of the questions. Team based learning is another popular active learning strategy, where students work in groups to solve problems or collaborate on projects. Both in class discussion and after class assignments are expected to be completed by group members [4]. Research shows that the students outcomes are improved when active learning approaches are utilized [5, 6]. However, some researchers point out that some aspects of active learning techniques, such as clicker questions, group work and cold call/random call, may cause anxiety for certain student populations [7]. They suggested that adopting or designing lectures to keep students engaged should also aim to build an inclusive learning environment.

Despite the growing body of research and evidence in its effectiveness, the active learning practices are not widely implemented across the higher education institutions for various reasons [8]. The traditional method, where “The professors talk and the students listen” still dominates many classrooms. One significant barrier to change is the limited lecture time. Many Mechanical Engineering (ME) core courses are traditionally technical content-heavy, requiring instructors to use most of the lecture time to cover technical material. In this work, the authors explores several learning activities to promote active learning. These activities are easy to implement and do not require significant lecture time. They can be replicated in other ME courses with minimal revisions. These learning strategies include:

- peer discussions during class,
- weekly self-assessed quizzes,
- flexible assignment deadlines, and
- self team formation for collaborative project.

The implementation of these strategies in a ME course is descried, along with survey data reflecting the student’ perspectives.

Method

The implementation of four mini modules in a ME undergraduate level course is explained. Specifically, they were introduced in ME 417 (Heat Transfer), a senior level course at a Western New England University. Two sessions of classes were involved, for a total of 55 students (one session has 30 students registered, and the other has 25). Student feedback was collected through a survey and analyzed to identify both the perceived and measurable impacts of these interventions. The survey was conducted near the end of the semester, two weeks before the project was due.

Peer discussions during class: In class examples often follow or accompany theoretical explanation in Heat Transfer. These example problems help clarify abstract concepts, demonstrate how the theory can be applied to practical problems, and teach students a structured approach to solving similar homework problems. For example, after introducing the concept of thermal resistance and thermal circuit analysis, an in-class problem was solved comparing the temperature of a turbine blade with and without thermal barrier coating. Traditionally, the professor works through example problems on the board or explains them using slides. This format was replaced with peer discussions three to five times during the semester. The instructor prepared handouts with example problems, pointed out the relevant theories and equations, and then asked students to work with peers to find solutions. Students were paired in two ways: (1) forming discussion groups with classmates seated nearby (used when time was limited) or (2) being randomly paired by an algorithm developed in Python based on the class rosters. For the latter, students changed seats to sit closer to their assigned partners.

The students were more engaged in discussions and actively sought solutions during the process, as opposed to passively taking notes if the professor solved the problems. When surveyed, 88% of the 41 respondents preferred discussing with nearby classmates, while 12% preferred random pairings.

Weekly self-assessed quizzes: Weekly quizzes that covered content from recent lectures are given to the students. Examples of quiz questions include: *"What is the driving potential for heat transfer?"*, *"What is Fourier's Law? Can you write the equation from memory?"*, and *"What is the difference between heat flux and heat rate?"* Most questions required short answers. Students treated quizzes as learning tools rather than tests to reduce anxiety level. The answers to the quizzes were presented immediately after completion. Students were required to self-assess their work and correct any inaccuracies, to reinforce their learning. Academic integrity and honesty were emphasized.

This approach allowed the instructor to observe students during quizzes and provide immediate feedback. When surveyed, 98% of students preferred the self-assessment format with immediate answers, while one student preferred instructor-graded quizzes.

Flexible Assignment Deadlines: To support self-paced, personalized learning, students were allowed to submit assignments after the deadline. This policy aimed to help students use assignments as learning tools even when delayed. Students received credit and met learning goals despite late submissions. While this flexibility benefited students balancing full time jobs, other coursework, and health issues, it also posed challenges. One student noted *"procrastination kicks in without the strict deadlines."* They managed to submit all the work, "but was under lots of stress towards the end.". By the end of the semester, all students completed every assignment, and the quality of their work remained consistent throughout. Survey results showed 61% of students favored flexible deadlines to allow more time for planning and revisions, while 41% preferred strict deadlines to avoid procrastination. Additionally, 49% wanted reminder emails from instructors to monitor progress. (Students were allowed to select more than one option for this question, resulting in a sum of all response rates of over 100 percent.)

Self team formation for collaborative project: In ME 417, students conducted experiments on heat transfer in pin fins (i.e., extended surfaces) outside of class time while working in self-formed teams. To encourage collaboration and connection-building, students were given the freedom to form their own teams. If students were unable to assemble a team, they could reach out to the instructor for assistance with placement.

The goal was to establish highly functional teams with healthy dynamics to facilitate efficient and effective project completion. Survey results revealed that 95% of students preferred working in teams, particularly groups with more than two members. When asked about their preference for teammates with similar backgrounds (e.g., in the same concentration program, in the same club etc), 71% of the students indicated that they have no preference, highlighting an openness to diverse team compositions. When reporting team contributions, most teams shared responsibility for the project. For example, multiple team members participated in Data Collection, Results and Analysis, as well as writing and revising the report. This indicates a high level of collaboration.

Future work

This research is part of an ongoing effort to incorporate active learning strategies throughout the ME curriculum, spanning all four years of study. These include courses such as *Introduction to Engineering* (1st year), *Statics* (2nd year), *Thermodynamics* (3rd year), and *Heat Transfer* (4th year). This will require instructors to collaborate and discuss how to adapt and modify the modules to better integrate them into their lectures. The impact of these strategies on student engagement and learning outcomes will be systematically assessed over time. By presenting student feedback and data gathered through surveys, this work seeks to inspire educators to adopt active learning modules that are adaptable, effective, and capable of fostering an engaging and motivating educational experience.

Ensuring that students are supported by both their instructor and peers is crucial throughout the learning process. The active learning tools implemented in this study were designed to require minimal deviation from standard instructional methods, making them straightforward to adopt without placing undue burdens on instructors. These tools aim to foster intrinsic motivation, enhance peer collaboration, and provide students with a more engaged and interactive learning experience. By integrating small, manageable activities into class time, the goal is to complement traditional lecture formats while promoting deeper understanding and engagement without compromising content coverage.

Additionally, a subset of the data will explore the role of cohort-building activities, further examining how collaborative learning environments influence student outcomes. Previous research has demonstrated that even minor, structured interventions can significantly enhance student engagement and retention in engineering education. This work aims to build on that evidence, particularly within the field of Mechanical Engineering. The retention rate will be tracked for classes that implemented the mini modules discussed in this work-in-progress paper to evaluate their impact.

The findings from this work will provide some insights for educators seeking to implement short, flexible, and effective active learning strategies in both classroom settings and beyond. By fostering a more interactive and inclusive learning environment, the study hopes to support instructors in creating opportunities for meaningful student engagement and improved learning outcomes.

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