Board 11 : Work in Progress: An Enhanced Active Learning Approach to Turning Classroom into a Neighborhood

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Introduction

Biomedical engineering is an interdisciplinary major that offers lectures, team projects, and laboratory tasks. One of the milestone courses, Biothermodynamics, which encompasses formulas, equations, and physical applications of biology systems, is traditionally taught passively through lecturing and note-taking. In the past two decades, active learning methods have been studied and promoted vastly in engineering education, including adding group work and peer interaction into the teaching and learning of such courses to increase student engagement [1-4]. This work-in-progress study further explores the ability to create a "neighborhood" in a sophomore-level Biothermodynamics classroom. The present study aims to design a new learning environment that maximizes students' learning capability through individual development and peer engagement. The course design allows students to actively participate in learning as a "resident" living in a "neighborhood". Besides the traditional individual work, various group activities are performed inside one group and among multiple groups, or the "households". Students feel more obligated to better performance and high-quality learning outcomes. Another focal point of this study is the assessment of student learning under the proposed course frame, where tailored tutorials and guidance are vital. Although support from the teaching team is essential in this "neighborhood", we still want to put students in the center as the leader of their study. The ongoing data collection reflects the development of such competencies of both students and teachers for active learning. We want to use the data to seek evidence of better practice in promoting student learning in engineering core courses, especially the traditional lecture-based ones.

Course structure

This study has been conducted in a sophomore-level Biothermodynamics class for two semesters (2022 Spring and Fall). Previously, the course was taught with lecture-based materials relying on note-taking and individual homework traditionally. Under the new design, students will receive a detailed content structure at the beginning of the semester, shown in Appendix, Figure 1. Students will obtain a general view of the course content, types of assignments/exams, and their due times from this plan. "Topics balloons" are provided in different sizes and locations in a "time vs. hardness" quadrant. It indicates the time the class spends on each topic and the expected hardness. The balloons are labeled in blue and yellow, indicating the focused areas (general engineering or biomedical-specific thermodynamics). The color bars show the focused engineering skills and learning outcomes. Students will work individually or as a group each week to finish a particular type of assignment. The plan helps the student establish their vision of the class and set learning goals when they just "move" to a new "neighborhood".

Assignment and assessment plan

A healthy neighborhood relies on effective community engagement and contributions from individuals and families. To further emphasize independent learning skills and the interaction among students and student groups, the students are randomly grouped into eight households (groups) of 4-5 members. Various assignments and assessment schemes are developed, as shown

in Appendix, Figure 2. Students will still be assigned individual homework focusing more on theoretical and conceptual knowledge and group work that is more for practical and open questions.

In addition, as one can experience in an actual neighborhood setting, the interaction between neighbors (other groups) and the entire community (the entire class) is also expected. There is, for example, a type of activity called “visiting” that each household is asked to visit different neighbor groups multiple times. This is a type of inter-group activity in which a group designs homework problems, assigns them to the group they are visiting, and offers hints and evaluations during the visit. One house (e.g., group A) first needs to use the lecture and external reading materials to work together and make homework questions related to the recent topics. They must also create solutions and tutoring plans. Then, one of the group members will bring their questions to another “house” (e.g., group B) and join the group as a tutor, monitor their work progress, collect their answers, and give feedback. Group A’s effort and the quality of their work will be evaluated by the teaching team with comments and corrections. In the “visiting”, a student can actively work with three groups of students since a group is visiting and being visited in the same homework cycle. Another “inter-house” activity is called “gifting”. This is a one-time visit when each group is preparing their final project. The final project, or the “block party” (introduced later), asks the groups to study a new peer-reviewed journal article and give a presentation to the class at the end of the semester. At the “gifting” stage, one “house” shares the article they selected and sends it to another “house”. In return, a 1-page review of the article is collected. The two “houses” will exchange exciting ideas and share comments on the article. The group sending out the “gift” needs to spend more time on the article since they will make a presentation on it, not just a 1-page review. Again, the group receiving the “gift” also sends their “gift" out to a different group.

The last inter-house activity in the “neighborhood” is the “block party”. As mentioned above, students participate in a journal club-style whole-class open discussion on peer-reviewed journal articles and research proposals. Although this task is assigned at the beginning of the semester, a group usually only starts the work passing half the semester. The presentation is set in the last week of the semester when more details and topics about biomedical engineering thermodynamics are provided, and all groups have been fully equipped with the knowledge this course tries to deliver. At this point, students feel more confident in selecting and studying the research article. They are also more willing to work with the rest of their classmates after multiple rounds of interactions throughout the entire semester.

The entire assignment and assessment plan requires the instructor to design the logic of the interaction carefully and deliver the structure efficiently to the students. Hence, students can maximize their active learning experience using a “neighborhood” analogy without being overwhelmed by a variety of learning activities. While the regular calculation-based individual and group homework can be graded by the teaching assistant using a solution sheet, the instructor will focus more on reviewing and providing constructive feedback on the quality of each group’s tutoring work, including the questions and the solutions the groups generated, the feedback they provided to the answers they received, the group work dynamics, job allocation, and contributions.

Roles in the Neighborhood

To develop and apply the plans discussed above, we must redefine the relationship between the instructor and the students pedagogically. All events in the "neighborhood" are multi-way activities. These methods require the instructor to design the teaching materials carefully, foster positive relationships with their students, be conducive to learning, and meet students' developmental, emotional, and academic needs. Taking classes is not only about reading textbooks or finishing homework and exams. The learning experience is reconstructed and redefined in three domains: the teaching domain, where the teaching group provides pure engineering knowledge and principles, designs and evaluates individual and group work; the cognitive domain, where all participants actively think and discuss, challenge the basis of accepted ideas, and testing assumptions; and the social domain, where learners can function as an individual or a group in inter-group and whole-class activities that allow them to seek answers and provide support to peers.

Data Collection and Analysis Plan

In the current and future data collection, with a general goal of exploring new teaching and learning methods in traditionally lecture-based courses, we focus on analyzing the following aspects for evidence of their active learning skill development, as well as the quality of the course design.

First, Students' individual homework (30% of the total) is continuously examined in terms of each question's score and the overall grades. They are compared with those from the past three years when no or little group work was organized. While assigning similar questions, we want to test if the reinforced group activities can help students understand fundamental concepts more efficiently. In addition, we record and evaluate the quality of the questions and the solutions the students make in the "visiting" homework, where students need to demonstrate the capability of interpreting textbook knowledge into engineering skills. Their work is examined using the following criteria: A. recently learned fundamental principles are selected. B. the practical questions they make can trigger some extra readings and discussion. C. the solutions they make are correct. D. their comments on the other team's solution are comprehensive. Throughout the semester, we track each team's grades in each round of "visiting" and their progress in the next round after receiving the instructor's comments. The data mentioned above can be used to calibrate the weights and percentages of each activity to maximize the efficiency of both group work and individual work. We will also rely on pre/post quizzes and surveys to reflect the mastery of concepts commonly taught in Physic I (the prerequisite of Bioengineering Thermodynamics) at the beginning of the course and the ability to apply those principles in the bioengineering area after training under the proposed learning methods. When necessary, we are also interested in seeing how purposefully paring specific team players (e.g., strong to strong, strong to weak) can provide tailored support among groups based on group dynamics and individual skills.

The development of students' active learning skills depends on layers of contributions from the entire neighborhood, which involves careful guidance from the instructor, intentional self-improvement, and inter-team engagement in the community. Following the proposed active learning approach, the students are expected to feel a more substantial personal impact from the instructor and peers, so more engaged in learning and be more willing to find the logical connection between ideas in problem-solving.

References

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[4] Hernández-de-Menéndez, M., Vallejo Guevara, A., Tudón Martínez, J.C. et al. "Active learning in engineering education. A review of fundamentals, best practices and experiences". Int J Interact Des Manuf 13, 909–922 (2019). https://doi.org/10.1007/s12008-019-00557-8

Appendix

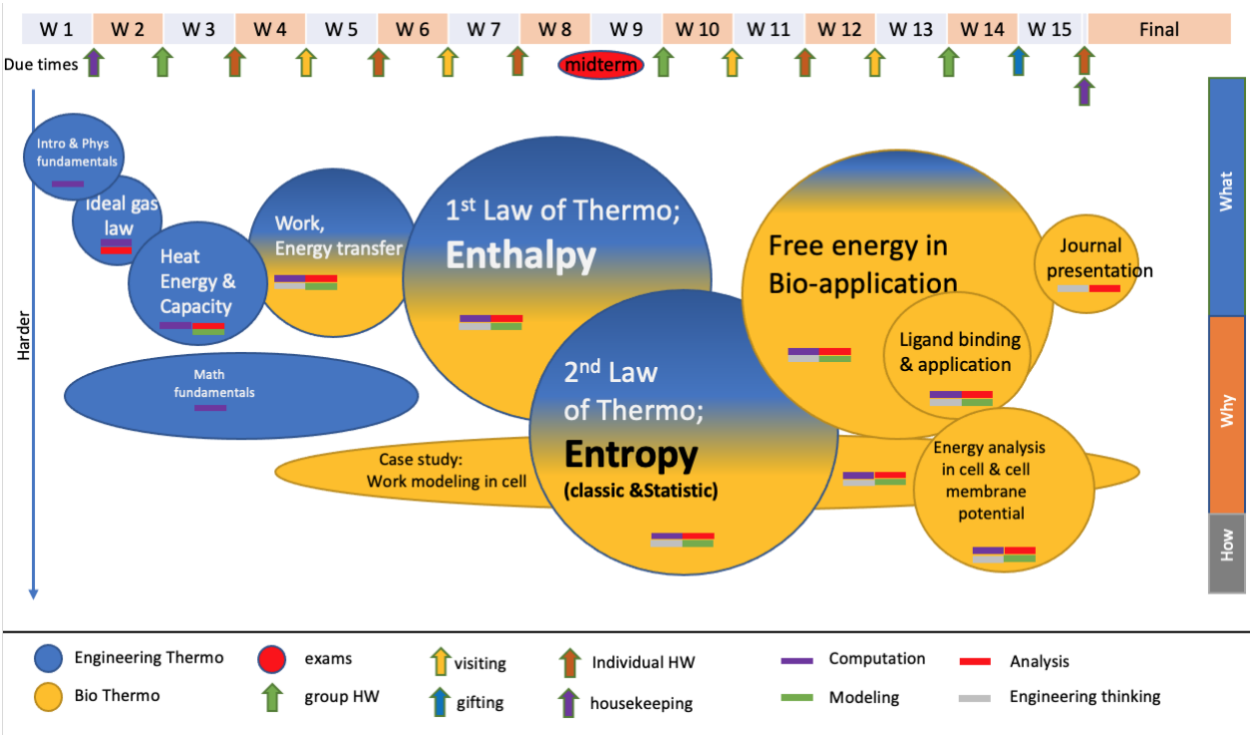

Figure 1. Course schedule and topics that show a general map to the students to follow.

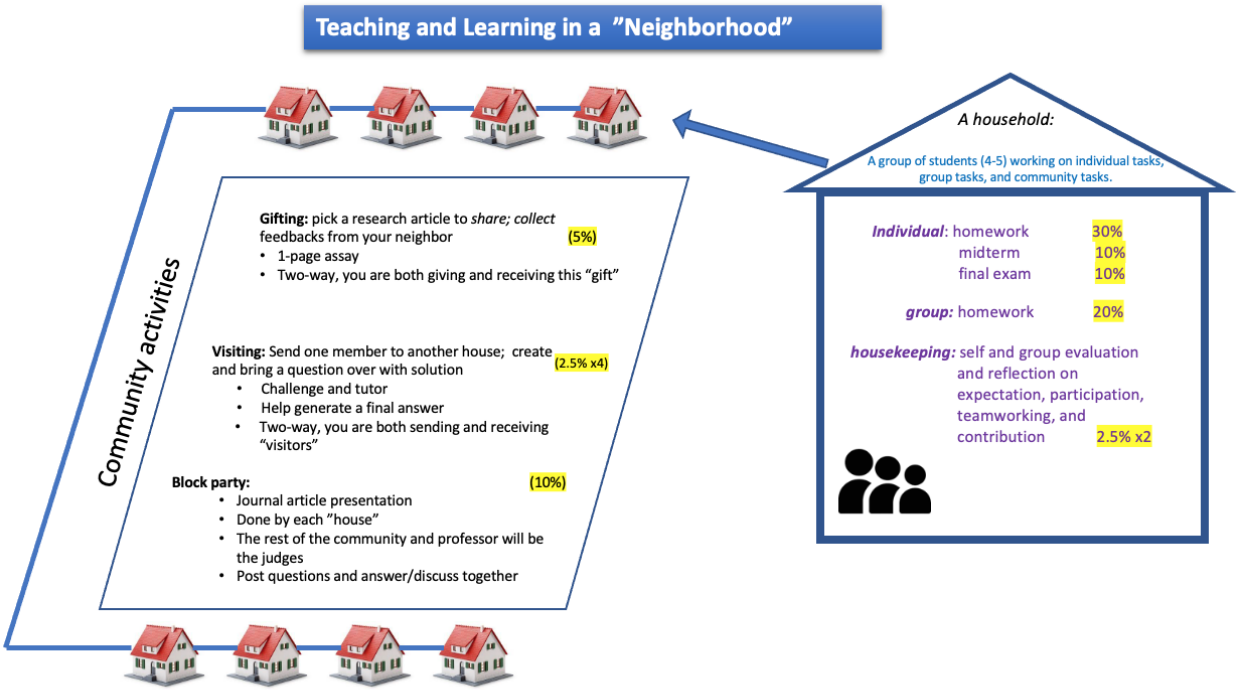

Figure 2. Community activities and their weights in the "neighborhood" learning.