

Student Self-Reflection in Scaffolded Undergraduate Thermodynamics Course

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Abstract

Thermodynamics I has a reputation for being a challenging course for undergraduate students. It is taught in the Mechanical and Aerospace Engineering (MAE) department at North Carolina State University for sophomore MAE students. About half of the enrolled students come from other engineering disciplines, and these students are typically juniors and seniors. Most MAE students also take Thermodynamics II so their learning in the introductory course is critical to earning their degree. The scaffolded structure of Thermodynamics I means that lower-performing students are at risk of falling behind during the semester. Three learning modules are taught in such a way that student success in one module directly influences their success in sequential modules. This research provides a method for collecting data on student metacognition for each learning module in a large enrollment class.

Keywords

Thermodynamics, undergraduate education, self-reflection

Introduction

Student cognition can be measured using the six levels of Bloom's taxonomy: remembering, understanding, applying, analyzing, evaluating, and synthesizing new knowledge¹. By developing metacognitive skills in class, students gain a better understanding of their own knowledge². One way these skills can be developed is within a reflection framework. Some studies, such as Case et al.³, have students complete journals and interviews to measure their self-reflections. Quinton and Smallbone⁴ used an approach to reflective learning that involved assessment, feedback, and reflection to enhance learning in future work.

The purpose of this study is to determine if students' confidence in their learning of the material improves with an end-of-module assessment and to see if that confidence continues to the next module. The current study is a work in progress tracking the learning of 145 students during the fall 2021 semester. Results from the first module are presented in this paper. The results show if the assessment and feedback are beneficial or if changes to one or both are necessary.

Method

For each learning module, learning outcomes were defined and measured using an assessment based on homework assignments that students had already completed. There were two homework sets per module prior to each assessment. At the end of each unit, students were provided with reflection questions to determine how the students felt about what they had

learned. Then they completed a graded assessment that provided immediate feedback. A second chance at reflection showed if the assessment and feedback improved student cognition. All reflection questions and assessments were administered through the course learning management system.

The reflection questions asked before and after each module's assessment were as follows:

1. *I feel confident that I understand the material that has been taught thus far.*
2. *When I solve a problem based on this material, I feel confident that I will get the right answer.*
3. *I feel confident that I can apply what I have learned to other problems involving this material.*

The assessment included questions in which students were asked to review previous problems done in class and for homework. The following is an example of the type of questions asked:

- Look back at homework 1, problem #2. If the tank had a gage pressure of 14 psig instead of 7 psig, what would be the height, h ?*
- a. Changing the gage pressure would not affect h .*
 - b. Increasing the pressure would decrease h .*
 - c. Increasing the pressure would increase h .*
 - d. Doubling the pressure in the tank would double h .*

Any answer that the student chose in the assessment provided feedback so that the student could reconsider any wrong answer for their next attempt. Students were given two attempts to complete the assignment. The average grade for this assignment was 91%.

Analysis

The same three reflective statements were given before and after the students completed the graded homework assignment. The first statement shown in Figure 1 asked students to determine if they feel confident in the material taught in the first module of the course. Over 100 students either definitely agreed or somewhat agreed with that statement. After completing the assessment, the number of students who definitely agreed more than doubled and there were fewer students who marked "somewhat disagree" or definitely disagree".

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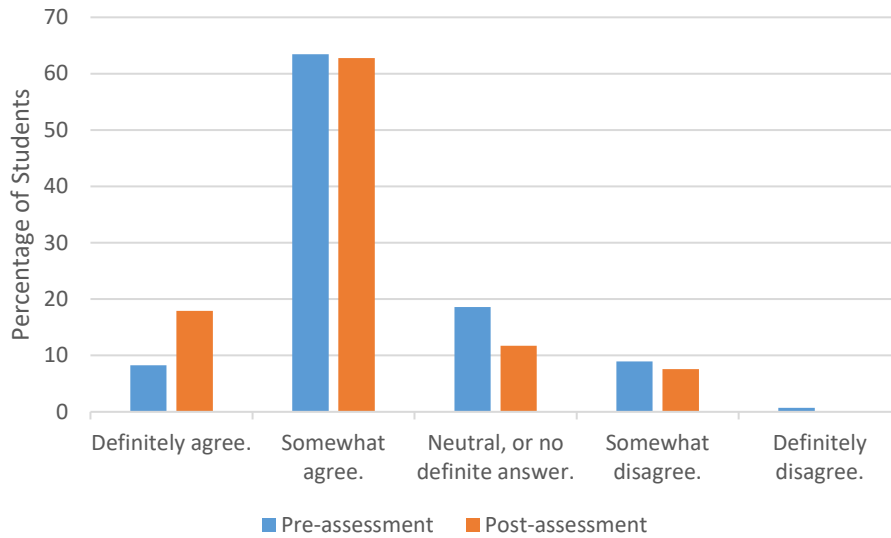


Figure 1. Students' Answers to "I feel confident that I understand the material that has been taught thus far."

The second statement had students reflect on their confidence that they will get the right answer. As shown in Figure 2, the number of students who either somewhat or definitely agreed was lower than for the first statement. Post-assessment the number of students who marked "definitely agree" more than doubled (as is also seen in Figure 1).

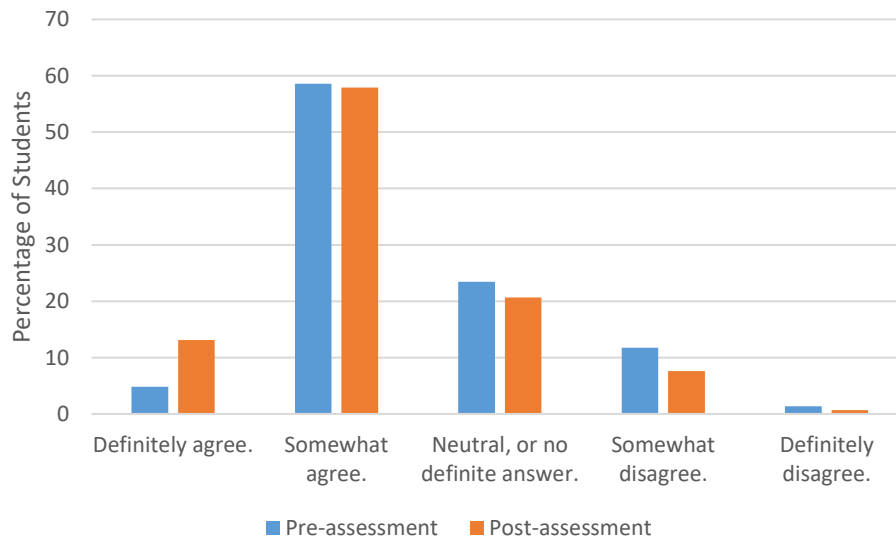


Figure 2. Students' Answers to "When I solve a problem based on this material, I feel confident that I will get the right answer."

Figure 3 shows the results of the third reflective statement asking students to consider if they can apply what they have learned. Fewer students agreed with this statement overall and there was less improvement in the numbers post-assessment for this statement than the others.

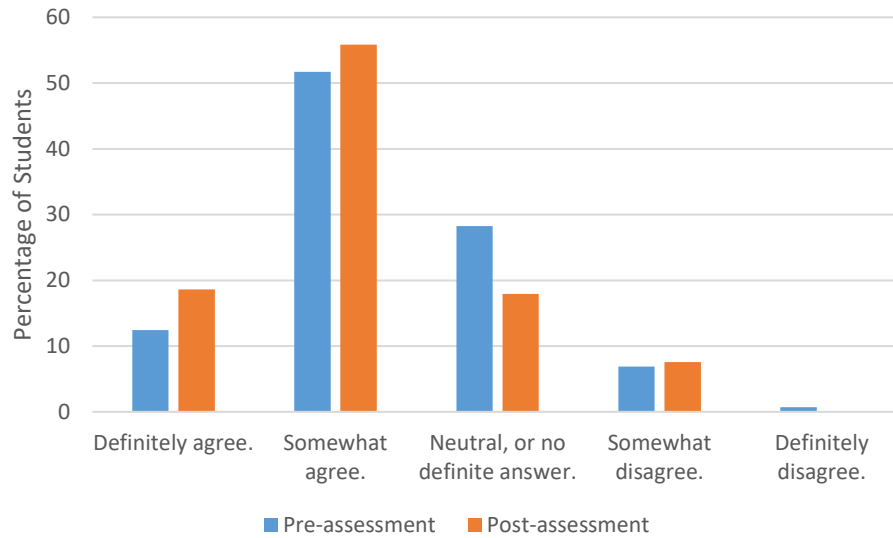


Figure 3. Students' Answers to "I feel confident that I can apply what I have learned to other problems involving this material."

For the post-assessment, students were also given the opportunity to comment on their answers. Of the 145 students who completed the assignment, 69 offered comments. Some of these comments were as follows:

"I feel far more confident after reflecting on these questions, however, I worry for the further content, and I worry of the current speed of the course. But thus far I am confident with where I am at in the course."

"Just struggling at knowing which tables to look at. But when the feedback said to make sure you always start with the Saturated tables, that answered that question. Just pressuring to have to sift through the tables and pick the right one."

"This isn't really a reflection on my answers, but I just wanted to say that I like that you asked questions that had us go back to previous hw to understand what we did in more detail and being able to take the problem a step further or rework it."

"I feel better than I did, and I am sure going through practice problems will help me become more confident."

Conclusions

Students were given the opportunity to reflect on their understanding of the material by answering reflective questions and completing an assessment of specific concepts in the course. The data shows that the assessment improved their understanding. Students' comments indicate that this exercise was helpful.

In the future, this study will include the results of the other two learning modules in the course. The assessments will be analyzed to determine if students find them helpful to understand the current module and to build on their knowledge of the previous module.

References

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