Does Group Work Preclude a Student's Individual Success: A Thermodynamic Case Study

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Abstract

Thermodynamics I for undergraduates is primarily taught in the flipped class format at North Carolina State University. Most students in the Mechanical and Aerospace Engineering department take the class as sophomores but approximately half of the enrolled students come from other engineering disciplines. Before class, students learn of concepts from videos. Students then discuss and apply those concepts to problems done in class in groups of three. The current study focuses on the knowledge obtained by students working in groups during class as compared to when those students work individually. There is value to learning effective skills for working with others and communicating ideas. One outcome of this course is to express to students the importance of being able to explain a problem's solution both verbally and in an abbreviated report form. However, testing is done for individuals, and so the current research determines how well students are able to translate the success of the individual's group to perform classwork to success on the individual's test.

Keywords

Flipped class, undergraduate thermodynamics, group work

Introduction

The Thermodynamics I course as offered by the Mechanical and Aerospace Engineering (MAE) Department is a required course for MAE students. About half of the enrolled students are majoring in other engineering disciplines. The learning objective for these students is to understand how to analyze systems using the first and second laws of thermodynamics[1].

The author has taught this course as a flipped class for several semesters. As a flipped course, students use time in class to answer numerical problems and conceptual questions via clickers[2-4]. The instructor provides short lectures in class to emphasize solution methodology and to reinforce concepts taught in video lectures students are required to watch before class. While students work in groups during class, homework assignments and tests are done individually. The current study compares students' grades on individual assignments with group work done in class. Performance on the test and homework assignment that focuses on the first law of thermodynamics is compared to answers submitted during group work in class.

Student Performance Analysis

This study includes 53 students from one course section. Twenty-five students in the section were omitted from the study due to not having completed all the problems. The homework assignment included here had two problems: one with a closed system and one with a control volume. Students are required to follow a homework format with eight sections that mimic an abbreviated report. Part of the homework grade is dependent on this format, so homework grades are generally elevated.

Figure 1 shows students' homework grades compared to their test grades. The test had two numerical problems with closed systems and two with control volumes. The homework assignment average of 85.5% (with a 12.4 standard deviation) is significantly higher than the test average of 71.3% (with a 13.6 standard deviation), and the trendline shows that the grades generally correlate between these two individual assignments. Figure 1 also shows that for the homework and the test separately, 8 students were below one standard deviation, but only 3 students were below for both.

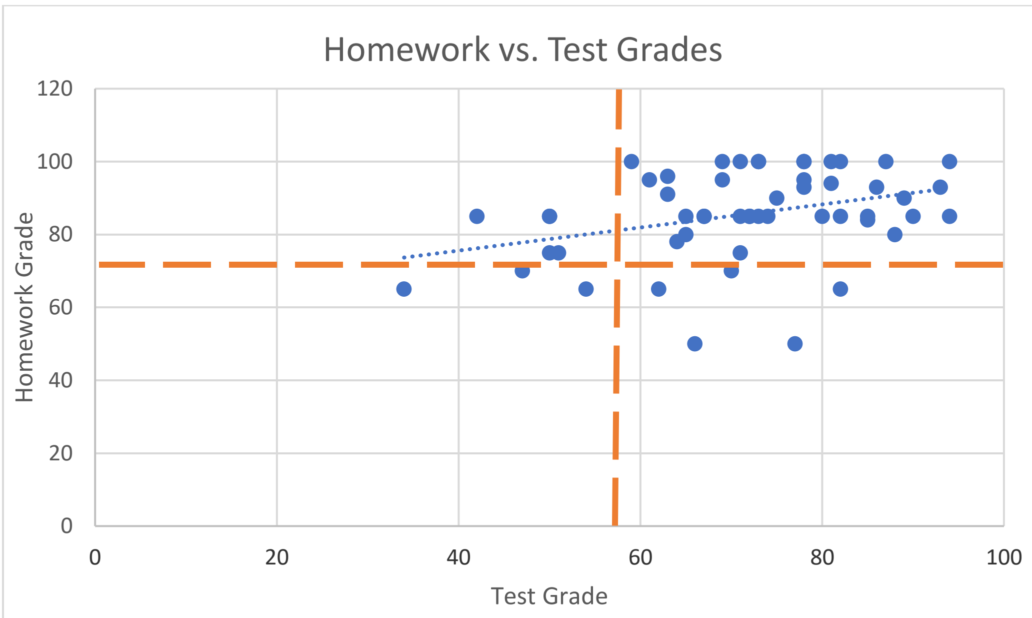

Figure 1. Homework grades for each student arranged by test performance

The problems in class are done by students in groups of three, and students submit their answers via clickers. Students are not required to submit the same answer as the group but are encouraged to work together and discuss solutions. Eight numerical problems on closed systems and six problems on control volumes were provided in class in preparation for the test and are included in this study. For each student, the percentage of correct answers for each type of system was calculated. Figure 2 shows these averages with the test grades for each student. Overall, students did better with the closed system problems. More than half of the students who scored below 60% on the test, have "passing" grades on the classwork. Some students who scored better than average on the test show a poor class performance.

Two conceptual questions were given to students in class but solved individually. For these questions, students had to choose the form of the first law that would solve the problem. Students generally do not handle conceptual questions well as the percentages shown in Table 1 prove. For this table, the 53 students are divided into groups based on their test grades. Then the average grade for each group was calculated for homework and class problems. When divided in this way, the best performing group on the test was also the best performing on the homework. This group performed the best in group work and best in the combined percentage of the individual class work. As the test grades decreased, so did the grades in the other categories.

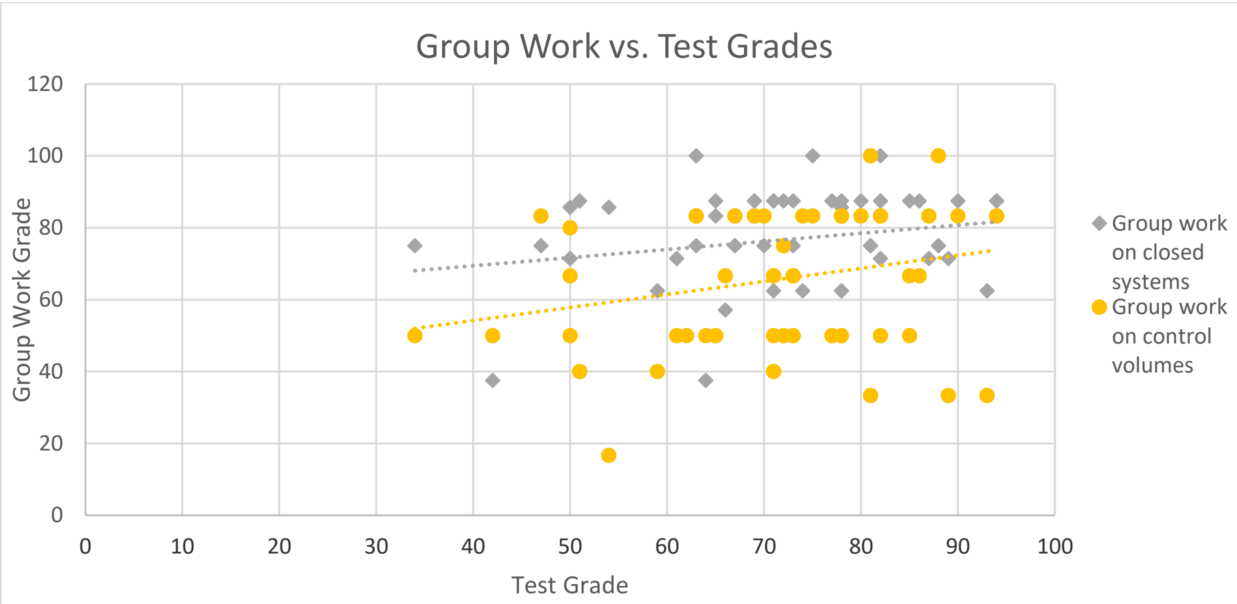

Figure 2. Each student's performance during group work versus his/her individual test grade

Table 1. Average grades on homework and classwork compared to test

	Individual Work				Group Work	
Number of students			Class problems		Class problems	
	Test	Homework	Closed system	Control volume	Closed system	Control volume
16	≥ 80%	89%	31%	31%	80.06%	69.79%
16	70-79%	87.4%	38%	19%	77.23%	66.56%
12	60-69%	83.8%	17%	8.3%	73.91%	68.06%
9	< 59%	78.3%	11%	11%	72.42%	52.96%

Conclusions and Future Work

The current investigation indicates that the highest performing students in the class do well in individual assignments and group work when viewed together. However, Figures 1 and 2 indicate homework and class work performance is not a guarantee of a particular test grade. Therefore, broadening this study is necessary before its definitive question can be answered.

More students will be added to this study to see if the trends are consistent. Analysis will also be extended past the topic of the first law and include the other tests and homework assignments in the course. Future work will include determining how to better communicate to students how classwork and homework prior to a test will translate to a favorable test grade.

References

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The author has been a Teaching Assistant Professor at North Carolina State University in the Mechanical and Aerospace Engineering Department for six years. She teaches undergraduate courses in the thermal-fluid sciences. She is the course coordinator for Thermodynamics I and has implemented the flipped format for over four years.