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What Kinds of Advice do Chemical Engineering Students Give to Future Students for Success in High-structure Courses?

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Work-in-Progress: What kinds of advice do chemical engineering students' give to future students for success in high structure courses?

Introduction

High structure courses are designed to guide students through the learning process by using graded pre-class content acquisition assignments, in-class active learning and group work, and graded after-class review work [1, 2]. High structure courses have also been shown to improve student learning and reduce achievement gaps in introductory courses [3, 4]. As with all class types, instructors will give advice to students for how to succeed in high structure courses which is based off of their experiences, other colleagues' experiences, and literature suggestions on how to optimize these classes and student success. Students can also give advice on how to be successful in the classes. This advice will ideally be used to improve the design of classes for future students by utilizing the suggestions on how to be successful and structuring the classes based on what made previous students successful.

There is some evidence in the literature for what kinds of advice students give in different course situations. Computer science students gave advice to future students at the end of an introductory programming course and most commonly gave advice on general study tips, following by attitudinal suggestions, and finally with specific programming advice [5]. A similar study with students that had finished a physics class were asked to give advice to future students. The new physics students were then asked to read the feedback from the previous students, and it was found that around 90% of the students read majority of the 160 comments, showing that students are at least interested in what previous classmates had to suggest. At the end of the semester, the students were asked to give feedback about the advice and over 98% of the students appreciated the advice and suggested continuing the approach in future semesters [6]. Last, while study abroad students from Mexico gave some advice to future cohorts about the courses they would take while studying abroad, the vast majority of comments were concerned about practical tips for living in another country [7].

While these reports from the literature provide insight into what kinds of advice students give in courses, we are not aware of any prior studies demonstrating what kinds of advice students give in high structure courses and for chemical engineering courses. The goals of this study, therefore, are to:

1. Determine what kinds of advice chemical engineering students give each other for success in high structure introductory chemical engineering courses, and
2. Determine if there are differences between the advice given for high structure chemical engineering classes and biology courses.

Methods

Students ranging from freshman to seniors were invited to give feedback on what made them successful in their high structure courses. The feedback was collected on the last day of lecture by handing out notecards to each student to give anonymous comments. These students were enrolled in either material and energy balances (MEB), introductory thermodynamics (thermo), introductory biology (intro bio), or anatomy and physiology (anatomy and phys.). A total of 224 students were asked to participate, while 183 students gave feedback (81.7%). One of the authors (JS) was the instructor for each course and the high structure course format was

used in each course as described previously [2, 8, 9]. Briefly, in all courses, students were required to read their textbook, complete optional reading guides [8], complete graded quizzes before class, attend class and participate in active learning activities during class, and complete a weekly quiz or homework assignment after class.

The advice comments from the students were reviewed by the two authors of the paper using an iterative thematic analysis method [10, 11]. During their independent reviews, each author came up with common themes seen throughout students' advice. The authors met to discuss the themes and agreed on four major categories with a total of 18 sub-categories. The authors then coded the comments from each student in each course and compared their coding for each response. They debated on any discrepancies until a consensus was agreed upon. The percent agreement between the two authors for all four courses is shown below in Table 1. In Table 1, the "% of matches" column represents how frequently the two authors agreed on the individual coding for all of the responses, while the remaining columns represent the percent agreement for the students' responses exactly or partially.

Table 1. Percent for coding student advice from each course

Class	% of matches:	% exact student match:	% partial student match:
MEB	92.8%	32.6%	67.4%
Thermo	98.6%	79.7%	20.3%
Intro Bio	98.3%	71.4%	28.6%
Anatomy and Phys.	98.7%	75.6%	24.1%

Results

Table 2 shows a summary of the determined categories for the students' advice with a description and example quote for each. All of the advice that was categorized as a study tip involved directly stating that a certain form of studying led to success in the class, while advice categorized as an interaction involved collaboration with other students, the TA, or the professor. On the other hand, the expectation category had advice that aimed to give the future students an insight into a component of the class. Finally, the positive thinking category comprised of advice revolving around having a positive attitude in class or some other motivating advice.

The data collected show that the most common type of advice was classified as a study tip, appearing in 58.6% of the total comments. Expectations was the next most prevalent response, as 23.6% of the comments from students had that type of feedback. On the other hand, only 17.8% of the students that responded gave advice regarding positive thinking or interactions. Comparisons between the classes for frequency of responses that fall under each of the four categories are shown in Figure 1 that gives a general summary of the responses provided by each class. The data suggest that the overall types of advice given between the courses is similar, but the biology courses tend to give more study tips and less advice on interactions. Figure 2 shows the distribution of responses for each sub-category (see Table 2 for category definitions) between the two chemical engineering courses (MEB and introductory thermodynamics) and the two biology courses (introductory biology and anatomy and physiology) which again demonstrates slight differences between the two types of courses.

Table 2. Categories used for analysis of student advice comments

Category	Sub-category	Description	Example
Study Tips	Course Specific Study Tip	This included tips that related specifically to the content or setup of a class such as: labeling diagrams, using models or steam tables, homework's relation to tests, etc.	"Focus on the set up and writing out the mass and energy balances."
Study Tips	General Study Tip	This included tips that can relate to most classes such as: redoing homework, practice problems, good notes, homework resources, etc.	"Make sure you take the time to understand the concepts as the class proceeds."
Study Tips	Reading Guide	This tip involved directly mentioning completion of the study guides.	"Fill out all of the reading guides."
Study Tips	Read Book	This tip involved directly mentioning reading the textbook.	"The textbook reading is useful for understanding the class."
Study Tips	Don't Procrastinate	This tip referenced not procrastinating/staying on top of work.	"Don't try to learn everything the night before the test."
Interactions	Attend Class	This tip referenced going to class specifically.	"I recommend you never miss class if possible."
Interactions	Participate in Class	This tip required mentioning taking notes in class, answering questions in class, etc.	"Listen and take notes in class."
Interactions	Ask Questions	This tip mentioned asking questions or looking for help.	"Ask for help when you don't understand a topic."
Interactions	Work Together	The tip talked about working with classmates in class or on assignments.	"Study with your friends."
Interactions	Office Hours	This tip referenced going to office hours.	"Go to office hours to get explanations on quizzes."
Interactions	Instructor Interactions	This included comments about listening to the teacher's suggestions.	"Follow all the directions given by the teacher."
Expectations	Course Expectations	This tip involved suggestions about course set-up, amount of homework, etc.	"Class is confusing, if you don't do the pre-class work."
Expectations	Difficulty Expectations	This tip involved mention of the class' difficulty.	"This class is not as difficult as they say it is."
Expectations	Environment Expectations	This referenced whether a class was boring, fun, interesting, etc.	"The class is a lot of fun."
Positive Thinking	Positive Thinking	The tip talked about having a positive attitude with the class.	"Enjoy yourself"

Discussion

It was observed that engineering classes yielded more similar responses to each other than biology classes. For example, in Figure 1, students in MEB and thermo gave advice regarding interactions and expectations more than students in the two biology classes, while they also gave study tips less frequently than the biology students. Further, these results can be seen in Figure 2, when directly comparing the engineering classes' responses to the responses from both biology classes. There were several categories where the students gave the responses at similar rates, such as course specific study tips, course expectations, and instructor interactions. On the other hand, the engineering classes' students gave future students more general study tips, while the biology class student gave tips about reading the book significantly more often. These observations would suggest that students believe different techniques are more useful in some types of classes, rather than others.

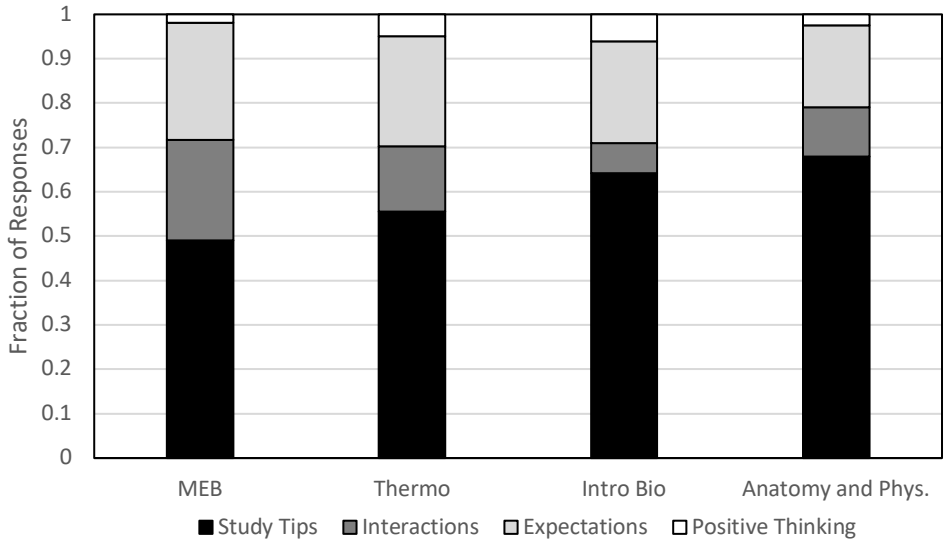

Figure 1. Overall summary for types of advice given in the four courses

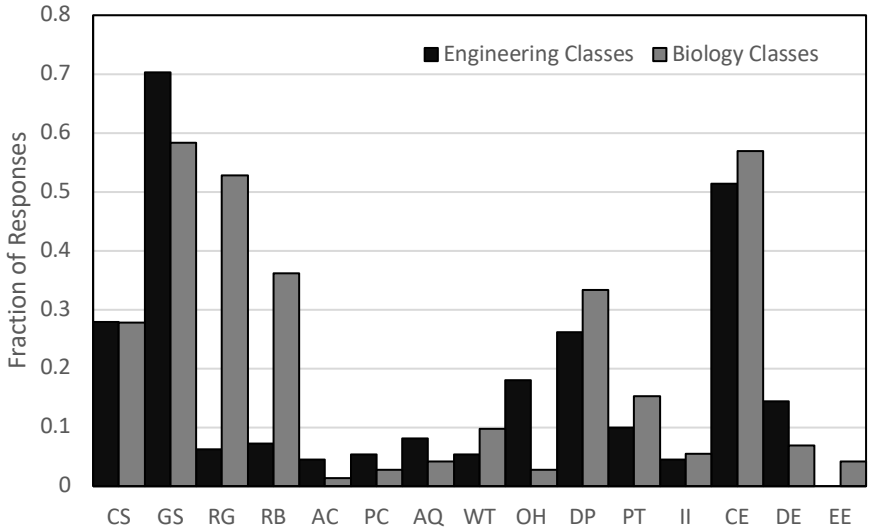

Figure 2. Sub-category types of advice given in the four courses grouped by subject area

Engineering and science classes are typically seen as difficult, but high structure courses are being utilized to improve the overall performance of students. The presented information can be useful in designing future high structure courses; combining current studies in high structure courses with what students believe made them successful could optimize student learning. From the data, it can be concluded that the different classes require different techniques to be successful, so performance can be optimized by giving students the tools to be succeed.

This study utilized small sample sizes and only had one section per class. This limits comparisons that can be made in the study, but in the future, more data will likely be added to help address this limitation. The study will also be expanded in the future to include more online and summer classes, in addition to the traditional face-to-face classes. This will help determine whether students need the class to be structured differently from traditional face-to-face classes.

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