



## Chemical engineering students' emotions towards biology

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# **Work-in-Progress: Chemical engineering students' emotions towards biology**

## Introduction

Emotions and attitudes towards a subject can play a large part in a student's decision to take more courses or pursue a major in that subject area. The theory of planned behavior states that a person's intentions to perform a behavior can be directly tied to their attitudes towards that behavior [1, 2]. For example, engineering students likely have strong positive emotions and attitudes towards math which could be a reason that they major in engineering. Positive attitudes or emotions may also impact retention of students in a major, as positive feelings towards engineering have been shown to be correlated with retention rates in engineering programs [3]. This can have important outcomes with regards to diversity in engineering programs as females have been shown to have more negative attitudes or feelings towards engineering than males [4], which may contribute to differences in gender balance in some engineering programs.

As attitudes and emotions are important in shaping a student's interests and major choice, it is important to explore these facets with regards to specific majors and career choices. Biology is becoming an integral part of chemical engineering education, and biological courses are even required in curricula for chemical engineering programs with the terms "biochemical" or "biomolecular" in their names [5]. While chemical engineering students are therefore being exposed to more and more biology, it is unknown whether they have positive or negative emotions towards biology. Indeed, from the authors' own anecdotal experiences, chemical engineering students do not seem to be overly positive or excited about biology. The goal of this study was therefore to test the hypothesis that chemical engineering students have overall negative emotions towards biology by surveying students and asking them to explain what emotions they have towards biology and why.

## Methods

Sophomore chemical engineering students enrolled in two sections of a material and energy balances course in Spring 2019 ( $n = 177$ ) were invited to participate in this study by giving their consent and completing a survey. This study was determined to be exempt by our university's Human Subjects Research Committee.

The survey used in this study was developed using the Attitudes towards the Subject of Chemistry Inventory (ASCI) [6, 7] and the Attitudes towards the Subject of Math Inventory (ASMI) [8] as a guide. The survey was designed to assess students' emotions towards biology. The survey consisted of nine pairs of adjectives based on the semantic differential technique [9] wherein respondents choose between pairs of terms (e.g. exciting – boring) on a seven point scale to measure their emotional response to a topic. The students were instructed to "Rate how well these words describe your feelings about biology. Think carefully and try not to include your feelings toward biology teachers or biology courses." The nine pairs of adjectives were developed by surveying engineering students in an introductory physics course by asking them to "Please list three emotions that you feel when you think of biology. Think carefully and try not to include your feelings toward biology teachers or biology courses." A total of 219 students

responded and listed 584 total emotions. These students may or may not have been enrolled in college biology, so they may be basing these emotions on high school or college coursework. The most common responses were used and adapted as the nine pairs of adjectives in the survey. The survey also asked students to choose whether, overall, they had positive or negative emotions towards biology and to explain why they made that choice. The survey was given in class and 139 students (79%) completed it. While students were forced to choose between overall positive or negative emotions towards biology, in their explanations they could leave comments that had both positive and negative elements.

The open-ended answers to the question where students had to explain why they had overall positive or negative emotions towards biology were analyzed using a thematic analysis method based on previous studies [10, 11] as follows. Two of the authors of this paper each independently read the 139 responses and came up with a list of themes or codes that best described them. The list of themes was discussed and a consensus list was formed. Each researcher then independently coded each response. The coded responses were compared and the responses that were not in agreement were discussed one by one until consensus was reached for each response. The list of themes used in this analysis are shown in Tables 1 and 2.

## Results

Students were asked to choose, overall, if they had positive or negative emotions towards biology. In this population of 139 sophomore chemical engineering students, 109 (78.4%) responded positively and 30 (21.6%) responded negatively.

After choosing positive or negative, students were asked to explain their choice. While the majority of students left only positive or only negative comments, 16.5% ( $n = 23$ ) left both positive and negative comments. The most common reason (represented in 27.5% of responses) for having overall positive emotions towards biology was some unspecific or general positivity for biology which included interest or enjoyment without further explanation. (Table 1). The second most common reason (23.7%) was that biology and its applications is important for humanity or society. Of note, only 10.0% of explanations noted that they have positive emotions for biology because biology is important for their careers.

There were two explanations for why students have negative emotions towards biology that were most frequently cited (each represented in 28.1% of responses). One was that students had a poor biology course experience based on the course structure, the assignments, or the instructors (Table 2). Even though the survey instructions stated to “try not to include your feelings toward biology teachers or biology courses,” students still most frequently mentioned negative course experiences. The other most frequently cited explanation was that biology is memorization heavy and includes too much terminology.

An analysis of the semantic differential responses is still underway and will not be presented in this paper at this time. The presentation of these results will occur at the conference if completed by then.

Category	Fraction of surveys with representative comment	Example survey response
Unspecific positivity about biology	27.5%	“I've always been interested in biology which is why I have a positive emotion towards it”
Biology is important for humanity	23.7%	“I think biology can be pretty fascinating and applicable to life”
Biology as a discipline is interesting	11.5%	“The mechanisms and functions of molecules in life systems is an interest of mine”
Enjoy learning about biology	11.5%	“I enjoy the topics, and I feel like it is the most challenging subject for me personally”
Biology is important for career goals	10.0%	“I want to be more in the biomedical field. My perfect job is combining math, chemistry, and bio”
Prior experience in a biology course or lab was positive	10.0%	“I did a lot of bio in high school so I am much more comfortable doing it”
Biology is important for health or medicine	6.2%	“Biology helps me to know more detail about how body function works”

Table 1. Summary of chemical engineering students' explanations for why they have positive emotions towards biology (n = 131 codes applied to 117 students who left positive comments).

Category	Fraction of surveys with representative comment	Example survey response
Poor biology course experience	28.1%	“Everything [in the class] was too general and the workload was huge”
Biology is memorization heavy	28.1%	“Because there is so much material to remember it turns into memorization rather than actual learning and application”
Biology is boring or uninteresting	15.8%	“Bio is easy and intuitive, but a little boring”
Biology is confusing	15.8%	“I don't enjoy the content of biology and find some of it hard to understand and so I feel more negative towards it”
Biology is not important for career goals	7.1%	“I do not think that any of it really applies to what I do in my major courses”
Unspecific negativity about biology	5.3%	“I do not like biology”

Table 2. Summary of chemical engineering students' explanations for why they have negative emotions towards biology (n = 57 codes applied to 45 students who left negative comments).

## Discussion

The results from this study suggest that this population of sophomore chemical engineering students have overall positive emotions towards biology that are most frequently explained by some unspecific and generic interest and enjoyment for biology, following by the importance of biology for humanity. The most commonly cited reasons for having negative emotions towards biology was a poor biology course experience and that biology requires too much memorization. These results are important to consider for the instruction of chemical engineering students as while the majority have positive emotions, the explanations for why students have negative emotions can be used to improve course design and curricula in the future. For example, because many students had negative emotions due to memorization, study tips for how to learn terminology well can be introduced early in the course and also instructors can let students know early on that they are essentially learning a new language so again more specific instructional and study strategies can be used. For the group of students who said that biology is not important for their careers, instructors can use more specific examples in class that clearly show how biology can be used in engineering applications (e.g. generating biofuel from algae) or how biology itself can be engineered for medical purposes (e.g. using CRISPR for gene therapy).

These results do not support the hypothesis of this study in that chemical engineering students would have overall negative emotions towards biology. While the students in this population have overall positive emotions, they may still have negative attitudes (other than emotions) towards biology which may affect their decisions to pursue a biology related engineering career. One possible area in which they may have negative attitudes is utility value which is a measure of the value one puts on a task in terms of how the task will positively impact their life or career [12]. If a student had low utility value for biology, this would suggest that they do not think biology is relevant or useful for their careers. Based on anecdotal observations, this is a likely outcome for chemical engineering and other engineering students as they may not see the direct relationship or benefit from learning biology to using it in their careers. Additionally, the results from this study support this notion as only 10.0% of students' comments noted that biology is useful for their career.

Future work on this project will involve analyzing the semantic differential scale data and also repeating the thematic analysis with other cohorts of students. Additional types of attitudes towards biology will also be explored, including utility value (and the other values involved with expectancy value theory) and self-efficacy towards biology. This will be an important area to explore because even though emotions do not seem to be the reason while anecdotally engineering students may not be enjoying biology, these other psychological aspects could potentially explain this observation.

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