Supplemental Material

CBE—Life Sciences Education

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Supplemental Material for "Peer-Modeled Mindsets:
An Approach to Customizing Life Sciences Studying Interventions"

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Contents

1. Overview

This document provides supplemental information for the research presented in this article.

In the Research Questions and Concordance with Preregistered Analysis Plan section, we present the research questions from our preregistered analysis plans and differences between the reported and planned analyses.

In the Sample Details section, we provide additional information on the samples for each of the two studies.

In the Covariates from the Baseline Survey section, we provide items and reliability information for covariates from the baseline survey.

In the Experimental Balance on Baseline Characteristics section, we report tests for balance between the two experimental conditions on baseline variables.

In the Intervention Prototype for Interview Purposes section, we provide the intervention prototype that was shown to interviewees in the present research.

In the Intervention and Control Materials section, we provide the full set of intervention and control materials from the present research.

In the Peer-Modeled Mindset Intervention Development Protocol section, we provide a full protocol for developing a customized peer-modeled mindset intervention.

In the Models Demonstrating Lack of Differential Attrition on Self-Reported Outcomes section, we report models showing that missingness on self-reported outcomes did not significantly differ as a function of condition or Condition × Baseline Measure interactions.

In the Multiple Regression Models for Primary Outcomes section, we report findings from regression models that include the same moderators and covariates as the Bayesian Causal Forest models.

In the Multiple Regression Models for Additional Preregistered Outcomes section, we report findings from regression models on additional preregistered outcomes that were not reported in the main text.

In the Preregistration Files section, we reproduce the full preregistration (also available at https://osf.io/ywp9q).

2. Research Questions and Concordance with Preregistered Analysis Plan

Below, we list what was planned as an analysis and what analyses were presented in the article text.

Research Questions

RQ1: Will students who receive the intervention develop more positive attitudes and beliefs about the class?

RQ2: Will students who receive the intervention earn higher grades in the class?

RQ3: Will intervention effects on attitudes/beliefs and grades depend on students' racial/ethnic, gender, and socioeconomic backgrounds or early performance in the class?

Planned Analyses

- Our preregistered plan was to regress each preregistered outcome on a single intervention contrast and covariates in OLS regression (RQs 1-2) and to test male vs. female identified gender, first-generation college student status, race (Black/Hispanic/Latinx/Indigenous vs. not), and Exam 1 score as moderators in a separate model (RQ3), using Bayesian Causal Forest (BCF) analysis as a robustness check

Differences between Reported and Planned Analyses

- We reported BCF as the primary analysis, rather than a robustness check, because BCF provides conservative estimates of treatment effects and heterogeneity. This reduces the likelihood of Type-I error and is consistent with calls to abandon the all-or-nothing thinking inherent in statistical significance testing and instead report probabilities that a hypothesis is true as a continuous measure (Gelman, 2016; McShane et al., 2019; see Bryan et al., 2019, Yeager et al., 2019, 2021, for other examples of published research that employs this approach to hypothesis testing).
- We report estimates from the preregistered OLS regression model in section 10.
- We tested only a single model that included moderators, rather than separate main effects and moderation models, for parsimony.
- We did not include Exam 1 score as a moderator because it was measured after a dose of the intervention had already been administered.
- We did not report effects on outcomes from the second (of three) surveys because the full intervention dosage had not yet been administered at this point (students had completed two of three intervention activities).
- For conciseness, we reported intervention effects on key, immediately relevant preregistered outcomes in text. We report effects on other preregistered outcomes in section 11. In addition, as described in text, we tested effects on several exploratory outcomes.

3. Sample Details

The data for this study came from students across three instructors' sections of the first introductory biology course in a two-course sequence at a large, public university. The number of students in each of the three instructors' sections were 200, 300, and 417. The vast majority of students in this class (90%) were in their first semester of college while taking this course. 30 students withdrew before completing the course. However, these students are retained in the sample for the purpose of analyzing dichotomous outcomes for which their lack of course completion is relevant (i.e., receiving an A, continuing to the next course in the sequence).

642 students were women, 272 were men, and gender was missing for 3 students. 293 students were from underrepresented racial/ethnic groups (i.e., Black, Hispanic/Latinx, Native American/Alaska Native, or Native Hawaiian/Pacific Islander), 514 students were from racial/ethnic majority groups, and race data were missing for 110 students. 234 students were first-generation college students (i.e., neither parent had completed a four-year college degree), 579 students were continuing-generation students (i.e., at least one parent had completed a four-year college degree), and generational status data were missing for 104 students. Models regressing missingness indicators for each demographic variable on experimental condition indicated that missingness did not differ as a function of condition (ps > .524).

4. Covariates from the Baseline Survey

Baseline covariates from the pre-intervention survey included attributions of struggle to strategy usage, reliance on memorization in high school biology, feelings of belonging in the course, uncertainty about belonging in the biological and health sciences, and confidence about performing well in the course. Items and reliabilities are presented below. All items were measured on a 6-point *Strongly disagree—Strongly agree* Likert-type scale, except for attributions of struggle to strategy usage, which was measured on a 5-point *Not at all likely to think this—Extremely likely to think this* Likert-type scale.

Attributions of struggle to strategy usage (r = .56, α = .72)
- Pretend that, later today or tomorrow, you got a **bad** grade on a very important assignment in this class. Honestly, if that happened, how likely would you be to think these thoughts?
    - "This means I'm probably not very good at biology."
    - "I might just not have the right background to be successful in this course."
    - "I can get a higher score next time if I find a better way to study."
    - "I will need to change the way I prepare for exams in this class if I want to get a higher score."

Reliance on memorization in high school biology
- In high school, I mostly used memorization to study for biology.

Course belonging (α = .87)
- I feel comfortable in this class.
- I feel accepted in this class.
- I feel like I can be myself in this class.
- I feel like I belong in this class.

Field belonging uncertainty (r = .76, α = .86)
- I don't know if I really belong in the biological and health sciences.
- Sometimes I'm not sure if I really belong in the biological and health sciences.

Confidence about performance (r = .73, α = .84)
- I am confident that I will do well in this course.
- I expect to get a good grade in this course.

5. Experimental Balance on Baseline Characteristics

Random assignment produced balance between the intervention and control groups in terms of reliance on memorization in high school biology, course belonging, field belonging uncertainty, and confidence about performance. There was, however, a small significant difference between conditions on attributions of struggle to strategy usage, with baseline values slightly higher in the intervention group than the control group ($p = .041$). This baseline difference highlights the importance of including this variable as a covariate in all models of treatment effects. In addition, given these differences in baseline attributions, students in the treatment group had less room to increase on this variable, making tests of treatment effects more conservative. See Table S1.

Table S1. *Experimental Balance on Pre-Treatment Characteristics.*

Variable	Control			Intervention			Comparison	
	M	*SD*	*N*	*M*	*SD*	*N*	*t*	*p*
Attributions of struggle to strategy usage	4.15	0.67	438	4.24	0.62	442	2.05	.041
Reliance on memorization in high school biology	4.37	1.06	438	4.35	1.02	442	-0.27	.785
Course belonging	4.78	0.71	402	4.73	0.74	410	-0.96	.338
Field belonging uncertainty	2.80	1.11	438	2.87	1.11	442	0.84	.401
Confidence about performance	4.56	0.77	438	4.54	0.77	442	-0.45	.656

6. Peer-Modeled Mindset Intervention Development Protocol

Stage 1: Draw on Prior Experiences Teaching the Class

Stage 1, Step 1: Identify potentially harmful mindset(s)

What is a "harmful" mindset?
- Mindsets are beliefs, assumptions, or perspectives that shape how students experience a course
- Mindsets can be harmful when they imply that behaviors we normally understand to be maladaptive (e.g., reducing effort, dropping the course or leaving the field) are a logical course of action
  - Examples of harmful mindsets:
    - A student's belief that struggle signals a lack of potential to succeed in the course and/or the field
    - A student's belief that they are alone in doubting whether they belong in the class, and/or that doubts about belonging are not likely to go away over time
    - A student's belief that the main purpose of school is earn grades/a degree, rather than to work toward achieving more purposeful goals

How to identify common harmful mindsets within a class?
- Instructors may have direct insight into harmful mindsets within a class through previous conversations with students
- In some cases, the relevant maladaptive behavior may be apparent, and some inference may be necessary to identify a potential harmful underlying mindset
  - E.g., A student's continued reliance on surface-level strategies, despite struggling, may indicate that they attribute struggle to something else (e.g., a lack of potential to succeed in the field)
- Informal interviews with former students in the class may help to identify harmful mindsets they or their peers held
  - In these interviews, it can help to situate the discussion in the relevant overarching problem in the course (e.g., "Many students struggle throughout the course, and I'm hoping to figure out why so that I can help future students")
  - Relevant prompts include the following. The goal is to (a) get students to tell real stories about their experiences in the class, and (b) to ask not only about what happened, but about *how they felt* and *what they thought* during those experiences. This is what can reveal the relevant harmful mindset
    - Tell me about a time that you (or one of your peers) struggled in the class
      - …how did you feel when that happened?
      - …what was your thought process during that?

Stage 1, Step 2: Identify positive change(s) in mindset that have helped students adapt to the class

What is a "more positive" mindset?

- An alternative to the harmful mindset that implies that behaviors we normally understand to be adaptive (e.g., increasing effort, persisting through challenge) are a logical course of action
  - Examples of more positive mindsets (alternatives to the harmful mindsets, above):
    - A student's belief that struggle is normal and signals a need to adjust one's approach to studying
    - A student's belief that doubts about belonging are common and likely to fade over time
    - A student's belief that the main purpose of school is to make progress toward personally-important and purposeful goals

How to identify a positive alternative to the harmful mindset
- Consider what alternative belief would imply a positive course of behavior
- Informal interviews with former students who overcame struggle may help to identify a positive alternative
  - Ask these students about how their thinking changed over time
    - E.g., "You said you doubted whether you were cut out for the medical field after you failed your first exam. How did that change throughout the semester?"

Stage 1, Step 3: Identify former students who experienced positive change(s)

How to identify students who experienced the positive change in mindset
- A reliable way to identify students who overcame struggle is to look at students' grades, targeting students who did poorly on an early evaluation (e.g., the first exam) but were ultimately successful in the course (e.g., received an A)
- Another option is to target students you already know or have spoken to about their experiences in the course
- You might also use other sources of data to identify students who experienced a positive change (e.g., based on former students' responses to a survey or course evaluation)

Stage 2: Prepare to interview former students

Stage 2, Step 1: Develop intervention prototype that models the targeted change

What are the goals of the intervention prototype?
- The goal of the intervention prototype is to prime former students' thinking about the targeted change in mindset
  - This can help bring to mind each student's own relevant experiences, whether they are similar or different to those described in the prototype

What are the components of the intervention prototype?
1. An introduction that explains:
   a. The source of the information to be presented (e.g., a survey, conversations with previous students)

      b. The purposes of the activity (typically to share previous students' experiences in the course, to better understand the participating student's thoughts and feelings, and to help provide incoming students with more accurate expectations about the course)

2. A summary of the key information and themes; for example:
   a. It is common for students to find it more challenging to learn the material in college biology than high school biology
   b. It is common for students to struggle early in the course and worry about whether they can be successful
   c. By adjusting study strategies, students who struggle at first can learn the material and do better on exams
   d. This helps students to gain a deeper understanding of biology and become more confident

3. A set of quotations from former students that communicate the key information and themes
   a. Note that the specific language can be edited (heavily, if necessary) from real student quotations, or written by the intervention designers based on conversations with former students, to communicate the key themes. This is because the goal for the prototype is just to prime former students' thinking rather than to provide direct quotes—direct quotes from former students will be included in the final intervention

4. A writing activity that asks students to describe why they think students have the types of experiences communicated in the intervention (e.g., why it is common for students to struggle early in the course, but to later overcome these struggles as they find new and better ways to study)

Stage 2, Step 2: Recruit small focus groups

- Recruit 2-4 focus groups of $\leq$ 5 former students
- Target students who are likely to have experienced the targeted change in mindset
  - A simple way to do this is to target students who received poor grades early in the semester but later performed well in the course (e.g., received an A on the final exam)
  - Instructors may also recruit students who they know and believe experienced the targeted change in mindset in the course
- Target a diverse group of students (e.g., in terms of gender, race/ethnicity), ensuring that the most vulnerable groups of students (e.g., those historically underrepresented in the field, those susceptible to negative stereotypes within the field) are well represented

Stage 3: Conduct recorded interviews with former students

Note: An appropriate interview length is ~60-90 minutes

Stage 3, Step 1: Position interviewees as experts who can help new students

Who should conduct the interviews?
- It may be ideal for interviews to be conducted by a neutral third party, such as a teaching assistant, colleague, or researcher so that students do not feel pressured to censor descriptions of their experiences in the course
  - However, if necessary, an instructor may personally conduct the interviews

How can the interviewer position students as the expert?
- During introductions, the interviewer should explain that they need the interviewees' expertise to help them understand recent students' experiences in introductory biology
  - If the interviewer has never taken the course, it is useful to point this out here to highlight the interviewer's own lack of expertise

Stage 3, Step 2: Create a safe environment

How can the interviewer create a safe environment?
- Promise that interviewees' names will be withheld from any video clips that are shown to incoming students
- Tell interviewees that any comments made during the interview can be taken off the record at any point (e.g., by emailing the interviewer afterward), and that any such comments will not be shown to future students

Stage 3, Step 3: Have interviewees go through the prototype

How should the interviewer introduce the prototype?
- Explain that the department developed this activity to give incoming students more accurate expectations about the course
- Emphasize that the activity is only a draft and the goal of the present session is to improve it by getting feedback about what does and doesn't resonate from students who recently took the course, like them

How should the prototype be administered?
- The prototype can be administered through an online survey platform (e.g., Qualtrics), a simple word document, or any other format
- The interviewees should be given privacy while they complete it. If completed virtually (e.g., through Zoom)—which is recommended for ease of generating video clips— interviewees can be asked to turn off their cameras while they complete it. If completed in person, the interviewees can be allowed to spread out and find a separate space to complete the activity, if such space is available

Stage 3, Step 4: Ask follow-up questions

What questions should be asked?
- The first question should be what resonated with them from the activity and what experiences seemed to be missing from it

- This question should be highly generative, leading students to talk about their personal experiences. In many cases, this may be the only formal question needed for the entire interview
- Additional questions can be prepared in advance, in case participants do not readily open up about their experiences
  - E.g., Can you tell me about a time when you felt like (or felt different from) the students in the story?
  - E.g., Can you tell me about a time when you struggled in the course? What did that feel like?
  - E.g., How did you overcome this struggle? What did that feel like?

Stage 3, Step 5: Listen and probe for stories that vividly model (a) the initial mindset, (b) the change in mindset, and (c) eventual success

How can the interviewer listen and probe to get the most out of students' initial responses?
- Listen carefully for students' experiences that related to a-c above
- When students describe these things, ask them to elaborate
  - The most important thing to uncover is (a) their thought process and (b) their associated emotions
    - E.g., "What was that like?"
    - E.g., "What kinds of thoughts were going through your head when that happened?"
    - E.g., "How did that feel?"
  - An effective way to get vivid descriptions is to ask for specific stories that illustrate broad experiences students talk about
    - E.g., If a student says that they did poorly on the first exam, ask them recall the whole process of the exam—the days or weeks leading up to it, the actual exam itself, and after the exam
    - Encourage them by explaining that it is helpful for incoming students to hear specific stories like these because they will probably have similar experiences
- Encourage students to "riff" on one another's stories
  - E.g., If you see a student nodding along as another student speaks, you can later ask them if they had a similar experience or wanted to add something
- Ensure that you get descriptions of *each* of points a-c
  - E.g., If students mostly just talk about their initial struggle and doubts, encourage them to talk about how their mindset changed during the semester and their eventual success
- When each of a-c have been covered in detail, with vivid accounts to illustrate them, the interview can be concluded

Stage 4: Develop intervention activities

Stage 4, Step 1: Choose interview clips that vividly model the change in mindset (i.e., a-c, above)

Processing the interviews

- One effective method for processing the interviews is to watch them (starting after the intervention prototype) and to save only clips that vividly model points a-c above using basic video-editing software, such as iMovie or Windows Movie Maker
- These clips can be sorted in terms of which themes they most clearly convey (e.g., the initial experience of struggle and doubt, the process of experimenting with different study strategies)

Choosing interview clips
- Once the interview clips are sorted by category, specific clips can be chosen for inclusion in intervention activities by (a) finding the clips that seem most powerful, personal, or vivid, and (b) identifying which clips might be most relevant at different times of the year (e.g., a clip about studying for the final exam may be more useful later in the term)

Creating coherent videos
- The interview clips can then be assembled to convey the relevant theme at a given time in the semester
  - E.g., If providing one of three intervention doses prior to the first exam, this intervention video may focus on the experience of struggle on the first exam, the resulting feeling of doubting one's ability, the realization that struggle is common and can be overcome with better study habits and strategies, and the ultimate experience of success
- It is useful to include slides with explanatory text before particular sets of video clips to explain the themes those clips will discuss

Stage 4, Step 2: Write accompanying narrative text and writing prompts

Process for writing narrative text and writing prompts
- The narrative text and writing prompts can be easily adapted from the intervention prototype used for the former student interviews (or from the materials used in the present study)
  - Again, the introductory text should (a) provide background on the interviews, (b) summarize the core themes, (c) show students the intervention video (in place of the quotes used in the intervention prototype), and (d) include a writing activity asking students to describe why they think many students have the types of experiences communicated in the intervention (e.g., why it is common for students to struggle early in the course, but to later overcome these struggles as they find new and better ways to study)

Stage 4, Step 3: Sequence elements into coherent intervention activities

Create complete intervention activities
- The intervention text, video, and writing prompts can be incorporated into a single activity
  - It may be easiest (though not necessary) to use some sort of online survey platform, such as Qualtrics, to create these

- The number and timing of interventions should be tailored to expected points of vulnerability in the semester
  - E.g., In the present study, these timepoints were (1) before the first exam, to prepare students for the possibility of initial struggle, (2) soon after the first exam, to help students reappraise challenges they encountered on the first exam, and (3) prior to the final exam, which was cumulative and required students to integrate concepts learned throughout the term
- Each activity should reiterate the core intervention message, but vary somewhat to remain relevant to the point in the term at which they are to be shown

7. Intervention Prototype for Interview Purposes

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Overview

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A team from the UT Biology Department and Psychology Department is interested in students' experiences in the transition to college. We have asked a group of previous BIO311C students what they thought (reported in the "Biology Students Survey", which you'll see later). Now we are interested in the experiences and attitudes of incoming BIO311C students—you and your future classmates.

<u>This survey has three purposes:</u>

(1) To share with you the experiences of previous students about their experiences in BIO311C.

(2) To better understand your thoughts and feelings about BIO311C

(3) To help us provide incoming biology students in future years with more accurate expectations about the transition from high school biology to BIO311C.

As you can imagine, the transition to new courses can go smoother if you know what to expect. We want to learn more about students' experiences coming into BIO311C, so we can pass this information on to future students to help them learn in their transition to college.

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Overview

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To help us better understand students' transition to BIO311C, we would like to ask you for your help in understanding the results and meaning of the <u>Biology Students Survey</u>. As an incoming freshman who is just starting the transition to college, your thoughts and feelings about coming to college are very important to us.

So first we will share with you some of the results of the Biology Students Survey. Later we will ask you to help us interpret them. Please read through the summary of results on the next pages, and take your time. Afterward, we will ask you for your thoughts and reactions to these materials.

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Biology Students Survey: Introduction

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What is the Biology Students Survey?

The survey focused on students' transition from high school biology to BIO311C.

Who completed the Biology Students Survey?

These data were collected from a broad sample of UT Sophomores, Juniors, Seniors, and recent graduates who took BIO311C, so the experiences described generally were the same for UT students at different stages.

Students from all groups reported similar experiences. There were no differences by students' race/ethnicity, gender, class year, and so forth.

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Biology Students Survey: Introduction

Almost all current students reported at least some positive experiences in BIO311C, including learning new material, exploring their interests, making new friends, etc.

But here we will focus on some of the *challenges* students face in the transition from high school biology to BIO311C, and how students overcome these challenges with time.

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Biology Students Survey: A Summary of Results

Almost all students reported that they experience at least some level of challenge adjusting to BIO311C. Students commonly reported that when they started the course, they:

- Found the material to be more challenging than the material in high school biology
- Were not able to do as well as they had hoped on the exams when they used the same study strategies that had worked for them in high school (e.g., rote memorization)
- Worried that they might not actually be cut out for a career in the biological, medical, or health sciences

But with time, students came to feel that they could be successful in BIO311C. They reported:

- Adjusting to the level of the material by finding new ways to master it
- Experimenting with new study strategies that helped them to learn the material and do better on the exams
- Gaining a much deeper understanding of biology once they found better ways to learn the material
- Gaining confidence in their ability to succeed in a biology-related major and career path

Conclusions

Most students struggled at least somewhat when they began BIO311C. With time, they found new, better ways to master the material and they came to feel a new appreciation and sense of confidence in biology.

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Biology Students Survey: Representative Quotes

Next you will read three quotations that illustrate the major findings of the Biology Students Survey. These quotations are representative of the responses of participating students across different gender identities, races/ethnicities, class years, and so forth. Quotations have been edited for clarity.

Please take your time and read these carefully.

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Biology Students Survey: Representative Quotes

Quote 1:

I took biology in my freshman year of high school. I was usually able to do well on tests and quizzes by just memorizing all the required information. I really like biology and I want to be in healthcare. As I prepared for Exam 1 in BIO311C, I continued to study by memorizing the textbook and looking over questions in our assignments. I was disappointed when I didn't do as well as I had hoped on exam 1.

 After talking to other students, I realized I wasn't alone in my struggle. I started going to office hours to get some guidance on how best to study. I realized that just memorizing facts wasn't going to be enough to really do well in biology. I asked my friends about different study strategies and eventually figured out what helped me learn best. I made a schedule and put study time on my calendar, and forced myself to be disciplined and not get distracted by social media during that time. I also joined a group of students to study together. In the group, we would try to explain topics to each other to make sure we understood them. At first, even when I thought I understood topic, I realized I didn't understand completely when I would try to teach it to others. So, my goal became to learn the material well enough that I could teach it to other people. After that, I started doing a lot better on the exams.

Looking back, I didn't just learn biology content in BIO311C—I learned how to learn more effectively, and that skill has really helped me in my other classes.

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Biology Students Survey: Representative Quotes

Midsemester, the material was getting complex and I started feeling overwhelmed. Sometimes I had multiple exams for different courses in the same week. I decided to be more disciplined and organized with my studying. I created a dedicated study time on my calendar for different

courses. A bunch of my friends in the class were feeling overwhelmed and unmotivated too and a few of us decided to discuss our situation with our TA, and I am so glad we did. Our TA mentioned that when she took this class, she would draw out cellular processes until eventually she could do them from memory and even explain them to other people. I hadn't done that before but I decided to give it a try. It was a little tricky at first, but it worked faster than I thought. I could learn new cellular processes and draw them along with names of all proteins and enzymes involved. It was actually pretty exciting, and it felt great to be able to clearly understand some of the minor details of these processes as well as see the bigger picture—I felt proud of my ability to understand these complex processes and it gave me a new appreciation for biology. It didn't just feel like random facts that I was memorizing anymore… I was learning about how living beings actually function.

I showed a few friends how I was learning and after that, our study sessions were a lot more fun and useful. some of us have even maintained our study group as we've gone into more advanced biology classes. It's kind of become our "thing" to get creative and find interesting ways to learn the material and share our ideas with each other.

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Biology Students Survey: Representative Quotes

The material I learned in BIO311C has been helpful in my upper division courses. For example, in Intro Bio I learned about molecular mechanisms of gene expression. Then in my upper division courses, we went deeper into this. It was really exciting to get to apply the skills and knowledge I had gained in BIO311C to learn more complex material in advanced courses. I am glad I took the time to understand and retain the information in Intro Bio so I could build on this knowledge and not spend time relearning the basics. One strategy I learned in BIO311C that helped me understand the connection between bite size concepts was making concept maps. Through this activity I saw connections across the course topics that I had missed when I just read about them. I have continued using this learning strategy in my other courses as well.

Seeing connections between topics has helped me gain a clear understanding of concepts. I came to realize how topics tend to build on each other through successive courses in my major. Every course I took, I made it a point to visit the instructor's/TA's office hours to get clarification on concepts. I spoke with them not just about content, but also careers and about exciting and relevant advances in the field I had read about. I am glad I explored different learning approaches in my Intro Bio course—if I had just kept studying the way I studied in high school, I don't think I would have been as successful in my upper division courses as I ended up being. Using different approaches to learn content over the years has helped me understand complex concepts, which has increased my appreciation for biology and made me more excited (and prepared to pursue my dream career.

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Your Thoughts on the Biology Students Survey

<u>Review:</u> Most students struggled at least somewhat when they began BIO311C. However, over time students reported finding new and better ways to master the learn and they came to feel a new appreciation and sense of confidence in biology.

<u>Writing Activity:</u> In an effort to further understand the transition to BIO311C, we would like to ask you why you think this would be so.

Please answer the two-part question in the box below.

Please <u>illustrate your answer with examples from your own feelings about starting BIO311C</u>. You can also draw on the quotations, which are copied below. For instance, consider worries or concerns you might have about starting BIO311C, how these concerns are likely to be common when students begin new, challenging college-level science courses, and how they are likely to change over time as you learn new ways to study and master the material.

Please take as much time as you like.

Note: Your response may be provided, anonymously, to incoming BIO311C students in future years to help give them a better understanding of the transition to this course.

<u>Type Your Answer in the Box Below</u>

First, describe why you think it is common for students to struggle when they first begin BIO311C.

Then, describe *how and why* you think students overcome these initial struggles as they find new and better ways to learn and understand the material. For example, you can describe how finding a good study group, teaching the content to others, making concept maps, drawing processes, or any other strategy can help students to gain a better understanding of challenging biology content. Please illustrate your response with examples from your own experience.

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8. Intervention and Control Materials

All intervention and control materials are shown below. Video clips are hosted here https://osf.io/ywp9q.

8.1. Intervention Activity 1 (Before Exam 1)

Overview

A team from the UT Biology Department and Psychology Department is interested in students' experiences in the transition to college. We have asked a group of previous BIO311C students about what it was like to be an BIO311C student (reported in the "Biology Student Interviews", which you'll see later). Now we are interested in the experiences and attitudes of this year's incoming BIO311C students—you and your future classmates.

This activity has three purposes:

(1) To share with you the experiences of previous students about their experiences in BIO311C.

(2) To better understand your thoughts and plans for BIO311C.

(3) To help us provide incoming biology students in future years with more accurate expectations about how to be successful in BIO311C.

As you can imagine, the transition to new courses can go smoother if you know what to expect. We want to learn more about students' experiences coming into BIO311C, so we can pass this information on to future students to help them learn in their transition to college.

[PAGE BREAK]

Overview

First, we will share with you some of the findings from the Biology Student

Interviews. Later we will ask you to help us interpret them. Please read through the summary of findings on the next pages, and take your time. Afterward, we will ask you for your thoughts and reactions to these materials. As an incoming student to BIO311C, your thoughts and feelings about starting this class are very important to us.

[PAGE BREAK]

Biology Student Interviews: Introduction

What are the Biology Student Interviews?

The interviews focused on students' transition from high school biology to BIO311C.

Who completed the Biology Student Interviews?

These data were collected from a broad sample of UT Sophomores, Juniors, Seniors, and recent graduates who took BIO311C in past years, so the experiences described generally were the same for UT students at different stages.

Students from all racial, ethnic, gender, and class year groups reported similar experiences.

[PAGE BREAK]

Biology Student Interviews: A Summary of the Findings

Almost all students reported that they experienced at least some level of challenge adjusting to BIO311C. Students commonly reported that when they started the course, they:

- Found the material and the exams to be more challenging than the material in high school biology
- Were not able to do as well as they had hoped on the exams when they used the same study strategies that had worked for them in high school (e.g., "cramming" for exams, using rote memorization)
- Worried that some of their early struggles could mean that they were not cut out for a career in the biological, medical, or health sciences

But with time, students came to feel that they could be successful in BIO311C. They reported:

- Experimenting with new study strategies that helped them to deeply understand and retain the material, which helped them do better on their exams
- Quitting some of the study habits that may have worked for them in high school biology but didn't work anymore in BIO311C
- Gaining a much deeper understanding of biology once they found better ways to learn the material
- Gaining confidence in their ability to succeed in a biology-related major and career path

Conclusions

Most students struggled at least somewhat when they began BIO311C. With time, they found new, better ways to master the material and they came to feel a new appreciation and sense of confidence in biology.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Next you will watch a few video clips from students who participated in the biology student interviews. These video clips are representative of the responses of participating students across different gender identities, races/ethnicities, class years, and so forth.

We hope you will enjoy hearing from these previous students.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Please watch the video below. When it finishes playing, you can click the "next" button to continue.

<u>Note</u>: The video should begin playing automatically. If it does not, please copy and paste the link below into a **new tab** in your browser. When you finish the video, you can return to this page and click "next" to continue.

<u>Link if video doesn't play automatically</u>: [link to video]

[See Intervention Video 1 at https://osf.io/ywp9q]

[PAGE BREAK]

Your Thoughts on the Biology Student Interviews

Review: Most students struggled with their approach to studying and learning the material when they first began BIO311C. Usually, this was because they didn't know what to change about how they had studied in high school. However, over time students reported adjusting to college-level biology and finding new and better ways to master the material. Then, they came to feel a new appreciation and sense of confidence in biology.

Writing Activity: In an effort to further understand the transition to BIO311C, we would like to ask you why you think this would be so.

Please answer the two-part question in the box below.

Please illustrate your answer with examples from your own feelings about starting BIO311C. For instance, consider worries or concerns you might have about starting BIO311C, how these concerns are likely to be common when students begin new, challenging college-level science courses, and how they are likely to change over time as you learn new ways to study and master the material.

Please take as much time as you like.

Note: Your response may be provided, anonymously, to incoming BIO311C students in future years to help give them a better understanding of the transition to this course.

Type Your Answer in the Box Below

First, describe why you think it is common for students to struggle when they first begin BIO311C.

Then, describe *how and why* you think students overcome these initial struggles as they find new and better ways to learn and understand the material. For example, you can describe how experimenting to find more effective study strategies (e.g.,

finding a good study group, teaching the content to others, drawing processes) can help students to gain a better understanding of challenging biology content.

In your answer, please be sure to describe study strategies that were really common in high school—such as cramming, outlining, or making flash cards—and explain how your approach to learning may need to change to be successful in this course

8.2. Intervention Activity 2 (Before Exam 2)

Biology Student Interviews: Part 2

Welcome to Part 2 of the Biology Student Interviews project!

As a reminder, a team from the UT Biology Department and Psychology Department is interested in students' experiences in the transition to college. We asked a group of previous BIO311C students about what it was like to be a BIO311C student, and now we are interested in the experiences and attitudes of this year's students—you and your classmates.

This activity has three purposes:

(1) To share with you more of the experiences of previous BIO311C students.

(2) To better understand your thoughts and plans for BIO311C.

(3) To help us provide incoming biology students in future years with more accurate expectations about how to be successful in BIO311C.

We want to learn more about students' experiences coming into BIO311C so we can pass this information on to future students to help them adjust during their transition to college.

[PAGE BREAK]

Overview

First, we will share with you some more of the findings from the Biology Student Interviews. The findings you will see today are about **students' experiences with the "midsemester push"**—the period of the semester between the first and final exam.

Later we will ask you to help us interpret these findings.

Please read through the summary of findings on the next pages, and take your time. Afterward, we will ask you for your thoughts and reactions to these materials. As a BIO311C student, your thoughts and feelings are very important to us.

[PAGE BREAK]

Biology Student Interviews: A Refresher

What are the Biology Student Interviews?

The interviews focused on students' transition from high school biology to BIO311C. The section you will see today focuses on students' experiences during the "midsemester push".

Who completed the Biology Student Interviews?

These data were collected from a broad sample of UT Sophomores, Juniors, Seniors, and recent graduates who took BIO311C in past years, so the experiences described generally were the same for UT students at different stages.

Students from all racial, ethnic, gender, and class year groups reported similar experiences.

[PAGE BREAK]

Biology Student Interviews (Part 2): A Summary of the Findings

Almost all students struggled at least somewhat on the first exam in BIO311C. Students commonly reported that when they struggled, they:

- Were surprised or even shocked, as they were used to receiving better grades on exams in high school biology
- Felt a sense of "imposter syndrome"—like they weren't as smart or capable as other students at UT
- Worried that some of their early struggles could mean that they were not cut out for a career in the biological, medical, or health sciences

But with time, students came to feel that they could be successful in BIO311C, even after struggling at first. They reported:

- Seeking advice from professors, classmates, or upper-classmen on how to study more effectively
- Actively engaging with the material in a way that helped them to deeply understand and retain the material, which helped them do better on their exams
- Developing a strong, consistent study routine (rather than "cramming" before exams)
- Appreciating biology more deeply once they found better ways to learn the material
- Becoming more confident in their ability to succeed in a biology-related major and career path

<u>Conclusions</u>

Most students struggled on the first exam in BIO311C. But with time, they found new, better ways to master the material and they came to feel a new appreciation and sense of confidence in biology.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Next, you will watch **part 2** of the set of video clips from the Biology Student Interviews. These video clips are representative of the responses of participating students across different gender identities, races/ethnicities, class years, and so forth.

We hope you will enjoy hearing from these previous students.

[PAGE BREAK]

Biology Student Interviews: What Students Said

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<u>Link if video doesn't play automatically</u>: [link to video]

[See Intervention Video 2 at <u>https://osf.io/ywp9q</u>]

[PAGE BREAK]

Your Thoughts on the Biology Student Interviews (Part 2)

Review: Most students struggled at least somewhat on the first exam in BIO311C. Usually, this was because they didn't know what to change about how they had studied in high school. However, students were able to improve substantially in the course when they (1) asked for help and advice, (2) actively engaged with the material, and (3) developed strong, consistent study routines. Then, they came to feel a new appreciation and sense of confidence in biology.

Writing Activity: In an effort to further understand the transition to BIO311C, we would like to ask you why you think this would be so.

Please answer the two-part question in the box below.

Please illustrate your answer with examples from your own experiences so far in BIO311C. For instance, consider your experiences with the first exam, how any struggles you experienced are likely to be common when students begin new, challenging college-level science courses, and how they are likely to change over time as you learn new ways to study and master the material. Even if you were satisfied with your score on the first exam, please write about why the transition to BIO311C can be difficult and what changes you can make this semester to continue to enhance your understanding of the material.

Please take as much time as you like.

Note: Your response may be provided, anonymously, to incoming BIO311C students in future years to help give them a better understanding of the transition to this course.

Type Your Answer in the Box Below

First, describe why you think it is common for students to struggle on the first exam in BIO311C.

Then, describe *how and why* you think students overcome this initial struggle as they find new and better ways to learn and understand the material. For example, you can describe how seeking help and advice, actively engaging with the content (e.g., testing your comprehension, manipulating processes and scenarios), and developing a strong study routine can help students to gain a better understanding of challenging biology content. Please illustrate your response with examples from your own experience.

In your answer, please be sure to describe changes you might make to your own approach to studying that may help you to be more successful in this course.

8.3. Intervention Activity 3 (Before Final Exam)

Biology Student Interviews: Part 3

Welcome to Part 3 of the Biology Student Interviews project!

As a reminder, a team from the UT Biology Department and Psychology Department is interested in students' experiences in the transition to college. We asked a group of previous BIO311C students about what it was like to be a BIO311C student, and now we are interested in the experiences and attitudes of this year's BIO311C students—you and your classmates.

This activity has three purposes:

(1) To share with you more of the experiences of previous students about their experiences in BIO311C.

(2) To better understand your thoughts and plans for BIO311C.

(3) To help us provide incoming biology students in future years with more accurate expectations about how to be successful in BIO311C.

We want to learn more about students' experiences coming into BIO311C so we can pass this information on to future students to help them adjust during their transition to college.

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Overview

First, we will share with you some more of the findings from the Biology Student Interviews. The findings you will see today are about **students' experiences finishing the semester strong** as they prepared for the final exam.

Later we will ask you to help us interpret these findings.

Please read through the summary of findings on the next pages, and take your time. Afterward, we will ask you for your thoughts and reactions to these materials. As a BIO311C student, your thoughts and feelings are very important to us.

[PAGE BREAK]

Biology Student Interviews: A Refresher

What are the Biology Student Interviews?

The interviews focused on students' transition from high school biology to BIO311C. The section you will see today focuses on students' experiences finishing strong leading up to the final exam.

Who completed the Biology Student Interviews?

These data were collected from a broad sample of UT Sophomores, Juniors, Seniors, and recent graduates who took BIO311C in past years, so the experiences described generally were the same for UT students at different stages.

Students from all racial, ethnic, gender, and class year groups reported similar experiences.

[PAGE BREAK]

Biology Student Interviews (Part 3): A Summary of the Findings

Almost all students felt at least some stress heading into the final exam. Students commonly reported that this stress was related to:

- Comparing themselves to others and doubting themselves if they didn't perform as well on exams as some of their classmates
- Worries that struggling in the course could mean that they were not cut out for a career in the biological, medical, or health sciences

But over time, students came to see that everyone in the class could succeed. They reported:

- Finding that they could *lean on their classmates and instructors* to help them improve
- Finding that it was important to *not slow down* as they approached the final exam, even if they had been successful on previous exams
- Continuing to use the strategies that had been most effective for them during the semester. For example:
  - Actively engaging with the material in a way that helped them to deeply understand and retain it
  - Developing a strong, consistent study routine (rather than "cramming" before exams)
- Appreciating biology more deeply and becoming more confident in their ability to succeed by the end of the semester

Conclusions

Most students felt at least some stress as they approached the final exam. But they

found that with help from others and dedication to their study routine, they could be successful in the course, and they came to feel a new appreciation and sense of confidence in biology.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Next, you will watch **part 3** of the set of video clips from the Biology Student Interviews. These video clips are representative of the responses of participating students across different gender identities, races/ethnicities, class years, and so forth.

We hope you will enjoy hearing from these previous students.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Please watch the video below. You can click "next" when the video has finished (**i.e., when the timer above reaches zero)**.

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Link if video doesn't play automatically: [link to video]

[See Intervention Video 3 at https://osf.io/ywp9q]

[PAGE BREAK]

Your Thoughts on the Biology Student Interviews (Part 3)

Review: Most students felt at least some stress as they approached the final exam. Often, this happened when they compared their performance on previous exams to that of their classmates or worried about how their performance would affect their career plans. However, students were able to substantially improve their performance in the class (and on the final exam) when they (1) leaned on their classmates and instructors for help and advice, (2) didn't slow down their studying, even when they had already performed well on previous exams, and (3) used deep, active learning strategies as they studied. Then, they came to feel a new appreciation and sense of confidence in biology.

Writing Activity: In an effort to further understand the transition to BIO311C, we would like to ask you why you think this would be so.

Please answer the two-part question in the box below.

Please illustrate your answer with examples from your own experiences so far in BIO311C. For instance, consider any feelings of stress you have had in the class, how stress is likely to be common as students approach the final exam, and how all students can be successful in the class when they get help from others and make a strong final push before the final exam. Even if you have been satisfied with your performance so far, please write about why BIO311C can be difficult and what changes you can make to continue to enhance your understanding of the material as you head toward the final exam.

Please take as much time as you like.

Note: Your response may be provided, anonymously, to incoming BIO311C students in future years to help give them a better understanding of the transition to this course.

Type Your Answer in the Box Below

First, describe why you think it is common for students to feel stress as they approach the final exam.

Then, describe *how and why* you think students overcome these concerns and are able to succeed as they find new and better ways to learn and understand the material. For example, you can describe how seeking help and advice, keeping a strong study routine before the final exam, and actively engaging with the content (e.g., testing your comprehension, manipulating processes and scenarios) can help students to gain a better understanding of challenging biology content. Please illustrate your response with examples from your own experience.

In your answer, please be sure to describe changes you might make to your own approach to studying that may help you to be successful in this course.

8.4. Control Activity 1 (Before Exam 1)

Overview

A team from the UT Biology Department and Psychology Department is interested in students' experiences in the transition to college. We have asked a group of previous BIO311C students about what it was like to be a BIO311C student (reported in the "Biology Student Interviews", which you'll see later). Now we are interested in the experiences and attitudes of this year's incoming BIO311C students—you and your future classmates.

This activity has three purposes:

(1) To share with you the experiences of previous students about their experiences in BIO311C.

(2) To better understand your thoughts and plans for BIO311C.

(3) To help us provide incoming biology students in future years with more accurate expectations about how to be successful in BIO311C.

As you can imagine, the transition to new courses can go smoother if you know what to expect. We want to learn more about students' experiences coming into BIO311C, so we can pass this information on to future students to help them learn in their transition to college.

[PAGE BREAK]

Overview

First, we will share with you some of the findings from the Biology Student Interviews. Later we will ask you to help us interpret them. Please read through the summary of findings on the next pages, and take your time. Afterward, we will ask you for your thoughts and reactions to these materials. As an incoming student to BIO311C, your thoughts and feelings about starting this class are very important to us.

[PAGE BREAK]

Biology Student Interviews: Introduction

What are the Biology Student Interviews?

The interviews focused on students' experiences in BIO311C.

Who completed the Biology Student Interviews?

These data were collected from a broad sample of UT Sophomores, Juniors, Seniors, and recent graduates who took BIO311C in past years, so the experiences described generally were the same for UT students at different stages.

Students from all racial, ethnic, gender, and class year groups reported similar experiences.

[PAGE BREAK]

Biology Student Interviews: A Summary of the Findings

Almost all students reported that they found at least some topics in BIO311C to be challenging. Students commonly reported that the following types of topics and problems were especially difficult:

- Technical concepts, such as complex cycles and processes that have many interacting components
- Problems that require students to apply abstract knowledge to specific scenarios

But the students we interviewed found better ways to address these challenging topics and problems. Students mentioned:

- Using external resources and visual aids (e.g., videos) to help them understand complex processes
- Drawing out processes in order to better understand them
- Using techniques to develop an increasingly detailed understanding of the material

Conclusions

Most students found at least some of the topics and problems in BIO311C to be challenging. However, they found that some approaches were more effective than others to help them learn this material and solve these problems.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Next you will watch a few video clips from students who participated in the biology student interviews. These video clips are representative of the responses of

participating students across different gender identities, races/ethnicities, class years, and so forth.

We hope you will enjoy hearing from these previous students.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Please watch the video below. When it finishes playing, you can click the "next" button to continue.

Note: The video should begin playing automatically. If it does not, please copy and paste the link below into a **new tab** in your browser. When you finish the video, you can return to this page and click "next" to continue.

Link if video doesn't play automatically: [link to video]

[See Control Video 1 at https://osf.io/ywp9q]

[PAGE BREAK]

Your Thoughts on the Biology Student Interviews

Review: Most students struggled with at least some of the topics and problems in BIO311C. However, over time students found ways to master these topics and solve these challenging problems.

Writing Activity: In an effort to further understand the transition to BIO311C, we

would like to ask you why you think this would be so.

Please answer the two-part question in the box below.

Please illustrate your answer with examples from your own experiences so far in BIO311C. For instance, consider challenging topics and problems you've encountered in BIO311C so far.

Please take as much time as you like.

Note: Your response may be provided, anonymously, to incoming BIO311C students in future years to help give them a better understanding of the transition to this course.

Type Your Answer in the Box Below

First, describe why you think certain types of topics and problems in this course may be especially challenging.

Then, describe *what students might try to do* to master this challenging material.

In your answer, please be sure to describe specific material that has been challenging so far.

8.5. Control Activity 2 (Before Exam 2)

Biology Student Interviews: Part 2

Welcome to Part 2 of the Biology Student Interviews project!

As a reminder, a team from the UT Biology Department and Psychology Department is interested in students' experiences in the transition to college. We asked a group of previous BIO311C students about what it was like to be a BIO311C student, and now we are interested in the experiences and attitudes of this year's students—you and your future classmates.

This activity has three purposes:

(1) To share with you more of the experiences of previous BIO311C students.

(2) To better understand your academic interests and how they may develop throughout college.

(3) To help us provide incoming biology students in future years with more accurate expectations about how students' academic interests grow and change over time.

We want to learn more about students' experiences coming into BIO311C so we can pass this information on to future students to help them adjust during their transition to college.

[PAGE BREAK]

Overview

First, we will share with you some more of the findings from the Biology Student Interviews. The findings you will see today are about **how students' academic interests (e.g., in biology, the sciences, and mathematics) developed throughout college.**

Later we will ask you to help us interpret these findings.

Please read through the summary of findings on the next pages, and take your time. Afterward, we will ask you for your thoughts and reactions to these materials. As a BIO311C student, your thoughts and feelings are very important to us.

[PAGE BREAK]

Biology Student Interviews: A Refresher

What are the Biology Student Interviews?

The interviews focused on BIO311C students' experiences in college. The section you will see today focuses how students' academic interests changed and developed in college.

Who completed the Biology Student Interviews?

These data were collected from a broad sample of UT Sophomores, Juniors, Seniors, and recent graduates who took BIO311C in past years, so the experiences described generally were the same for UT students at different stages.

Students from all racial, ethnic, gender, and class year groups reported similar experiences.

[PAGE BREAK]

Biology Student Interviews (Part 2): A Summary of the Findings

Many students reported at least some initial level of interest in biology, the sciences, or mathematics starting in high school. Students commonly described:

- Especially enjoying biology or other science courses in high school
- Having a teacher that helped spark and foster a growing interest in biology, science, or mathematics

Many of the students we interviewed reported that these interests continued to grow and develop throughout college. Students mentioned:

- Beginning to connect their initial interest to possible long-term career plans
- Moving beyond a general interest and becoming increasingly interested in specific subfields or topics
- Becoming intrigued by new career options within their field that they hadn't previously considered

Conclusions

Many students began BIO311C with at least some initial interest in biology, the sciences, or mathematics. As they progressed through the course, and through college more generally, these interests continued to change and develop.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Next, you will watch **part 2** of the set of video clips from the Biology Student Interviews. These video clips are representative of the responses of participating students across different gender identities, races/ethnicities, class years, and so forth.

We hope you will enjoy hearing from these previous students.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Please watch the video below. The "next" button will appear once the video has finished **(i.e., when the timer below reaches zero)**

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Link if video doesn't play automatically: [link to video]

[See Control Video 2 at https://osf.io/ywp9q]

[PAGE BREAK]

Your Thoughts on the Biology Student Interviews (Part 2)

Review: Many students began BIO311C with an initial interest in biology, the sciences, or mathematics. But as they progressed through BIO311C, other science

courses, and college more generally, these interests continued to change, grow and develop. Over time, students' interests usually become more specific and more linked to possible career paths.

Writing Activity: In an effort to further understand BIO311C students' experiences in college, we would like to ask you why you think this would be so.

Please answer the two-part question in the box below.

Please illustrate your answer with examples from your own experiences so far in college. For instance, consider how your own academic interests have changed and grown so far.

Please take as much time as you like.

Note: Your response may be provided, anonymously, to incoming BIO311C students in future years to help give them a better understanding of the transition to this course.

Type Your Answer in the Box Below

First, describe why you think many BIO311C students begin the class with an initial interest in biology, the sciences, or mathematics.

Then, describe *how and why* you think students' interests continue to grow throughout college, becoming more specific and more linked to possible career paths.

In your answer, please be sure to describe your own academic interests, how they have changed so far, and how they may continue to develop throughout college.

8.6. Control Activity 3 (Before Final Exam)

Biology Student Interviews: Part 3

Welcome to Part 3 of the Biology Student Interviews project!

As a reminder, a team from the UT Biology Department and Psychology Department is interested in students' experiences in the transition to college. We asked a group of previous BIO311C students about what it was like to be a BIO311C student, and now we are interested in the experiences and attitudes of this year's BIO311C students—you and your future classmates.

This activity has three purposes:

(1) To share with you the experiences of previous BIO311C students about their experiences.

(2) To better understand your experiences adjusting to college.

(3) To help us provide incoming students in future years with more accurate expectations about how students adjust to college life.

We want to learn more about students' experiences so we can pass this information on to future students to help them adjust during their transition to college.

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Overview

First, we will share with you some more of the findings from the Biology Student Interviews. The findings you will see today are about **how students formed connections with other people throughout college.**

Later we will ask you to help us interpret these findings.

Please read through the summary of findings on the next pages, and take your time. Afterward, we will ask you for your thoughts and reactions to these materials. As a BIO311C student, your thoughts and feelings are very important to us.

[PAGE BREAK]

Biology Student Interviews: A Refresher

What are the Biology Student Interviews?

The interviews focused on BIO311C students' experiences in college. The section you will see today focuses how students formed connections with other people in college.

Who completed the Biology Student Interviews?

These data were collected from a broad sample of UT Sophomores, Juniors, Seniors, and recent graduates who took BIO311C in past years, so the experiences described generally were the same for UT students at different stages.

Students from all racial, ethnic, gender, and class year groups reported similar experiences.

[PAGE BREAK]

Biology Student Interviews (Part 3): A Summary of the Findings

Almost all students felt at least some stress when they began college. Students commonly reported that this stress was related to:
- Adjusting to a large school environment
- Worries about how they would meet people and make new friends

But over time, students were able to adjust and acclimate to college. They reported:

- Making friends through recreational organizations (e.g., intramural sports teams)
- Meeting other students in professional and academic organizations
- Becoming connected through service and mentoring opportunities
- Making new friends when they connected with other students in their classes

Conclusions

Many students felt at least some stress when they first came to UT. However, with time, the students felt more comfortable as they met people and made new friends through organizations and classes.

[PAGE BREAK]

Biology Student Interviews: What Students Said

Next, you will watch **part 3** of the set of video clips from the Biology Student Interviews. These video clips are representative of the responses of participating

students across different gender identities, races/ethnicities, class years, and so forth.

We hope you will enjoy hearing from these previous students.

[PAGE BREAK]

Biology Student Interviews: What Students Said

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Link if video doesn't play automatically: [link to video]

[See Control Video 3 at https://osf.io/ywp9q]

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Your Thoughts on the Biology Student Interviews (Part 3)

Review: Many students felt at least some stress or concern when they began college. But with time in the university, they began to feel comfortable as they made friends and met new people. Many students made new friends through organizations and their classes.

Writing Activity: In an effort to further understand BIO311C students' experiences in

college, we would like to ask you why you think this would be so.

Please answer the two-part question in the box below.

Please illustrate your answer with examples from your own experiences so far in college. For instance, consider the ways in which you have formed connections with other people since you began college at UT. Of course, your experiences meeting people have probably been different amid the COVID-19 pandemic. Please elaborate on how changes due to the pandemic (e.g., online classes) have changed the ways that you have formed new connections at UT.

Please take as much time as you like.

Note: Your response may be provided, anonymously, to incoming BIO311C students in future years to help give them a better understanding of the transition to this course.

Type Your Answer in the Box Below

First, describe why you think many students feel stress or worry when they first come to college.

Then, describe *how and why* you think students are able to become more comfortable, meet new people, and make friends over time at UT.

In your answer, please be sure to describe your own experiences adjusting to college, and how these experiences may continue to develop throughout your time at UT.

9. Discussion of Associations between Outcome Measures

Correlations between the survey measures (Table 1) were consistent with the patterns that would be expected with valid measures of the theoretical constructs.

Students who attribute struggle to strategy usage would be expected to place more importance on experimenting with study strategies and rely less on high school strategies. Indeed, attribution of struggle to strategy usage (adapted from Yeager et al., 2016) was positively associated with importance of experimenting with strategies and negatively associated with reliance on high school strategies (ps < .001). In addition, our hypothesis was that if students attribute struggle to strategy usage rather than to their own lack of ability to succeed in the field, they would be less likely to doubt their belonging in the field. Indeed, our attribution was positively associated with course belonging and negatively associated with field belonging uncertainty (ps < .001).

The two novel "approach to studying" measures also showed expected patterns of associations. As described above, these measures were associated with attribution of struggle to strategy usage as expected. In addition, students who place more importance on experimenting with new strategies would be expected to rely less on strategies they had used in high school. Indeed, these two measures were negatively associated with one another (p < .001). Although we did not have specific hypotheses about how approaches to studying would predict measures of belonging, importance of experimenting with strategies was positively associated with course belonging (p < .001), suggesting that students who saw experimenting as an important component of success in the course were more likely to feel that they belonged.

Finally, the two belonging measures showed the expected pattern of associations with the other scales. As discussed above, these measures were associated with attribution of struggle to strategy usage as would be expected. In addition, uncertainty about belonging in the field of biology would be expected to predict a lower sense of belonging in the introductory biology course, and indeed, these two measures were negatively associated (p < .001).

10. Models Demonstrating Lack of Differential Attrition on Self-Reported Outcomes

The end-of-semester survey was completed by approximately three-quarters of the sample (missingness = 26-27% depending on the outcome). We tested for differential attrition on any of these outcomes by testing the effect of condition, the baseline measure of the outcome (when available), and the Condition × Baseline Measure interaction on a missingness indicator (1 = missing, 0 = not missing) for each outcome. This informed whether there were differences in missingness as a function of condition, and whether condition made students at different levels of the variable at baseline more or less likely to provide a response at the end of the semester.

An identical measure was taken for each of the outcomes at baseline with the exception of the two approach to studying measures. For each of these, we used the following baseline item as the moderator: "In high school, I mostly used memorization to study for biology." There were no significant effects of condition ($ps > .276$), nor significant Condition × Baseline Measure interactions ($ps > .060$) on any of the outcome missingness indicators. See Table S2.

Table S2. *Regression Models Testing for Differential Attrition on Self-reported Outcomes.*

Regression term	Attributions of struggle to strategy usage		Importance of experimenting		Reliance on high school strategies		Course belonging		Field belonging uncertainty	
	β	p	β	p	β	p	β	p	β	p
Condition	0.03	.391	0.03	.409	0.03	.409	0.04	.277	0.03	.412
Baseline Measure	-0.01	.740	-0.04	.187	-0.04	.187	0.02	.588	0.02	.532
Condition × Baseline Measure	-0.06	.072	0.00	.990	0.00	.990	0.05	.160	-0.06	.061

Note. Missingness on baseline measures (4-12%, depending on the measure) was imputed using the mean. Dummy-coded missingness indicators (1 = missing, 0 = not missing) were included in the model as well, as were Condition × Baseline Missingness interactions. Coefficients are standardized.

11. Multiple Regression Models for Primary Outcomes

The findings presented in the main text were estimates from Bayesian Causal Forest (BCF) models. Here, we present comparable models using multiple regression. The models included condition (intervention = .5, control = -.5), gender (woman = high, man = low; mean-centered), race/ethnicity (underrepresented = high, majority = low; mean-centered), and generational status (first-generation = high, continuing-generation = low; mean-centered), the three Condition × Demographic Contrast (i.e., gender, race/ethnicity, generational status) interactions, and the same set of covariates included in the BCF models. Findings from the regression models were consistent with the BCF models (see Table S3).

Table S3. *Multiple Regression Models for All Outcomes.*

Regression term	Attribution to strategies		Importance of experimenting		Reliance on high school strategies		Course belonging		Field belonging uncertainty		Course grade		Received A in course		Continue to next course	
	β	p	β	p	β	p	β	p	β	p	β	p	β	p	β	p
Condition	0.08	.035	0.08	.039	-0.08	.040	0.06	.090	0.02	.546	0.03	.381	0.30	.065	0.08	.703
Generational status	0.08	.034	0.11	.010	-0.06	.161	0.03	.374	0.03	.356	-0.15	< .001	-0.80	< .001	-0.04	.855
Condition × Generational Status	0.08	.050	0.02	.597	-0.03	.531	0.07	.037	-0.07	.040	-0.02	.615	0.15	.392	0.20	.327
Race/ethnicity	0.02	.621	0.11	.007	-0.08	.076	-0.11	.003	0.06	.074	-0.24	< .001	-1.13	< .001	-0.43	.040
Condition × Race/ethnicity	-0.07	.070	0.02	.619	-0.08	.062	-0.03	.430	-0.04	.232	0.01	.749	0.31	.065	0.22	.283
Gender	0.09	.019	0.10	.006	-0.04	.366	-0.04	.176	0.04	.172	-0.06	.036	-0.31	.041	0.13	.502
Condition × Gender	0.00	.997	-0.02	.593	-0.07	.091	-0.01	.738	-0.03	.382	0.01	.668	0.11	.460	-0.21	.273
Instructor 2 vs. 1	-0.03	.462	0.06	.136	-0.06	.144	-0.25	< .001	0.11	.003	0.03	.356	-0.05	.754	-0.64	.006
Instructor 3 vs. 1	0.01	.777	0.08	.100	-0.10	.058	-0.02	.712	0.02	.731	-0.15	< .001	-0.41	.049	-0.21	.439
Attributions of struggle to strategy usage	0.33	< .001	0.18	< .001	-0.02	.660	0.08	.019	-0.02	.488	0.06	.063	0.33	.040	-0.06	.789
Reliance on memorization in high school biology	0.00	.908	0.01	.878	-0.03	.509	0.02	.635	0.00	.900	-0.02	.541	-0.01	.968	0.01	.949
Course belonging	0.10	.017	0.11	.011	0.03	.546	0.37	< .001	-0.10	.008	0.06	.093	0.06	.716	-0.57	.012
Field belonging uncertainty	-0.01	.777	0.06	.201	-0.04	.350	-0.13	.001	0.49	< .001	0.00	.930	-0.24	.172	-1.11	< .001
Confidence about performance	0.01	.803	0.00	.964	0.05	.301	0.06	.129	-0.04	.255	0.03	.337	0.19	.291	0.37	.100

Note. Missingness on baseline measures (4-12%, depending on the measure) was imputed using the mean for continuous measures and the mode for dichotomous measures. Dummy-coded missingness indicators (1 = missing, 0 = not missing) were included in the model as well, as were Condition × Baseline Missingness interactions. Models for continuous outcomes were tested using ordinary least squares regression and models for binary outcomes were tested using logistic regression. Coefficients for all other outcomes are standardized.

12. Multiple Regression Models for Additional Preregistered Outcomes

Table S4. *Multiple Regression Models for Additional Preregistered Outcomes.*

Regression term	Confidence about performance		Attribution to self		Learning goals		Performance-avoidance goals		Interest	
	β	p	β	p	β	p	β	p	β	p
Condition	0.06	.108	-0.07	.048	-0.03	.468	-0.01	.882	0.05	.189
Generational status	0.01	.852	0.08	.026	0.07	.109	0.09	.037	0.04	.364
Condition × Generational Status	0.04	.249	0.04	.233	0.04	.286	0.02	.631	-0.02	.691
Race/ethnicity	-0.06	.098	0.09	.022	0.01	.746	-0.01	.839	-0.03	.486
Condition × Race/ethnicity	-0.01	.819	0.06	.123	0.06	.161	-0.02	.605	0.03	.430
Gender	-0.12	< .001	0.19	< .001	0.00	.959	-0.05	.196	0.03	.454
Condition × Gender	0.01	.765	-0.07	.056	0.02	.631	-0.07	.053	-0.03	.393
Instructor 2 vs. 1	-0.13	.001	0.03	.383	-0.02	.703	-0.11	.009	-0.17	< .001
Instructor 3 vs. 1	-0.05	.322	-0.01	.755	0.17	.001	-0.11	.041	0.00	.932
Attributions of struggle to strategy usage	0.09	.015	-0.05	.176	0.00	.967	0.12	.004	0.08	.039
Reliance on memorization in high school biology	0.01	.880	0.05	.121	-0.02	.524	0.11	.003	-0.04	.294
Course belonging	0.15	< .001	-0.08	.045	0.04	.415	0.04	.356	0.08	.049
Field belonging uncertainty	-0.08	.048	0.28	< .001	-0.04	.345	0.00	.958	-0.25	< .001
Confidence about performance	0.26	< .001	-0.06	.176	0.13	.006	-0.04	.426	0.08	.069

Note. Missingness on baseline measures (4-12%, depending on the measure) was imputed using the mean for continuous measures and the mode for dichotomous measures. Dummy-coded missingness indicators (1 = missing, 0 = not missing) were included in the model as well, as were Condition × Baseline Missingness interactions. Models were tested using ordinary least squares regression. Coefficients are standardized.

13. Raw Means by Condition and Demographics

Raw means and standard deviations for each outcome as a function of condition, generational status, race/ethnicity, and gender are presented in Table S5.

Table S5. *Raw Means and Standard Deviations as a Function of Condition and Demographics.*

	Generational Status				Race/ethnicity				Gender			
	First-generation		Continuing-generation		Underrepresented racial/ethnic minority		Majority		Woman		Man	
Outcome	Control	Intervention	Control	Intervention	Control	Intervention	Control	Intervention	Control	Intervention	Control	Intervention
Attribution to strategies	4.12 (0.73)	4.41 (0.68)	4.02 (0.75)	4.14 (0.70)	4.19 (0.76)	4.25 (0.74)	3.98 (0.73)	4.20 (0.68)	4.12 (0.74)	4.25 (0.66)	3.99 (0.77)	4.09 (0.79)
Importance of experimenting	5.16 (0.87)	5.44 (0.67)	4.90 (0.94)	5.03 (0.88)	5.18 (0.96)	5.42 (0.79)	4.88 (0.89)	5.01 (0.84)	5.08 (0.85)	5.20 (0.82)	4.84 (1.01)	5.01 (0.89)
Reliance on high school strategies	3.12 (1.34)	2.60 (1.45)	3.25 (1.41)	3.11 (1.30)	3.15 (1.43)	2.58 (1.31)	3.22 (1.37)	3.18 (1.35)	3.19 (1.40)	2.84 (1.33)	3.11 (1.30)	3.19 (1.36)
Course belonging	4.78 (0.91)	4.98 (0.78)	4.78 (0.87)	4.80 (0.77)	4.73 (0.86)	4.77 (0.89)	4.81 (0.89)	4.89 (0.71)	4.77 (0.87)	4.84 (0.79)	4.95 (0.84)	4.99 (0.75)
Field belonging uncertainty	3.20 (1.42)	3.01 (1.20)	2.80 (1.31)	2.99 (1.27)	3.17 (1.48)	3.01 (1.21)	2.79 (1.27)	2.98 (1.28)	3.00 (1.35)	3.00 (1.24)	2.58 (1.24)	2.83 (1.19)
Course grade	3.10 (0.86)	3.07 (0.97)	3.52 (0.72)	3.60 (0.58)	3.03 (0.89)	3.10 (0.93)	3.60 (0.64)	3.66 (0.53)	3.36 (0.78)	3.42 (0.76)	3.52 (0.78)	3.50 (0.76)
Received A in course	0.18 (0.38)	0.27 (0.45)	0.48 (0.50)	0.53 (0.50)	0.15 (0.36)	0.28 (0.45)	0.52 (0.50)	0.55 (0.50)	0.36 (0.48)	0.44 (0.50)	0.47 (0.50)	0.50 (0.50)
Continue to next course	0.71 (0.46)	0.77 (0.43)	0.76 (0.43)	0.78 (0.42)	0.68 (0.47)	0.74 (0.44)	0.79 (0.41)	0.79 (0.41)	0.77 (0.42)	0.77 (0.42)	0.71 (0.45)	0.79 (0.41)

Note. Standard deviations are displayed beside the means in parentheses.

14. Preregistration Files

Note: The preregistration and indices files, reproduced below, can also be found at
https://osf.io/ywp9q.

14.1. Preregistration File

Study Information

Title: Encouraging Introductory Biology Students to Reattribute Struggle to Study Strategy Usage (F21)

Description: In this study, we will manipulate whether Introductory Biology college students receive an intervention encouraging them to reattribute struggles in the course to the use of less effective study strategies, rather than to uncontrollable and internal alternatives (e.g., belief that one is simply not "cut out" for biology).

Hypotheses:

Research Questions

RQ1: Will students who receive the intervention develop more positive attitudes and beliefs about the class?

RQ2: Will students who receive the intervention earn higher grades in the class?

RQ3: Will intervention effects on attitudes/beliefs and grades depend on students' racial/ethnic, gender, and socioeconomic backgrounds or early performance in the class?

Design Plan

Study type: Experiment - A researcher randomly assigns treatments to study subjects; this includes field or lab experiments. This is also known as an intervention experiment and includes randomized controlled trials.

Blinding: For studies that involve human subjects, they will not know the treatment group to which they have been assigned.

Personnel who interact directly with the study subjects (either human or non-human subjects) will not be aware of the assigned treatments. (Commonly known as "double blind")

Study design: This study is a two-cell field experiment. Students will be randomly assigned to an intervention condition (50%) or a control condition (50%).

Randomization: Randomization to condition was done by sorting participants randomly (in R) and alternately assigning them to intervention or control.

Sampling Plan

Existing data: Registration prior to accessing the data

Explanation of existing data: This was the first time testing this intervention in this context and there were therefore questions about what would be feasible (e.g., how the intervention could be integrated into the course, how many measures could be included and at what timepoints). Therefore, we did not preregister the study prior to any data collection. Now that the study has been successfully launched, the pre-registration is being finalized prior to any human merging or analyzing of the data.

The intervention will be given in three doses over the course of the semester. At the time of this preregistration, doses 1 and 2 are complete. In addition, we have collected baseline survey data (survey 1). Survey 2 is currently being administered and survey 3 has not yet been administered. The data have not been linked and analyses have not been conducted.

Data collection procedures: Data will be collected from students in an Introductory Biology course (across three instructors' sections of the course). Students will complete either the intervention or control three times throughout the semester. In the treatment condition, students will read text and watch video clips from previous students communicating the message that (a) struggling in the course at first is normal, (b) that this often causes doubts about one's ability to succeed in the field, and (c) that students can improve when they experiment with and change their approach to studying. They will then do a short writing activity to reflect on this message. In the control condition, students will read, watch video clips from previous students, and write about a neutral topic.

Students will complete short surveys three times throughout the semester: once prior to treatment, once after the second treatment dose, and once after the third treatment dose. These surveys will allow us to assess any changes in students' attitudes and beliefs about the class throughout the semester, as a function of receiving the intervention.

Sample size: ~900 students.

Sample size rationale: We will collect data from all students in the course (907 students as of this preregistration).

Stopping rule: We will collect as much data as possible over the course of the semester (Fall 2021).

Variables

Manipulated variables: There is one experimental manipulation (intervention vs. control; see data collection procedures above).

Measured variables:

Outcomes:

(1) Attitudes and beliefs about the course (see "Indices" below).

(2) Course grades (see "Indices" below).

Moderators:

Racial/ethnic, gender, and socioeconomic background will all be tested as moderators. In addition, early performance in the course (i.e., Exam 1 score) will be tested as a moderator, even though this exam occurred after the first dose of the intervention. The reason is that the intervention focuses on reattributing struggles on the first exam in particular and is therefore expected to have stronger effects for students who struggle on the first exam.

Indices: See "f21_lj_indices" file.

[f21_lj_indices.docx]

Analysis Plan

Statistical models

Analytic Model:

All statistical models will compare the intervention condition to the control condition. Significant effects are expected for this contrast.

RQ1: An OLS regression at each time point will regress each of the attitudes and beliefs measures on the intervention contrast and baseline covariates. This will be a total of 12 models (6 outcomes at 2 time points).
- We will also test 6 mixed-effects models, one for each outcome, treating time as a within-subjects variable, to examine whether the intervention contrast alters the trajectory of students' attitudes and beliefs over time.

RQ2: An OLS regression will regress course grades on the intervention contrast.
- We will also test a mixed-effects model, treating time as a within-subjects variable, to examine whether the intervention contrast alters the trajectory of students' scores on the four exams in the class over time.

RQ3: We will conduct the same analyses described above, except testing male vs. female identified gender, first-generation college student status, race (Black/Hispanic/Latinx/Indigenous vs. not), and Exam 1 score as moderators.
- If statistical power is sufficient, gender will be crossed with either race/ethnicity or first-generation status to examine intersectional effects.

Transformations: Survey and grade outcomes will be untransformed.

Inference criteria: p < .05, two-tailed. We will also use Bayesian Causal Forest analyses as a robustness check and follow the lab's standard operating procedures for reporting Bayesian treatment effects (e.g., ATE and CATE and 90% posterior intervals).

Data exclusion: This is an intent-to-treat study and all participants will be included so long as they saw the first page of the first treatment exercise.

Missing data: Data will be imputed for covariates and moderators, if necessary. No condition variables or outcome variables will be imputed.

Exploratory analyses: We will also explore effects on additional survey outcomes that are already being collected in the course (i.e., miscellaneous surveys already administered by the course instructors, PERTS Copilot-Ascend surveys that are administered in the course).

14.2. Preregistered Indices

Survey Measures

Survey 1 (administered prior to first intervention dose)

Uncertainty about belonging in the field
- I don't know if I really belong in the biological and health sciences
- Sometimes I'm not sure if I really belong in the biological and health sciences

Confidence in course
- I am confident that I will do well in this course
- I expect to get a good grade in this course

Study skills
- In high school, I mostly used memorization to study for biology
- I will probably need to try new strategies to be successful in this course
- If my normal study strategies don't work, I will try new study strategies

Attributions for failure
- Pretend that, later <u>today or tomorrow</u>, you got a **bad** grade on a very important assignment in this class. Honestly, if that happened, how likely would you be to think these thoughts?
    - "This means I'm probably not very good at biology."
    - "I might just not have the right background to be successful in this course."
    - "I can get a higher score next time if I find a better way to study."
    - "I will need to change the way I prepare for exams in this class if I want to get a higher score."

Achievement goals
- It is more important for me to learn than to get the best grade in this class. [learning goals]
- One of my main goals is to avoid making "dumb" mistakes in this class. [performance-avoidance goals]

Interest in bio
- I'm really looking forward to learning more about biology
- To be honest, I just don't find biology interesting

Survey 2 (administered after second intervention dose)

Uncertainty about belonging in the field
- I don't know if I really belong in the biological and health sciences
- Sometimes I'm not sure if I really belong in the biological and health sciences

Confidence in course
- I am confident that I will do well in this course
- I expect to get a good grade in this course

Study skills
- So far, my approach to studying in this class has been similar to how I studied for biology in high school
- I will probably need to try new strategies to be successful in this course
- If my normal study strategies don't work, I will try new study strategies

Attributions for failure
- Pretend that, later <u>today or tomorrow</u>, you got a **bad** grade on a very important assignment in this class. Honestly, if that happened, how likely would you be to think these thoughts?
    - "This means I'm probably not very good at biology."
    - "I might just not have the right background to be successful in this course."
    - "I can get a higher score next time if I find a better way to study."
    - "I will need to change the way I prepare for exams in this class if I want to get a higher score."

Achievement goals
- It is more important for me to learn than to get the best grade in this class. [learning goals]
- One of my main goals is to avoid making "dumb" mistakes in this class. [performance-avoidance goals]

Interest in bio
- I'm really looking forward to learning more about biology
- To be honest, I just don't find biology interesting

Survey 3 (administered after third intervention dose)

Uncertainty about belonging in the field
- I don't know if I really belong in the biological and health sciences
- Sometimes I'm not sure if I really belong in the biological and health sciences

Confidence in course
- I am confident that I will do well in this course
- I expect to get a good grade in this course

Study skills

- So far, my approach to studying in this class has been similar to how I studied for biology in high school
- I will probably need to try new strategies to be successful in this course
- If my normal study strategies don't work, I will try new study strategies

Attributions for failure

- Pretend that, later <u>today or tomorrow</u>, you got a **bad** grade on a very important assignment in this class. Honestly, if that happened, how likely would you be to think these thoughts?
  - "This means I'm probably not very good at biology."
  - "I might just not have the right background to be successful in this course."
  - "I can get a higher score next time if I find a better way to study."
  - "I will need to change the way I prepare for exams in this class if I want to get a higher score."

Achievement goals

- It is more important for me to learn than to get the best grade in this class. [learning goals]
- One of my main goals is to avoid making "dumb" mistakes in this class. [performance-avoidance goals]

Interest in bio

- I'm really looking forward to learning more about biology
- To be honest, I just don't find biology interesting

Course Grade Measures

Course grade
- Final grade in the course, assessed on a 4.0 scale

Exam grades
- Grades scored on each of three midterm exams and a final exam in the course, assessed on a 0-100 percent scale.

Methods and Supplementary Information References

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