

Supplemental Material

CBE—Life Sciences Education

Corwin *et al.*

Supplemental Materials

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Supplemental Table 1. Participant demographic information

	All Participating Students	Students Reporting Technical Research Challenges (N = 226)		Students Reporting Technical Challenges in Data Collection (N = 180)	
		140L	150L	140L	150L
Total students	668	117	109	75	105
Students in BIO140L	339	117	-	75	-
Students in BIO150L	329	-	109	-	105
Year in college	%	%	%	%	%
First-year	59	53	72	55	72
Second-year	18	21	17	20	17
Third-year	16	15	4	13	4
Fourth-year	6	9	6	9	6
Unknown	2	3	1	3	1
Gender Identity[#]	%	%	%	%	%
Female	67	74	65	72	64
Male	28	22	29	25	30
Other	1	1	0	0	0
Unreported	5	3	6	3	6
Major	%	%	%	%	%
Biology*	69	64	78	71	79
Not Biology	29	33	19	25	18
Unknown	2	3	3	4	3
Race/Ethnicity	%	%	%	%	%
White	68	63	68	65	69
Other/ Not Stated ⁺	15	17	16	13	8
Black	5	9	4	8	4
Hispanic/Latino	5	5	6	5	6
Asian	6	3	6	4	6
Alaska Native or American Indian	1	2	0	1	0
Native Hawaiian/ Pacific Islander	0	1	1	0	1

*Biology majors include pre-health students who participate in a curriculum equivalent to biology students but with a greater emphasis on classes that serve pre-health requisites.

[#]The question that generated this data was taken from current measures of sexual orientation and gender identity (SOGI) in federal household surveys (Federal Interagency Working Group on Improving Measurement of Sexual Orientation and Gender Identity in Federal Surveys, 2016) and reads “Which gender do you identify as?” with response options: female, male, other, prefer not to answer. We wish to represent student responses to this question accurately, therefore we maintain the terms “female” and “male” throughout this work and use the term “gender identity” to adhere to the original wording of the question.

⁺The category “other” indicates individuals who either responded as “multiracial” or actively selected the option “other” from the demographic questionnaire.

Supplemental Table 2. Emotions codes, definitions, example quotes, counts and percent students reporting each code overall and within the sample of students reporting *Technical Research Challenges*.

Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
EMOTIONS						
Aggregate Code: Positive emotions (orange)	Expressions of a positive emotion. (Values aggregated from all positive emotions)	<i>see below</i>	124(18)	55(24)	29(24)	26(23)
Ease	Expressions of comfort, ease, or being okay with one's situation	Didn't feel too bad because there were sequences we could use.	45(7)	20(9)	11(9)	9(8)
Confidence	Expressions of belief in one's own ability to succeed or that the situation will work out for the best	When I couldn't be successful the first time around it was a letdown, but I didn't feel discouraged because i knew i would have another shot at it.	22(3)	11(5)	7(6)	4(4)
Hope	Expressions of hope or an expectation that things will turn out okay or turn out well	I stayed pretty calm, just hoping for the best and when it did work, i was relieved and kept working	13(2)	9(4)	0(0)	9(8)
Determination	Expressions of being resolute, determined, and/or motivated to complete a task	I felt frustrated and disappointed; however, I also felt determined to make it work the second time.	8(1)	6(3)	3(3)	3(3)
Excitement	Expressions of excitement, eagerness, or happy anticipation	I felt a bit unaccomplished but excited to be challenged once more.	5(1)	4(2)	3(3)	1(1)
Gratitude	Expressions of feeling gratitude, thankfulness, or appreciation	At first I was kind of upset because my sample had not amplified, however I am now somewhat thankful for it as I view it as extra experience in pipetting and PCR practice.	13(2)	3(1)	1(1)	2(2)
Rapport	Expressions describing a common experience. Often expressions associated with the shared experience alleviated negative emotions	I was disappointed but it was comforting to know I wasn't the only one it happened to.	5(1)	3(1)	3(3)	0(0)
Relief	Expressions of feeling relieved, reassured, or more relaxed	I felt relieved and acted more happy and free-going.	7(1)	3(1)	1(1)	2(2)
Enjoyment	Expressions of pleasure, enjoyment, or happiness connected with engaging in the activities at hand	I enjoy the mental challenge that this class offers. I feel as though the class offers good stimuli to my learning.	3(0)	2(1)	1(1)	1(1)
Satisfaction	Expressions of satisfaction or happiness associated with the outcome of a situation. Includes pride or accomplishment.	I was very satisfied with the results because I found out that a nectarine is basically a peach.	14(2)	1(0)	1(1)	0(0)

Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Negative Emotions (blue)	Expressions of a negative emotion. (Values aggregated from all negative emotions)		462(69)	192(85)	104(88)	88(80)
Disappointment	Expressions of sadness or displeasure associated with inability to fulfill a task	I was kinda disappointed because I had worked so hard to make sure nothing was contaminated and that I had chosen a species that would grind up well. So having no DNA in my sample was upsetting.	172(26)	82(36)	34(29)	48(44)
Frustration	Expressions of aggravation and frustration - especially those associated with not being able to change, control, understand, or achieve something	It was frustrating because I had done everything up to that point correctly. So why wasn't it working now?	156(23)	68(30)	42(36)	26(24)
Confusion	Expressions of being confused, unsure, uncertain, or having ambiguous understanding of what occurred	I was frustrated and confused as to why mine didn't work like my group members.	67(10)	35(15)	27(23)	8(7)
Annoyance	Expressions of being impatient, irritated, or annoyed at the circumstances	I was a little annoyed with it because it took much more time than I previously thought it would take.	48(7)	21(9)	11(9)	10(9)
Anxiety	Expressions of worry, nervousness, unease, and/or anxiety about an uncertain future outcome of one's efforts or actions	I felt anxious and worried during these challenges. I didn't want to have to repeat the procedures.	37(6)	16(7)	9(8)	7(6)
Insecurity	Expressions of a sense of inferiority, anxiety, and insecurity about oneself. Often expressions were associated with feelings of inadequacy as compared to others and self-blame.	I felt really incompetent, it felt like I was the only one struggling and I'm the bio major.	32(5)	12(5)	11(9)	1(1)
Discouragement	Expressions of being dispirited and feeling like things will not work out, a lack of hope often resulting in loss of motivation	I felt extremely discouraged when this failure occurred because I felt like my hard work was a waste of time.	38(6)	12(5)	10(9)	2(2)
Stress	Expressions of tension, stress, or feeling overwhelmed by the circumstances	Sometimes I feel very stressed because I cannot complete them in the lab, and I have to do them on my own time without my professor's input.	32(5)	7(3)	6(5)	1(1)

Anger	Strong expressions of being angry, mad, displeased, or feeling hostile	I was mad that we had to redo the data collection, and upset that we didn't just get it right the first time	18(3)	7(3)	5(4)	2(2)
<i>Indifference was neither a negative nor positive emotion.</i>						
Indifference	Expressions indicating an effect that has neither a positive or negative tone or connotation; lack of concern	I was not too shocked because part of me knew there was a decent chance we could possibly not get DNA results.	18(3)	9(4)	2(2)	7(6)

Supplemental Table 3. Coping codes, definitions, example quotes, counts and percent students reporting each code overall and within the sample of students reporting *Technical Research Challenges*.

COPING RESPONSES						
Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Adaptive Coping	Coping strategies predicted to be adaptive based on prior work in academic settings.	<i>see below</i>	286(43)	157(69)	88(75)	69(63)
Direct Action	Actions that are immediate and oriented toward solving the problem; these can include continuation with direct efforts after encountering a problem, slowing down or speeding up work on a task, working harder or paying more attention to a task.	It was helpful to just continue with the following steps although I had doubts.	109(16)	52(23)	41(35)	11(10)
Repetition with reflection	Directly acting to solve a problem by repeating steps taken to achieve the desired outcome while also considering why the procedure needed to be redone, what might have occurred in the first iteration to preclude achievement of a desired outcome, and/or what changes need to be made to achieve a positive outcome on the subsequent iterations	My group failed to have a positive feedback from the gel, which led us to believe our decision in choosing invertebrates for our collection sample was insufficient. The gel showed no markers for any of my group member's organisms, and we were required to test the experiment with a new sample. For the second time we used plant samples for the experiment.	79(12)	52(23)	16(14)	36(33)
Emotional regulation	Active attempts to influence one's own emotional distress (to alleviate or mollify emotional distress) and to constructively express emotions at the appropriate	I kept an open mind and didn't let it bother me too much or get me off focus. So, I found it to be helpful to stay lighthearted and just try again.	53(8)	39(17)	14(12)	25(23)

	time and place; finding ways to control and regulate one's own emotions.					
Support seeking	Using available social resources for either help in solving a problem or emotional comfort.	I was confused and lost, so I asked for help from the TA and the professor.	55(8)	33(15)	31(26)	2(2)
Planning	Strategically planning how to solve the problem. This includes time management, planning the use of new techniques, and planning to employ strategies that may support task achievement. This occurs prior to actually repeating a task	I questioned the instructions my group member's and I followed during the experiment, and I then looked over the lab's instructions for clarity.	28(4)	21(9)	4(3)	17(16)
Instrumental action	Taking action that will help to solve the problem even if it is not directly related to the problem (e.g., reading up on how to solve the problem). Attempting to learn more about a stressful situation or condition. Seeking information to understand the cause, consequences, or potential solutions to a problem	... and I studied the gel images more and what it means when there are bands in certain columns.	26(4)	14(6)	9(8)	5(5)
Collaboration	Working collaboratively or jointly with group members to solve the problem	I have no experience in biology prior to this class and had to work with other lab partners who explained how to interpret the data.	29(4)	13(6)	5(4)	8(7)
Cognitive restructuring	Attempting to reframe a stressful experience by focusing on the positive aspects of it and seeing it in a more positive light.	It was frustrating, but the important thing was that we gained experience and comfort in performing the DNA identification process. I was not very upset because I understood that I had learned a lot through the process.	14(2)	7(3)	3(3)	4(4)
Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)

Aggregate Code: Maladaptive Coping	Coping strategies predicted to be maladaptive based on prior work in academic settings.	<i>see below</i>	34(5)	15(7)	10(9)	5(5)
Opposition	Displaying projection, reactance, anger, aggression, venting, blaming and/or negative outbursts toward others in connection with the problem. Externalizing one's negative emotions as behaviors directed at others.	I was frustrated and threw a tantrum.	5(1)	5(2)	2(2)	3(3)
Helplessness	Acting to give up or the relinquish control of a situation. Seeing the situation as out of one's control and therefore acting as if one cannot change the situation.	I just kinda left the picture as is and said I was done with it...I got a lower grade, but it helped my stress out by giving up.	6(1)	5(2)	4(3)	1(1)
Delegation	Shifting the problem to someone else through maladaptive help-seeking such as whining and self-pity.	I was pretty upset about the results mostly because we had to redo a lot of testing because the method of testing wasn't fit to work for invertebrates. This seemed pretty unfair to my group.	16(2)	3(1)	1(1)	2(2)
Escape	Avoiding the problematic environment and/or situation; denial about a problem/failure or flight from the problem.	My actions when facing challenges and failure were not wanting to do that assignment for the day because I did not think I could do it right	4(1)	2(1)	2(2)	0(0)
Rumination	A passive and repetitive focus on the negative and damaging features of a stressful situation; this includes intrusive thoughts, negative thinking, catastrophizing, self-blame, and fear.	DNA barcoding was very challenging. It was difficult to interpret the data at some points of the experiment and there were so many steps that I often kept thinking to myself that I was going to mess something up. It was a tedious process.	3(0)	1(0)	1(1)	0(0)
Social withdrawal	Actions aimed at avoiding other people or preventing other people from knowing about a stressful situation or its emotional effects.	I felt a little insecure, and it made me want to not really talk to anyone.	1(0)	0(0)	0(0)	0(0)
<i>The codes below were not supported by literature as adaptive or maladaptive and were not combined into an aggregate code.</i>						
Repetition	Directly acting to solve a problem by repeating steps taken to achieve the desired outcome.	Even though I was annoyed I still worked hard while redoing the experiment	98(15)	65(29)	19(16)	46(42)

Acceptance	Accepting the problematic situation or problem and no longer trying to change it or solve it.	I was fine as I knew that sometimes it just doesn't work whether it is because of contamination or any other reasons.	14(2)	11(5)	6(5)	5(5)
Negotiation	Negotiating or proposing a compromise, persuading others, or making a deal to alleviate the problem (lessen its impact) or to help solve it. This includes delegating tasks out to team/group members or discussing strategies with group members to come to consensus on a plan.	I made sure that everyone that was responsible for collecting samples actually followed through with their promise to the group.	5(1)	2(1)	0(0)	2(2)
Distraction	Active attempts to deal with a stressful situation by engaging in an alternative pleasurable activity. Seeking relief from stress through engaging in otherwise enjoyable activities such as hobbies or social events.	<i>*No instances found. We did maintain this code, however, because it is drawn from Skinner and colleagues (2003) work.</i>	0(0)	0(0)	0(0)	0(0)

Supplemental Table 4. Outcomes codes, definitions, example quotes, counts and percent students reporting each code overall and within the sample of students who reporting *Technical Research Challenges*.

OUTCOMES						
Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Improvement in ability to cope with science challenges and failures	Descriptions of gains in one's ability to cope with or navigate scientific challenges and failures.	<i>see below</i>	218(33)	164(73)	85(73)	79(72)
Increased Persistence and perseverance	Expressing increases in one's intentions or ability to persist or persevere when encountering challenges in STEM or otherwise.	I now know to continue pushing through challenges in data until an answer is found.	71(11)	55(24)	26(22)	29(27)
Improved emotional regulation - non-specific	Expressing improvement in one's ability to control or regulate emotions during times of stress or in anticipation of stress. <i>This is a less specific code than the subcodes denoted with a "-" below.</i>	Dealing with long, complicated, or frustrating work	5(1)	5(2)	1(1)	4(4)

- Development of a patient, calm or balanced disposition	Expressing that one has developed a calm, balanced, stoic, or patient disposition when encountering challenges or stressors.	I just feel that I learned how to be patient with the scientific process.	28(4)	24(11)	12(10)	12(11)
- Ability to regulate negative emotions	Specifically expressing improvement in one's ability to control or regulate negative emotions during times of stress or in anticipation of stress.	Don't get frustrated if something does not work out; learn from it.	26(4)	23(10)	7(6)	16(15)
- Development of a positive disposition	Expressing that one has developed a generally positive attitude or disposition regarding challenges or stressors.	Maybe be more selective about sample collection and continue to keep a positive attitude despite setbacks	15(2)	11(5)	4(3)	7(6)
- Self-compassion	Expressions of self-care and kindness such as forgiving oneself after making a mistake or failing.	It helped me realize that I am not always going to get results but that doesn't mean that I am a failure myself.	11(2)	10(4)	4(3)	6(6)
- Increased self-awareness	Expressions of self-awareness regarding what "works" and what "does not work" for oneself. Also, self-realizations related to how one responds to a situation or acts.	For most of my life I have avoided doing challenging things in order to avoid failure. This incident was an opportunity for me to grow because it forced me to deal with failure and challenges head on.	6(1)	6(3)	3(3)	3(3)
- Increased humility	Expressions of an increased sense of humility, humbleness, or new-found appreciation of others as related to one's own limitations.	The experiences I have had will make me more humble in the future.	5(1)	3(1)	0(0)	3(3)
Increased ability to tolerate and navigate challenges - non-specific	Expressions of increases in one's ability to tolerate and/or respond constructively to challenges. <i>This is a less specific code than the subcodes below.</i>	If I fail I will just have to deal with it because I can change it	24(4)	19(8)	8(7)	11(10)
- Acceptance of failure as normal	Expressions that failure is common or normal. Statements of acceptance of failure as a normal process.	In life you're rarely going to be successful on the first try, unless you get lucky, so you have to respond maturely and make adjustments in order to make something work.	47(7)	41(18)	26(22)	15(14)
- Increased ability to troubleshoot	Expressions of increases in one's ability to "troubleshoot" or strategically evaluate past failures and use that information to improve upon or modify future actions to increase the probability of success.	I think that it will allow me to better handle situations where not everything works exactly as planned and finding ways to continue on with the research, whether that's modifying things or starting from scratch with a	36(5)	28(12)	16(14)	12(11)

		new specimen, hypothesis, etc.				
- Recognition that failure/struggle provides a learning experience	Expressions stating that one can learn while experiencing failure or that failure provides an opportunity for learning	Failure helps you learn from your mistakes. If you succeeded all the time you would never learn from your work.	39(6)	28(12)	13(11)	15(14)
- Recognition of the importance of seeking help	Expressions recognizing the importance and utility of seeking help when encountering problems.	If I fail I will just have to deal with it because I can change it and if something is uncertain I need to ask for help.	33(5)	20(9)	16(14)	4(4)
- Increased acceptance of criticism	Expressions indicating an increased ability to learning from and accept criticism as part of dealing with a challenge or obstacle	You also must be open to criticism so that you are able to improve.	5(1)	3(1)	1(1)	2(2)
Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Understanding the Culture of Science	Descriptions of increased understanding of the cultural aspects of science. Knowing the cultural expectations of aspects of science.	<i>see below</i>	60(9)	51(23)	26(22)	25(23)
Science involves failure and uncertainty	Expressing that doing science involves failure, that one should expect failure when doing science. AND/OR acknowledgement that scientific results can be uncertain or ambiguous.	I learned that especially with science, sometimes you fail, but you just have to try again until hopefully you succeed.	56(8)	51(23)	26(22)	25(23)
Science involves persisting through challenges	Expressing that to do science or be successful at science, one must persist through challenges	I learned that we're doing real science and you can't expect it to always work. Nothing is perfect so you need to roll with the punches.	3(0)	3(1)	1(1)	2(2)
Understanding the myth of the scientific method	Expressing a realization that the scientific method is not a linear set of steps; it is iterative and involves both backward and forward progress.	I felt like I learned more about the science process, like understanding that it's not a specific step-by-step and then you're guaranteed success.	3(0)	1(0)	0(0)	1(1)
Unexpected results are still results	Expressing that even if the results do not support a hypothesis or an expectation they are still legitimate results	I learned that just because you don't get the results you want, does not mean your research wasn't valid and that getting no answer is an answer.	1(0)	1(0)	0(0)	1(1)

Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Improvement in Research Skills	Descriptions of gains in skills related to performing science research.	<i>See below</i>	48(7)	33(15)	16(14)	17(16)
Increased research skills - non-specific	Expressing a sense of improving a skill associated with science research.	It will help me understand what and what not to do in the lab.	5(1)	3(1)	1(1)	2(2)
- Technical skills	Expressing improvement in one's technical research skills, for example in data analysis, data collection, etc.	I learned to be more comfortable when present with a large amount of data and information and to be able to determine what is useful and what is not.	27(4)	24(11)	12(10)	12(11)
- Logistical skills	Expressing improvement in skills needed to prepare to do research or manage research projects, for example in time management.	I learned to manage my time more efficiently in order to get the labs done on time.	10(1)	5(2)	2(2)	3(3)
- Communication skills	Expressing improvement in one's communication skills, for example in writing, presenting, or making presentations.	It gives me a reference of what not to do and what to do when writing results and discussion.	8(1)	2(1)	2(2)	0(0)
Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
<i>The codes below were not part of an aggregate code.</i>						
Increased caution	Expression of the intention to use more caution and/or care in future endeavors	It will definitely make me a much more conscious researcher and I will be a lot more cautious to avoid contamination in future labs.	69(10)	61(27)	36(31)	25(23)
Increased effort / Importance of effort	Expressing an intention to put more effort or work into future endeavors. Recognizing the importance of putting effort into work.	It helped me understand that nothing of value can be achieved easily the first time around, you have to put in hard work and dedication.	18(3)	11(5)	4(3)	7(6)
Academic Skills	Expressing improvement in one's ability to study or use other skills to succeed in an academic setting.	I will use every resource to ensure a good grade.	25(4)	7(3)	5(4)	2(2)

Increased collaboration skills	Expressions indicating an increased ability to collaborate or work with others toward a common goal.	I learned that I should be more encouraging to my teammates or complete some of the work myself if it needs to get done.	13(2)	5(2)	0(0)	5(5)
Increased self confidence	Expressing confidence in one's own abilities	This experience will give me confidence and help me be calm and levelheaded in future labs.	7(1)	4(2)	2(2)	2(2)
Increased research self-efficacy	Expressing a sense of self efficacy related to science research.	I learned more about the process and each individual step of DNA barcoding. It helps me to be able to step further into upper-level courses giving me the confidence to perform different types of research.	6(1)	4(2)	2(2)	2(2)
Increased knowledge	Expressions indicating an increase in one's content knowledge.	I learned that it is difficult to find some plant species in the middle of February.	8(1)	4(2)	2(2)	2(2)
Increased comfort with taking risks	Expressing increased comfort with or tolerance of situations involving risk.	This has taught me that it is okay to take risks.	2(0)	1(0)	0(0)	1(1)
Acceptance of responsibility	Expressions indicating intentions to accept responsibility for the outcomes of one's own work	I know not to slack off and to pull my end of the work.	3(0)	1(0)	0(0)	1(1)
General expressions of learning or growth	A non-specific statement about learning or growth with no specific outcome targeted	I grew as a scientist.	20(3)	10(4)	5(4)	5(5)
No / Negative outcome	Expressing that no learning occurred or that a negative outcome occurred	I don't think I learned anything from this experience.	71(11)	37(16)	15(13)	22(20)

Supplemental Table 5. Challenges codes, definitions, example quotes, counts and percent students reporting each code overall and within the sample of students reporting *Technical Research Challenges*.

CHALLENGES						
Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Technical Research Challenges	Challenges associated with the technical aspects of performing research, including both data collection and analysis.	<i>see below</i>	435(65)			
Data Collection Challenges	Challenges associated with the data gathering and collection. For example, challenges associated with collecting data including DNA extractions and PCR.	The first time our group conducted gel electrophoresis, the positive control showed no amplification so our PCR could not be trusted. This failure caused us to redo the	354(53)	180(80)	75(64)	105(96)

		experiment from the beginning.				
Analysis/Interpretation Challenges	Challenges associated with the analytical aspects of performing research. For example, challenges associated with interpreting and analyzing data, especially with regard to DNA subway or BLAST.	I have had difficulty with comparing my DNA to similar DNA on the BLAST list because of the many results and repeating results that came up. It was difficult for me to decipher between them.	81(12)	47(21)	43(37)	4(4)
Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Non-technical Research Challenges	Challenges associated with aspects of research not specific to STEM fields or non-technical in nature.	<i>see below</i>	82(12)			
Research challenges - non-specific	Challenges associated with doing and completing research	I've faced challenges when it has come to getting results that have supported my hypothesis or results that just weren't satisfactory for what I was doing	1(0)	0(0)	0(0)	0(0)
-Literature Review Challenges	Challenges associated with performing a literature review for a research project. For example, challenges finding sources, challenges finding enough research to support a claim, etc.	One of the major difficulties in our lab was not the lab exercises but the researching of our background information. We could not seem to find enough relevant data to elaborate on our project.	45(7)	5(2)	3(3)	2(2)
-Logistical Challenges	Challenges associated with the logistics of getting research done. For example, difficulties obtaining what is needed for the lab or difficulties with scheduling.	My group and I completed the data collection and analysis with the least amount of problems. Getting fresh and/or frozen halibut from some of the grocery stores around here was hard and very limited so we had to switch to cod.	18(3)	2(1)	1(1)	1(1)
-Research Creativity Challenges	Challenges associated with not being able to generate research questions. Having difficulty with the creative processes of science.	It was difficult trying to think of a research question unique to previous lab sections.	3(0)	0(0)	0(0)	0(0)
-Communication Challenges	Challenges associated with communicating research results or expressing results to others. For example, challenges with posters, written lab reports, or final papers.	I was challenged at first understanding the trees with my sample and how to describe them on my poster.	16(2)	0(0)	0(0)	0(0)

Aggregate Codes and Codes	Definitions	Examples	Overall Count (%)	Data from Students Experiencing Technical Research Challenges		
				All (%)	140L (%)	150L (%)
Aggregate Code: Non-research Challenges	Challenges not associated with performing research	<i>see below</i>	36(5)	(0)	(0)	(0)
Academic Lab Challenges	Challenges associated with being in an academic laboratory learning environment in general. These challenges are not unique to doing science research - they could be experienced by a student in any academic lab context.	I tend to skim through lab protocols and could have accidentally put in the wrong amount of product. Luckily my group members were there to help me get through my clumsiness.	12(2)	0(0)	0(0)	0(0)
Personal challenges	Challenges of a personal nature occurring outside of the class that affect the experience of the student in class. Also includes challenges arising from emotions students experience PRIOR to any real experienced challenge;	While I have not actually experienced much failure myself over the past few weeks, the fear of failure while doing an experiment or research in any way definitely had an effect on me while we were working on DNA extraction and PCR.	4(1)	0(0)	0(0)	0(0)
Social challenges	Challenges associated with the social environment that the students find themselves in such as challenges interacting with partners or groups	Being able to communicate effectively as a team to work on our project.	4(1)	0(0)	0(0)	0(0)
Academic challenges	Challenges associated with the academic aspects of the class (quizzes and tests)	It has been hard for me to think science related as taking this course for a general education cluster. I struggle in understanding the material and applying it in the laboratory.	5(1)	0(0)	0(0)	0(0)
General challenge - non-specific	Challenges that do not fall into any of the above categories and general non-specific statements of challenge.	When using DNA Subway, the screen would get stuck when I would try to enlarge it. It would force me to use backspace to get back to the subway and then I would have to restart.	11(2)	0(0)	0(0)	0(0)
No challenges	Absence of challenges is directly reported	No failures or challenges while conducting research	110(16)	0(0)	0(0)	0(0)

Supplemental Table 6. Descriptions of molecular techniques referenced in the article text.

Term/Technique	Description	Reference for further information
Basic Local Alignment Search Tool (BLAST)	Software programs that compare the similarity between nucleotide or protein sequences of samples to user-specified sequence databases	https://blast.ncbi.nlm.nih.gov/Blast.cgi
BLAST hits	BLAST output indicating matches between unknown query sequences and known sequences	https://www.ncbi.nlm.nih.gov/books/NBK1734/
DNA extraction	Isolation of DNA by chemically or physically means to separate from cellular components or viruses	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6425773/
DNA Subway	Bioinformatics platform that bundles tools and databases to allow the user to analyze DNA relationships, construct phylogenetic trees, assemble gene models, and investigate genomes	https://dnasubway.cyverse.org/
Gel electrophoresis	Technique used to separate mixtures of DNA, RNA, or proteins according to molecular size	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846332/
Polymerase Chain Reaction (PCR)/DNA amplification	Technique used to quickly copy or amplify small segments of DNA	https://www.genome.gov/about-genomics/fact-sheets/Polymerase-Chain-Reaction-Fact-Sheet