Exploring Ungrading in a Biochemistry Laboratory Course

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Imagine we have two first-year college students, A and B. Student A comes into an English course having spent a summer at a writing institute. All summer, they were learning and developing their skills in writing. Student B has spent the summer working to make sure they have money for books and housing in the fall. At the end of the semester, student A produces a paper that exceeds your expectations for a first-year student and would be considered upper-collegiate level. In comparison, student B has developed and worked on their writing skills to produce a quality paper, but still has areas for improvement. Who deserves the A? It can be easy to unintentionally marginalize students with less privilege than their peers, which is why it is important to assess student work with equity and consideration of the whole student. But how do we do that?

This chapter sets out to describe the pedagogical philosophy of "ungrading" proposed by Susan Blum (2020), but that builds on work by Alfie Kohn (1999) and others, which is a teaching style focused on removing grades from classrooms. Specifically, this chapter focuses on ungrading in a writing-focused junior-level undergraduate analytical biochemistry laboratory course at the University of Maine. I will begin this chapter by describing the background and inclusive strategies used in ungrading. Then, I will address how select strategies were employed in my biochemistry lab course and have become my standard approach in the course. I will finish with assessing the use of ungrading in my classroom using open-ended student self-reflections.

When thinking about ungrading, it is equally important to think about why we grade. What does a grade represent? What is it to give a grade or to be graded? The way higher education in the United States perceives grades is that they represent the instructor's evaluation of student work for the duration of the course (International Affairs Office, 2008). Grades are usually represented as letters (A, B, C, D, and F), numbers (0-100), or even a final grade point average (GPA). Ultimately, the intention of giving a grade or "grading" is the act of distilling all student work into a simplified representation (letter or number). It is hard to imagine that one letter or number could possibly encompass all of a student's work or growth during a semester or even, for that matter, on one assignment. James Felton and Peter Koper (2005) argue that grades are "inherently ambiguous evaluations of

performance with no absolute connection to educational achievement" (p. 2). Ungrading sets out to look at different ways we can assess student work without using these traditional grading systems.

Why Grades are Not Effective for Assessing Student Learning

When I have asked students to reflect on how they have been traditionally graded in a classroom, many strong feelings arise. Students often reflect that they feel anger, anxiety, fear, and disgust. This is troubling since grades frequently guide educational pathways, as students are often motivated in their coursework by subjects they feel they are "good at." Yet, research has shown that grades are not useful tools for incentivizing students in a classroom. In fact, college students avoid challenging assignments (Milton et al., 1986), are dissuaded from learning (Butler & Nissan, 1986), and have reduced creative thinking on course content (Milton et al., 1986). I often hear from students that grades in high school motivated them to choose their majors in college. These grades are a deciding factor in the career path of students and the potential jobs that they are going to pursue later in life.

Grades continue to influence students in college, as those students who receive higher grades in first-year science, technology, engineering, and mathematics (STEM) courses are more likely to continue in STEM fields (Thompson, 2021). This fact is particularly important for women and ethnic minorities as they have lower persistence rates in STEM majors and often have lower GPAs after the first year (Cimpian et al., 2020; Griffith, 2010). It is not a surprise, then, that these students are underrepresented in STEM, as students will likely stay in a STEM major if their ratio of GPA in STEM courses is higher than non-STEM courses (Griffith, 2010). It is an institutional problem when women and ethnic minorities are dropping out of STEM courses at a faster rate than their white male counterparts (Suran, 2021; Thompson, 2021). STEM, and I argue any field, can only benefit from a diversity of perspectives and backgrounds. Grades can have a negative impact at every level of student learning where they are utilized.

In thinking about how grades are meant to work and how grades work operationally, I argue that there are five ways in which grading falls short in assessing learning in a course. In my experience teaching at the collegiate level, I find that:

1. Grades do not take into consideration the whole student. They don't reflect the knowledge a student brings with them into the classroom and how much they learn over the course of a semester. Consider the student example described in the beginning of the chapter: a holistic approach to education seems more equitable because it accounts for the growth of the

individual rather than relying on skills taught before students enter the class-room. Overall, grades are not always representative of the skills a student has gained over the course of the semester.

2. Grades alone do not provide any meaningful feedback for students. A grade does not tell a student what could be improved upon on an assignment or where they are doing well. In fact, students tell me that the first thing they do when they get an assignment back is to look at the grade and then file the paper in their notebooks. They completely dismiss the comments given or the ways they could improve their learning. The grade appears to supersede feedback and demoralize students. Students often reflect to me that they are an "A" student or a "B" student. They appear to categorize themselves as a grade rather than a learner capable of growth. The question is, if there is feedback on an assignment and all the student does is just look at the grade and not the feedback, then is putting a grade on an assignment even worth doing? For me, it is important to focus on learning as a collaborative dialogue between student and instructor and not on grades. This shift to focusing on feedback as a tool for learning, rather than adding a grade, helps me to shift student mindsets to be more learning-focused.

3. Grades are not necessarily directly linked to our student learning outcomes. As part of our syllabi, we list carefully crafted student learning outcomes and student learning goals. Instructors often use two modes of assessing students on these outcomes: summative (cumulative) and formative (any feedback on improvement) assessments. If an assessment is linked with the learning goal (as we hope it is), there are several questions we can ask. Does giving a grade on that assessment help the student improve and meet the learning goal? When a student receives a grade on the assignment, does that give clarifica-tion on a sticking point? Would students be less motivated to improve if you left the grade off and just gave feedback? If I tell you that a student got a "B" on an assignment or learning outcome, does that tell you anything about a skill or knowledge that a student has developed? Most often, the answer to these questions is "No." I would argue that grades do not help guide learning as we may intend; it is the feedback and the growth from that feedback that is connected to our learning outcomes.

4. Grading can demoralize instructors. It severely underappreciates the amount of effort it takes to effectively give students feedback on completed work. Giving a grade requires that the instructor effectively describes expectations for student work, how those expectations align with course objectives, how the instructor will assess effort and learning based on the skill set of the student, and how the instructor will give effective feedback that will lead to student learning. Grading can turn the course culture from one focused on

learning into one focused on competition. Not only is there competition amongst students for the best grades, but there is competition between the teacher and the student for getting a higher grade. The focus of the class becomes on the grade and not on the learning outcomes. Moreover, there is often a deep mistrust between teacher and student. The student may not feel as though the teacher has their best interest at heart. Conversely, the teacher may not feel as though the student is putting their best effort forward and is constantly worried about ways to inhibit cheating.

5. Grading doesn't create a positive culture in our courses as it does not incorporate the whole welfare of the student. It doesn't take into consideration their background and mental health. College student mental health issues have doubled in the past ten years and are especially a problem in ethnic minority students (Colarossi, 2022). Grades do not encourage students to be comfortable in a classroom and are anxiety-inducing. As mentioned above, the culture is not one focused on mental health but on competition. Grades pit students against one another and do not provide students with a safe learning environment where they can take risks, make mistakes, and learn from those mistakes.

Alternative Methods in Ungrading

If the traditional grading scheme has negative impacts on student learning, can alternative methods be used to give positive impacts? Ungrading is the use of alternative methods to remove the focus on grades and switch the focus to learning. Changing the way we educate from traditional methods, as seen with Madison Brown's vignette (this collection), moves education to incorporating many modes of learning and supporting a variety of students in the classroom. If we can support women and ethnic minorities in STEM, we can create a space that supports and rewards creativity and learning rather than focusing on "correct" solutions. In the ungrading approach, students don't have to be perfect to be successful. Students can learn through mistakes and feel pride in their work and in their learning. Changing the approaches for assessment moves the classroom conversation from grades to feedback. Similar to what Janelle Johnson et al. describe (this collection), the ungrading approach seeks to avoid the "weed-out" approach and create a classroom that celebrates diversity and considers a more holistic approach to education. STEM classrooms typically have traditional formats, which often ignore other modes of assessment. The methods listed below, initially described by Jessie Stommel (2020), were those implemented in my classroom and could be used in any STEM undergraduate classroom to make the assessment process more transparent to students. When students are included in the conversation of grading,

they are more likely to feel like it is simple and fair. Not all of these methods will fit in every classroom, nor should they, but educators should choose the methods that work best with their teaching style. Additionally, the list below is not exhaustive, and instructors shouldn't limit themselves; they could create assessment strategies that work for them in their classrooms. The best relationships I have cultivated with my students have been when I am authentically myself in the classroom and don't pretend to be someone I am not. For example, I am naturally introverted, so I am not going to be a loud, joking personality type in my classroom. Additionally, I utilize many teaching practices that allow students to engage in self-reflection and anonymous course engagement. For example, using clicker questions and using think-pair-share to answer questions or reflect on learning instead of raising hands gives other introverted people a way to participate in the course other than directly asking questions. Furthermore, creating a classroom community is important to me, so focusing on relationship-rich teaching (Felten & Lambert, 2020) and pedagogy of kindness by Cate Daniel (2019) resonates with me as an instructor.

Minimal Grading

Minimal grading is using scales with fewer gradations. There are several methods that can be used, including strong/satisfactory/weak [three gradations], pass/fail [two gradations], +/- [two gradations], and turned in/not turned in [one gradation]. This accomplishes clarity in the classroom. First, there is wide variability between instructors grading the same work (Meadows & Billington, 2005; Schinske & Tanner, 2014). Simplifying the grading scheme can produce more consistent results between instructors. Second, it can be hard for students to understand how they performed and what they need to improve upon with number grades. Lastly, this approach focuses students on the learning rather than grades, as students will look at the feedback rather than the grade itself. This is especially powerful if an instructor allows students to resubmit work in combination with the use of minimal grading.

Grade-Free Zones

A zone is a defined period of time in a course. There are many different types of grade-free zones that can be implemented in a college course. An instructor can give grades on just a few assignments or not grade for two or three weeks, or it could be more extensive where students would not be graded for a third or half of a semester. It is up to the instructor to decide the length of time that grading will not occur and how it fits into the semester. This approach may seem a little perplexing to conceive, but the time that students are not graded could be spent simply letting them engage in course content before moving on to more traditional assignments. This time is often spent giving feedback and not grades.

Contract Grading

In contract grading (see Mallette, this collection), the course outlines in the beginning exactly what students need to do to earn specific grades. There are concrete criteria given for each grade a student could potentially achieve. Students can work toward whichever grade they would like to achieve based on the work they complete. The advantage for students is in the clarity of the expectations: there will be no additional work added or sudden removal of work from the grading scheme. If this approach is combined with flexibility where students can resubmit the work until they can get a satisfactory grade, it focuses the class on the quality of the work completed. There is less conflict over grades and less competition between students for the best grade: everyone can work toward their own individual goal.

Authentic Assessment

In this strategy, students apply course content to their real-life communities. The definition of community could be broad or narrow, as it could be for the town/ city, college, or classroom community. The most important aspect is involving students in designing an assessment that conveys information to a real audience. Not only does this involve students in the decision-making of the course (course buy-in), but these types of assignments are important to students' sense of identity. Every person has multiple identities based on differences that include, but are not limited to, socioeconomic status, age, gender, religion, race, and sexual orientation. Research has shown that creating a classroom where students can celebrate their identity can directly improve student motivation and learning (Lowe, 2019). The expression of identity in a classroom is important for all students, but it is especially important for helping low-income, first-generation, and racial/ethnic minorities (Harackiewicz & Priniski, 2018). Students who express their identity in the classroom have an increase in student persistence through tough course material and continued participation in STEM courses (Murphy & Destin, 2016; Gurin et al., 2002; Dewsbury & Brame, 2019).

Self-Assessment

Self-assessment utilizes the approach of metacognition, or thinking about learning. This is a cross-disciplinary approach that focuses on student awareness of their problem-solving skills, ability to judge how well they understand course material, and understanding their level of learning as the course progresses. As a part of the self-assessment, a growth mindset, or the idea that learning ability is not fixed, can be explored. Exploring growth mindset in the classroom has been found to especially benefit women and underrepresented minorities in math and science (Rattan et al.,

2015; Kricorian et al., 2020). For students coming into a course with insecurities in course content, it is important to instill in our students that they can improve their comprehension of course content with practice and time. Many studies have shown that students have increased learning gains when completing self-assessments (Andrade, 2019). More specifically, Heidi Andrade (2019) describes many benefits, including helping students take responsibility for their learning, development of critical thinking skills, and the ability to set achievable goals for a course. Self-assessment is a powerful tool that puts the ownership of learning back onto the student.

Process Letters

This strategy asks students to reflect on their learning and the work they have completed over the course of the semester. In these reflections, students detail, with examples, what grade they should receive. This typically takes the form of an essay or formal letter. This approach focuses on student reflection on the learning that has occurred over the course of the semester and creates a space for persuasive writing. Usually, there is a meeting with the professor to discuss the process letter and decide together on a final grade in the course. Students can feel empowered in the classroom by being able to take an active role in deciding their own grade.

Background on the Course

The Course

The current form of the Analytical and Preparative Biochemical Laboratory is a course-based undergraduate research experience (CURE). This is an upper-level biochemistry lab for juniors at the University of Maine and is required for all the majors in the Department of Molecular and Biomedical Sciences. The goal for the class is to do original research by answering a research question with no known outcome. To conduct research, we have a two-hour lecture that is discussion-based and a four-hour lab per week with two sections of the course. The purpose of the course is to purify a known enzyme from a new organism. This is novel research for which there are no protocols or data. The class must work together as a group to develop assays (or experiments) for expressing the enzyme, detecting the enzyme, creating the protein purification procedure for the enzyme, and characterizing enzyme function. This course, where faculty and students work together to research and create knowledge, reflects the critical pedagogy described by Ann Fink (this collection).

An assignment is given prior to each lecture period where students research how an assigned assay works (the chemistry behind it) and bring a protocol to the

lecture class for the assay from the primary literature. We discuss the background as a class, where everyone contributes to the discussion. Since we are designing our own experiments, this is a calculation-heavy course. As such, every class period, students break up into designated lab groups to work on practice problems related to data analysis they will encounter that week. After we have completed calculations, students are then given a loose experimental protocol to aid in protocol refinement. They work together in groups of two or three to complete the protocol and calculations to prepare them for their laboratory session. Often, students must meet outside of class time to finalize the procedure for the experiment in the week ahead.

During lab, students carry out the experimental protocols they developed and analyze the data. Sometimes, students will not have enough time to analyze data and must do this before the next lecture period. It is important that even if the student does not feel like an expert in the data analysis process, they try it on their own. I emphasize that they will learn a lot through mistakes or incorrect analysis, and they will not be graded on correctness, just completion.

The next week in lecture, we work in a group to go over data analysis from the prior week. This approach gives students the ability to make changes and corrections to their data analysis. We focus on learning through making mistakes. Also, students can analyze data in different ways: there is often not a yes/no (black/white) answer to the analysis, but there is gray area where we discuss different approaches used in the field. In research, we often stay in the gray area until we get more data that makes the path clearer. Working as a group, we try to reach some general consensus on the data analysis, but there is often not one correct way to approach the problem.

The major assessments in the laboratory are notebook checks and a final manuscript. The manuscript (described later) contains publishable quality figures and includes the traditional format of abstract, introduction, methods, results, and discussion with properly formatted references. While challenging, the manuscript represents a deep analysis and understanding of the context of the student's work in the larger scientific community.

Motivation for Ungrading

I have taught this course traditionally graded for three years, but the COVID-19 pandemic was announced, and I needed to pivot my laboratory course to an online experience. This caused me to completely switch my assessment strategies in the course. Coming out of the pandemic, I wanted to keep the changes I made because I saw decreased anxiety and increased performance on assessments. Then I read the ungrading book (Blum, 2020), and I knew that I needed to take the next step toward being a more inclusive course by implementing this teaching philosophy. The catalyst to use ungrading in my classroom has, and always will be, my students. For example, in my spring 2022 analytical biochemistry laboratory, a student said to me: "My

entire life I have tried to learn in an environment that seems like it was set up for me to fail." I wish this sentiment was the only time I had heard this type of comment, but I have increasingly seen an uptick of students with anxiety, depression, ADHD, and those with a variety of classroom accommodations. The feedback I get from these students is that they struggle mastering course content and managing workloads. As with most of us in the teaching profession, I want my classroom to be a supportive environment where my students can succeed regardless of their background or current life experiences. Unfortunately, many students feel like they are trying to learn in environments that are not geared toward their success. As Ann Fink describes (this collection), the COVID-19 pandemic upheaved our lives but also allowed us to upheave the way we approached education. I have always been willing to try new approaches in my classroom that can benefit students, but the COVID-19 pandemic certainly motivated me/let me grant myself permission to radically change the way I teach. It led me to think holistically of my students' needs and make sure they were included in classroom and grading decisions.

Implementation of Ungrading

One of the guiding principles of ungrading is to engage students in their learning and make them the conductors of their learning train. In my classroom, I wanted my ungrading journey to focus on flexibility, self-assessment, authentic assessment, and direct student involvement in the grading process. In what follows, I describe how I incorporated each one of those changes in the course.

Flexibility

Students' lives (as our own) can be very complicated with many moving parts. Rigid deadlines and a lack of flexibility in turning in assignments can impact student learning and feelings of success (Yoo, 2015). The goal with this course was to switch from a grade-focused course to a learning-focused course. To assist in this approach, instead of allowing students to turn in assignments once, each assignment and set of data analysis can be turned in as many times as needed to obtain full credit on the assignment. This includes the notebook checks and the final manuscript. A minimal grading system is used where students are given three levels of grades: 50 percent (weak), 75 percent (satisfactory), and 100 percent (strong) on assignments. Feedback is given within our learning management system (LMS) to allow students to make changes to those assignments.

In the lab notebook assignment, students analyze their data to the best of their ability, and then during our lecture time, we discuss the results. This allows all students to weigh in on the interpretation of the data and make corrections as a

group. Individualized feedback is provided to students through the LMS. If the feedback is not sufficient or students need more help, then they are able to meet with the instructor to get additional assistance. Toward the end of class, there are three to four weeks where students are not receiving grades but focusing instead on the generation and analysis of data.

The manuscript was a large undertaking since it was modeled on a journal article, including creating publishable quality figures (well-communicated, correctly formatted, with high-resolution). In terms of teaching how to write a manuscript, the assignment was broken down into two parts: the figures and the text. Every week, I would teach about the multi-step process of making publishable quality figures using professional software, and students would practice using the software to create figures with their data. Again, feedback was given through the LMS. Teaching about writing the text of a manuscript was broken down into sections: abstract, introduction, materials and methods, discussion, and overall specific journal formatting. Students were able to work on the first draft of the manuscript at their own pace, making individual appointments if they required immediate feedback. After completion of the first draft, feedback was given, and changes could be made until the due date. This approach allowed students to see that STEM as a whole, but specifically data analysis, making publishable figures, and writing a manuscript, are all iterative processes. The approach was used to demonstrate to students that revision is normal in science: despite our best attempts, perfection is rarely achieved the first time we try something new.

Another way I incorporated flexibility was by moving deadlines for students. Throughout the semester, I got to know my students and understand the complexity of their lives. I moved deadlines around for students who had significant personal struggles since I knew that other faculty at the university would not likely be as flexible. For example, I had a student with a concussion, and once the two-week period passed for healing (doctor's allowance), other professors made them turn in all of the missing work. This required the student to continue to work through the two weeks "off" even though their brain was still healing. As soon as I knew about the concussion, I told the student that I would be flexible with them on deadlines. They were very reluctant to move deadlines because they didn't want it to appear as though they didn't care about the class and wanted to appear "normal" (their words, not mine). I made sure the student knew they were going to be supported and could learn the material at their own pace so that they didn't feel so anxious about coursework. Being flexible on deadlines not only allowed the student to heal properly but also allowed for this student to feel less anxious overall because they knew they could get all the work done. If I had not moved deadlines, the amount of work and strict deadlines that other courses required would mean that this student would have been completing the work but not focusing on learning content in my course. At the end of the semester, this student was incredibly grateful for

this approach, but more importantly, very successful in learning course content as gauged by the quality of the final manuscript.

Self-Assessment

In order to pivot the course to student learning, I give students four self-reflection assignments to analyze their growth mindset, metacognition, overall learning, and group dynamics (Appendix). Each self-reflection starts with a metacognition awareness inventory which consists of several metacognition-oriented questions and then gives students the choice on a Likert scale. Additionally, each self-assessment asks for comments on concrete skills students could develop during the course. The reason I focus on skill sets is due to student feedback saying, "I am not going to be a protein biochemist. Why do I need this course?" Every year the National Association of Colleges and Employers surveys employers across the country for qualities they are looking for in college graduates (Koncz & Gray, 2022). I list the top ten skills and ask students to reflect on which skills they want to develop. As the semester progresses, I ask students to reflect on the skills they have developed in the course.

Other than the consistent questions and themes discussed above, the reflections often change in content throughout the semester. In the first reflection (first week of classes), students are asked open-ended questions on what knowledge and strengths they are bringing into the course and some weaknesses they would like help working on during the semester. The second assessment, given in week five, asks students about the hardest concept to master in the course so far and where they have received help on that concept. It also asks them to consider strategies that would improve their learning and one course norm they would change. In the third reflection in week ten, students are asked similar questions to the second assessment but also to comment on their progress so far in the course and think about assessing their grade in the course with evidence. This approach helps prime them for their last assessment in week fifteen, where they are asked about the structure of the course, struggles and successes, and, more importantly, where they write their process letter.

One crucial part of every self-assessment is an open-ended question where students can communicate to me any issue regarding their learning. Having a self-assessment where there is open dialogue between the instructor and students is essential. I have the opportunity and power to change the course based on student opinions, and this approach celebrates the critical pedagogy described by Fink (this collection). This creates an opportunity for discussion directly with me and lets students know that their opinions and perspectives are being valued. The feedback is often that students feel empowered when course norms change, and they feel like they are included in course decisions.

Authentic Assessment

To incorporate authentic assessment into my course, I give students a creative project. The authentic assessment described here is similar to Johnson et al.'s "Call to Action: Cultivating Activism Among Teacher Candidates" project described in this collection, as it was created to include and celebrate student identity and allow for flexibility in assignments. I also want this to be a student-driven assignment, and I focus the creative project around the theme of scientific communication. The communication of science from scientists to non-scientists is essential for both the advancement of science, as well as for human health. As a scientist, it is imperative that students are able to understand and explain primary scientific research. In this assignment, students have the opportunity to create their own project and rubric for peer grading centered around this theme. The overall purpose of the assignment is for students to have a direct contribution to the course in a way that celebrates their individuality and perspectives.

In this course, there are a variety of projects submitted; some people present pieces of art using various mediums including embroidery, digital art, acrylic painting, or charcoal/pencil on paper. Also, in the artistic category, students have created comic strips, children's books, and board games to convey scientific information. Other students have opted for a more traditional science approach with a five-minute lightning talk on scientific topic of their choice or a poster advertisement. The breadth of the projects has been vast, but the personal connection to the material has been clearly evident through student feedback. One student remarked: "The creative project was so much fun to do!! It was a good break from normal work and made me think and do something I enjoy in my free time."

Process Letters

At the end of the semester, students have an assignment to write a process letter to determine their grade for the course, which is their final self-reflection. Students are given a detailed list of grading criteria at the beginning of the semester so that they know what they have to do to receive an "A," "B," or "C" as a grade. There is no option for a "D" or an "F" as these grades reflect that there is no meaningful learning taking place, and that isn't something that is acceptable in the course. In the self-reflections, there have been students who described grades that were not consistent with the posted criteria for that grade. Moreover, there have been students who did not engage properly in the course. As a result, I hold individual meetings throughout the semester (the more often, the better) to discuss how they are not meeting course expectations. I explain in the grading criteria that my expectations for receiving an "A" are high but that I am on their side and am not trying to trick them into getting anything less than what they feel they deserve. In addition, to receive an "A," students don't have to fulfill

all the criteria, but they do need to fulfill most. The process letter reminds them of the grading criteria, but they are able to find and argue for other criteria that allow them to demonstrate their learning. Overall, in their process letter, students are asked to use concrete examples to show their understanding of the biochemistry content, how they engaged with the course, and how those correlated with grading criteria.

Assessing Success of Ungrading

It is incredibly nerve-racking to make large changes in a course, especially without guaranteeing they will result in increased learning gains for students. In summary, the ungrading experiment in my biochemistry laboratory course has been a success. After reflecting on my use of ungrading in this course, the major themes that emerged from the analysis included student trust building, appreciation of flexibility and feedback, increase in confidence, and gratitude for the ungrading approach.

In terms of building relationships with my students, I experienced more meaningful connections than in any prior time I have taught the course. Here is an example from a student:

> Yes, I confidently believe she does care [about my learning]. I think out of all the professors I have had she cares the most, which is so refreshing to have since she is very nurturing. I feel comfortable talking to her about my problems and ask for help, which I rarely do out of discomfort.

Students welcomed me into their lives and trusted me with their insecurities and struggles in STEM. Students were more comfortable focusing on learning course content and also healed some emotional wounds from interactions with previous instructors. One student commented that they "absolutely believe everyone involved with the course cares deeply about my learning of the material and not just assigning me a grade, which I can say is refreshing compared to other classes I have taken." Not only did students interact with me in more positive ways but with one another as well. This was especially evident with group work:

> I have noticed communicating with my lab partners and doing additional research has been excessively helpful to my learning. It helps me feel more comfortable in the classroom. I also really like the environment the TA's and the professor create and the kindness they show. It makes me feel more relaxed, which in turn makes the class more enjoyable for me, so I have noticed that I am doing better.

As the instructor, I have noticed more camaraderie, connection, and eagerness to interact with one another over the course of the semester.

Incorporation of flexibility into the course was a major goal in my ungrading approach. In an analysis of student reflections, students perceived my flexibility as caring more about their learning than their grade:

> I really enjoyed this semester. One of the best parts was how obvious it was that all the instructors [sic] are TRULY passionate about teaching and helping improve our learning experience. I felt completely comfortable asking for help and not knowing the answer 100% of the time. I could tell you all LOVE the topics in BMB 464 and really enjoy teaching and helping us to appreciate analytical biochemistry! I'm grateful for how pleasant the course experience was! Thanks to all for a great semester!

I have found that students consistently encounter obstacles during the semester that are outside their control. Being flexible when other courses were not allowed students to recover from these events. Moreover, students were more focused on learning than their grade in the course. As a student commented:

> The flexibility and level of understanding you have shown has actually allowed me to learn the material and complete the assignments with my best effort, rather than to turn in assignments just to check them off the list and get a grade. So, thank you again for all of the help and for being so understanding throughout the semester because it really had made such a difference in my semester and with all of my classes.

Overall, I believe that being flexible allowed students to capitalize on their strengths and work on their weaknesses.

Confidence was another theme that presented itself during the analysis. During prior iterations of the course, students were very anxious about their grades/performance. My perception of student anxiety over grades was less in this ungraded course. Students loved the design of the course:

> I could not effectively perform work due to the types of tests and assignments provided. I went from being very depressed (…) to enjoying and getting to know my professor and class. This class did not focus on tests but learning and developing confidence with the work. I learned that I am, in fact, prepared for a career and will do well in whatever career I chose.

This connection to themselves and the course could be a result of the ungrading approach but could also be, in part, due to the focus on metacognition (understanding themselves as learners) in the self-reflections:

> As a student and learner, I discovered that I am in a position
> to positively affect others. The conversations I have with my
> instructors has shown me that learning is an ongoing process,
> which only verified something that I believed. My instructors
> were honest with me and helped guide me down a pathway of
> growth. My peers taught me that I can (…) help improve their
> understanding on the material or I could learn from them.

Either way, the overwhelming feeling was of personal growth and confidence:

> I feel like I am suited for the major and this field. Before taking
> this class I was really lacking confidence and was second-guessing
> my decision to go into the field of biomedical sciences, but now
> I feel a lot more confident. The entire lab was amazing and it is
> a lab I would retake in a heartbeat if I could. I really think this is
> the way labs should be run because we actually are learning and I
> think students would be a lot more successful and want to go to
> the lab if more courses were taught like this. I wish our depart-
> ment had more courses like this.

Students appreciated the design of the course and appeared to gain confidence as biomedical scientists.

When I read their process letters and self-assessments, I was surprised to see that my students felt the same way that I did about the success of our course. With the ungrading approach taken, students still wanted to learn and seemed to want to learn more enthusiastically. During the course, they were able to focus on learning rather than grades:

> Asides from giving me the freedom to not stress about what my
> grade will be, it also gave me the option to make mistakes and
> try new things and learn from them. I was not afraid to get some
> questions wrong on my assignments or ask for help because I
> know that they will be learning moments and not a penalty to
> my grade. I know that I freeze up sometimes because I have the
> need to do everything perfectly and then, I get anxiety from that
> and so I don't even make the first step. Ungrading helped me
> in the sense that it slowly brought down my walls and had me
> not worry about messing up but instead put myself outside my
> comfort zone and helped me learn.

Even my strongest students felt like they had changed their approach to learning:

> I feel that my work ethic has actually increased—as a type A
> person, I honestly hadn't thought that was possible. I feel like my

> approach to work is more balanced at the same time—while I have been putting in more effort, it has also been more efficient. I have really enjoyed being able to not worry about grades and just stick to learning the material, which has been a relaxing change from the norm.

Students were also incredibly observant that the course was focused on personal growth. One student gave advice to students taking this ungraded course:

> If unsure about how to answer a question or analyze a data set: start by doing what you can. This will tell you what you truly do or don't understand. Don't give up! Give your best effort, and don't be afraid to speak up when you don't understand something and just ask for help!

In my observations, students were kinder to themselves by letting themselves make mistakes and then learning from them.

Challenges of Ungrading

I encountered some challenges with the ungrading process that were both expected and unexpected. One expected challenge was that since the course was focused on feedback rather than grades, there was increased feedback on assignments compared to past years. This resulted in more time spent providing written notes to students from both the graduate teaching assistant and me. Another challenge was preparation for the course in the form of making metacognition surveys, creating the grading rubric for the course, and designing the process letter criteria. Regardless of the preparation time I spent on the course, I expect each year will capitalize on preparations made in past years. For example, I was able to copy and paste comments from feedback given on assignments into a Word/Google document. I should be able to use many of those comments going forward. I also plan on re-using in-class problem sets and data analysis templates. These documents should speed up the preparation process and assignment feedback in the future.

Another challenge that I expected was that some students would not show up and/or complete the work. My approach was to meet with these students individually and learn why they hadn't participated to the level of the expectations of the course. Unsurprisingly, discussions with students often uncovered complicated challenges outside my control. I encouraged those students to engage with the course and helped them make a plan for makeup work and course completion. In one case, a student was very far behind, but what had been completed was excellent. We ended up settling on a grade that took into consideration how much work was completed and how much learning had occurred based on the process letter rubric.

When it came to self-assigning grades, I expected all students to give them-selves an "A." To my surprise, they didn't. Maybe it was a result of the high expectations and clear goals of the course, but students were honest in their reflections. Some students were harder on themselves than I would be, and others were more generous than I would have been (e.g., A versus B). I scheduled individual meetings with both types of students (higher or lower than expected) to discuss their overall growth, and together, we settled on a grade.

The biggest challenge to ungrading that I have encountered, which also happened to be an unexpected surprise, challenging the mindset of students towards grading. It took a lot of effort to convince students to trust me and to focus on learning instead of grades. For example, one of my students said that he had been graded since middle school and didn't know another way to think about learning. I had to continually repeat that if they focused on learning, the grade would follow. I also had to reiterate that the onus for learning was on them: the effort they put into the course would be reflected in their learning and their final grade. I eventually won most of them over to ungrading, but it surprised me that the ones most resistant to ungrading were my top performers. They were worried about grade inflation and that everyone would get an A. This simply was not the case. In this unique grading process, I learned to trust my students, and I believe I earned their trust as well.

In summary, I came away from my ungraded course with the knowledge that my students really love learning. Also, they wanted me to be a part of that jour-ney. In the end, I had a classroom that was built on trust, appreciation, and stu-dent-teacher collaboration. One student remarked:

> You [instructors] are amazing people, and I genuinely don't
> know if I can encapsulate my gratitude to you in words. I am so
> thankful that I took this class and even when I was lost or had
> no idea what was going on, I could count on you [instructors] to
> always help me though! This class has been very transformative
> in how I learn and perceive myself and what I am capable of, and
> it is thanks to the amazing people I had for my classmates, my
> TAs, and my instructor! My only complaint now that it is the
> last week of the semester, is that it ended too soon.

I will continue to ungrade in this course and try more ungrading approaches in all my courses.

Institutional Changes in Ungrading

Since teaching this course as ungraded, I have built relationships with my peers in the department and at the institution, surrounding the positive impacts of this

work in my classroom. The first way I have built relationships is with another instructor in the Department of Molecular and Biomedical Sciences. We both read the ungrading book (Blum, 2020) at the same time over the summer and were so inspired that we implemented different ungrading approaches in our courses the very next semester. Since then, we have talked about our successes and challenges in ungrading. We have formed a small community where we help one another develop our courses, troubleshoot problems, and strengthen our program. Excitedly, we both have expanded this ungrading approach to other courses that we teach and have been invited to talk about our teaching pedagogy during our departmental meetings. Perhaps as we discuss the success of our classes, we can normalize the perception of ungrading approaches and inclusive teaching.

The second way I have built relationships is with participation in several communities of practice that are offered through the Center for Innovation in Teaching and Learning at the University of Maine. Through interactions with faculty there, I have developed a pedagogical research project on ungrading. Additionally, I am applying this ungrading philosophy in an internally funded institutional grant focused on first-year undergraduate retention.

The last way I have built relationships is by talking with faculty in other departments. One example is that I presented a workshop on ungrading at a Maine Center for Research in STEM Education Conference. This book chapter is a direct result of giving that workshop. Further conversations about ungrading led to another STEM major at the University of Maine considering this course for incorporation into their degree path. Overall, it has not just been the interactions with my students that have been overwhelmingly positive and life-enriching, but also the interactions with my peers. I have simply no regrets about the incorporation of the ungrading philosophy into my life and my courses.

Small Changes, Big Impacts in Ungrading

While the methods employed above were major changes to a course, there are many small steps that anyone can make to move a classroom to one focused on learning rather than grading. One change would be to grade less often using grade-free zones. If there is a way to simplify or remove some grading, this could be an easy way to make a course modification. A second change would be to involve students in the discussion of course expectations and grading. This approach gives a voice and some control over the course to students. It will empower them. A third change would be to have students complete self-reflections. Remember this method increases learning outcomes for all students. This could be as simple as asking students about their learning over the course of the semester or as complex as using validated methods for measuring satisfaction and self-confidence (Bray et al., 2020). A fourth change would

be adding flexibility to a course. Some suggestions for being flexible include giving students two options on an assignment, making flexible deadlines on an assignment, or engaging with concepts in multiple ways. Some examples of choices could be allowing students to work alone or in groups, letting students watch videos or read transcripts, and, last, having students complete a writing assignment or a presentation. This choice is engaging and encourages student course buy-in. A fifth change would be to listen to and trust students when they are facing conflicts in their lives. Having an open and safe relationship between the instructor and students will help everyone feel comfortable learning in the course.

My hope is that these changes are seen as manageable and can be included in any STEM course. However, it is important to remember that not all of these above-mentioned changes need to be implemented at one time. Small, meaningful steps to incorporate ungrading can make big impacts in any classroom. Everyone can ungrade in their own way, using their own timeline.

Acknowledgments

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Appendix: BMB464 Self-Reflection #1

Metacognition is thinking about the way you think and learn. It is a very important strategy for success in college. It is so important that I want this to be a weekly habit for you throughout your college career. Please take your time and answer the questions thoughtfully and truthfully. You are not graded on correctness, just honesty.

1. Please check the box that best describes you.

Metacognition Awareness Inventory*

	I NEVER do this	I do this INFRE-QUENTLY	I do this INCONSIS-TENTLY	I do this FRE-QUENTLY	I ALWAYS do this
I ask myself periodically if I am meeting my goals.					
I consider several alternatives to a problem before I answer.					
I try to use strategies that have worked in the past.					
I pace myself while learning in order to have enough time to learn the material.					
I understand my intellectual strengths and weaknesses.					

Questions selected from Gregory, S.; Sperling D.R. (1994) Assessing Metacognition Awareness. Contemporary Educational Psychology. 19(4), 460-475.

2. Please check the box that best describes your opinion.**

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
You have a certain amount of science ability and you can't do much to change it.					
Memorizing formulas will make you a good scientist.					
You can greatly change your ability to do science.					
Practice exercises are the best way to learn science.					
Watching a teacher do examples is the best way to learn science.					
Trying a problem I don't know how to solve is the best way to learn science.					
Teaching someone how to solve a problem is a good way to learn science.					
Knowing why an answer is right is just as important as how to find it.					
Being able to build protocols from literature will be important in my future.					
Being an independent researcher will be important in my future.					
Being able to solve complex problems will be important in my future.					

**Questions adapted from a Growth Mindset Survey by Dweck, C.S. (1999)* Self-theories: Their role in motivation, personality, and development. *Psychology Press. and Dweck, C.S. (2006)* Mindset: The new psychology of success. *Random House.*

3. What do you already know about biochemistry and research that could guide your learning this semester?
4. What was one of the hardest concepts for you to master in a prior biochemistry course?
5. What is research? Describe what it means to you. How is research important in your life?

6. Please identify one or two strengths as a student that you think that you are bringing to this class?
7. Please identify one or two weaknesses as a student that you would like to work on this semester? Please indicate what they are and how you aim to improve.
8. Thinking back on your education so far, how do you learn best?
9. Please check the box that best describes your behavior prior to BMB464.***

	I NEVER do this	I do this INFRE-QUENTLY	I do this INCONSIS-TENTLY	I do this FRE-QUENTLY	I ALWAYS do this
I preview lecture material before coming to class.					
I attend class on time.					
I take notes in class by hand.					
I review my notes after each class.					
I study biochemistry with concentrated time and specific goals.					
I work/ study in groups.					
I understand the lecture and classroom discussion while I am taking notes.					
I try to determine what confuses me.					
I try to work out the example calculations problems without looking at the example problems or my notes from class.					
I review the lecture notes and practice problems before com-ing to class.					

***Questions adapted from a Study Skills Questionnaire from the University of Houston Clear Lake UHCL Counseling Services (2021) Study Skills Assessment Questionnaire [The University of Houston Clear Lake]. https://www.uhcl.edu/cmhc/resources/documents/handouts/study-skills-assessment-questionnaire.pdf

10. Please indicate what actionable tasks (1-2) you are going to do to be successful in the course this semester.
11. Every year the National Association of Colleges and Employers surveys employers across the country to rate the top skills/qualities that employers seek in new college graduates. Here is the list:

   ◦ Ability to verbally communicate with persons inside and outside the organization.
   ◦ Ability to work in a team structure.
   ◦ Ability to make decisions and solve problems.
   ◦ Ability to plan, organize, and prioritize work.
   ◦ Ability to obtain and process information.
   ◦ Ability to analyze quantitative data.
   ◦ Technical knowledge related to the job.
   ◦ Proficiency with computer software programs.
   ◦ Ability to create and/or edit written reports.
   ◦ Ability to sell or influence others.

   In BMB464 we are going to be working on all of these skills. Please comment on which above skill you are most excited about developing and why.
12. Please list class members you would like to work with in a group (if any).
13. Please list class members you would NOT like to work with in a group (if any).
14. Anything you would like to communicate to your Instructor or TA in regards to your learning? Anything I should know to help you succeed in the course this semester?