

Ungrading in Chemical Engineering: Attempting to Eliminate Exams, Deadlines, and Anxiety by Refocusing on Learning Instead of Grades

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Abstract

Modern means of assessment require approaches that consider fair and equitable means of determining students' understanding and performance. For example, students frequently connect exams to stress and anxiety, which can lead to an inability to demonstrate their mastery of the subject matter, and thus believe exams to provide inaccurate representation of their ability level. From a motivational viewpoint, centering the focus of a course on what is necessary to achieve the highest grade drives students to focus more on numerical scores as the primary description of their ability rather than on the breadth and depth of their learning. Effectively, by having student motivation focused on grade points rather than course concepts, the course outcomes become achieving a grade instead of achieving student understanding.

Ungrading provides an approach that shifts the emphasis of each course back onto learning and what students should be able to do at the end of a course. Grades are de-emphasized in exchange for greater levels of discussion and feedback focused on how well students have learned, processed, and applied the instruction in the course. There are many approaches to ungrading, such as contract grading, but the broader approach allows an instructor to provide less stressful, more equitable assessment.

In a process control course, an ungrading method was applied that eliminated exams and most deadlines in the course. Students were provided a number of optional problems and exercises that could be conducted that aligned with each of the course outcomes. Exercises could be submitted for feedback throughout the semester, allowing students to correct their work and assemble a completed portfolio of work demonstrating their mastery over the course outcomes at the end of the semester. In process control, course outcomes could be completed by work on a semester-long course project, while other exercises were simply homework and exam problems from previous iterations of the course restructured to allow students to process their understanding and better apply their skills for a more considered performance of understanding.

Students completed a number of self-assessment assignments throughout the semester, and a final grade was determined for each student in discussion with the instructor based on a reasoned consideration of their efforts and completed correct work.

This paper will discuss these ungrading efforts in the course, student feedback throughout the semester, and recommendations for other instructors interested in applying an ungrading approach in their courses.

Background

The process of assessment through standard letter grades and the traditional 100-point scale has developed over the past few centuries, driven by the push for uniformity and consistency in assessment between institutions.¹ Of course, the degree to which uniform objective assessment system through grades has ever been truly achieved can easily be questioned, as in part noted by the wide range of grades that could be assigned to the same submitted work from a range of different assessors.²⁻⁵ However, the greater concern with the establishment of letter grades and the 100-point scale as the means by which student achievement is assessed and evaluated is the impact on the nature of learning itself. Students desiring to be successful and do their best in their studies have come to approach their education not seeking to learn what is important and necessary, but instead seeking to get the best grade.⁶ Their emphasis is effectively “what do we as students need to do to get an ‘A’ in this course” as opposed to “what do we as students need to learn”. This mindset and approach to education deemphasizes both learning and students’ efforts to develop

mastery over the subject matter, instead placing the focus on whatever means of assessment are implemented in each course. To refocus students' efforts and intentions in their education, a different means of approaching assessment is necessary.

Further complicating the problem is that current traditional approaches to assessment are often inequitable and provide inaccurate evaluations of student mastery and achievement. Students entering college with different levels of preparation may perform differently on exams, effectively meaning that the exams provide less insight into a student's ability within the course and more insight into the student's background before the course began.⁷⁻⁸ Some students may experience high levels of stress and anxiety that adversely affect their performance on exams, pushing the exam into an assessment not of student knowledge but instead of student stress.⁹ Thus, a more equitable approach to assessment is necessary, preferably also providing a means for the focus to be centered back on learning itself.

In attempting to determine how students perceive the traditional grading system, a set of 54 senior and junior students in a process control class at Northeastern University were asked in a survey at the beginning of the semester to describe what the term 'grading' meant to them in three words or less. From this group, 68 percent reported associating grading with 'stress', 'anxiety', or 'pressure', as opposed to answers of 'assessment' or 'evaluation'. An additional 5 percent of students described grading as 'inaccurate assessment'. These answers help speak to the need for a new approach to be implemented.

A recent approach that has been growing in popular implementation is 'ungrading'. The term ungrading itself refers more to a broader style of assessment with less emphasis on grades, and in fact consists of a number of different assessment approaches. These can include:¹⁰

- contract grading, by which students agree to complete a certain set of assignments and other deliverables at the beginning of the course in return for receiving a specific grade at the end of the course, thus reducing stress and placing the emphasis on the work itself;
- self-assessment, by which survey responses and feedback from students throughout a course in addition to dialogues with them help to build a final grade and provides a means for evaluation to be achieved working together;
- peer-assessment, in which students are actively engaged with each other and help to provide evaluations for each other, thus driving their collective engagement in the course as the insight for assessment;
- mastery based grading, in which students are evaluated using a scale describing their ability such as 'meets expectations' and 'needs improvement', directly associating performance not with a graded number but instead the depth of their learning and how it is applied;
- portfolios, by which students assemble examples of their proven mastery over the subject matter for a set of specified student outcomes, and assessment is then determined based on the breadth and depth of the body of work collected, thus allowing students to self-determine the amount of work that constitutes mastery and achievement;

and many other variations that fall under the broader category of ungrading. These approaches have been used in several fields as well as at different levels of education, but given the examples reported have tended to be in non-STEM fields and more often at the K-12 level, there remains opportunity to more readily apply these techniques in STEM courses in undergraduate courses.¹¹

In this study, an ungrading approach was applied in a process control course for senior and junior students, incorporating several ungrading techniques as part of the overall assessment approach for the semester. Student experiences were evaluated through a series of surveys throughout the semester in an effort to

reduce student stress and anxiety while also providing a more equitable means of assessing student understanding and mastery of the course content.

Methods

In previous iterations of the process control course, students had been assigned seven to eight weekly problem sets, as well as two midterm exams and a semester-long course project. Strict deadlines were employed for all weekly assignments with an exam schedule established at the beginning of the semester. The semester-long course project involved group work designing, simulating, and analyzing a theoretical control system for a plant-scale unit operation equipment, with a presentation and report as deliverables.¹² Student performance was aligned and analyzed based on fourteen course outcomes expected for student achievement as determined by the chemical engineering department's Undergraduate Education Committee. These previous iteration of assessment and analysis helped to guide the development of the ungrading assessment.

While there are many potential ways that ungrading approaches can be and have been implemented, the primary method employed for the purposes of this educational effort was the portfolio method. Before the semester began, exercises were compiled and grouped by their alignment with each of the fourteen course outcomes. Students would be provided the complete set of course outcome (CO) exercises on the first day of class, with the flexibility to select as many exercises for each CO as they believed was necessary to demonstrate their mastery and satisfy their belief that their understanding was documented.

CO exercises were designated at three different levels: fundamental, requiring only a base level of understanding; intermediate, necessitating more complex interpretation and application; and advanced, involving a deep application of the associated concepts. On average, 3.1 foundational exercises, 2.9 intermediate exercises, and 1.1 advanced exercises were provided for each CO. These exercises included problems, case studies, critiques of visual learning tools, and ConcepTest questions among other options. Additionally, students were still tasked with completed the semester-long course project through group work, as was the case in previous iterations of the course. However, the alignment of the project to different COs was made clear so that students could use the work from the project as part of their final portfolio of demonstrated mastery.

Students could submit any work throughout the semester as part of optional weekly submissions. Each week, a teaching assistant would review any submitted work and provide feedback informing students of mistakes and misconceptions. Students could then resubmit the work as many times as necessary in future weekly submissions until it was marked as fully correct. At the end of the semester, the students would then assemble all completed work into a portfolio for final review.

As part of this initial application of ungrading, no firm deadlines during the semester were applied. Students were provided full flexibility to complete their exercises without the need for review from weekly submissions, and simply were instructed to have their completed project and portfolio submitted by the end of the semester. This flexibility is not a standard ungrading approach, and in fact may stand out as a more extreme option to associate with ungrading assessment.

To help maintain track of their progress throughout the semester, all students were required to complete three mid-semester self-evaluations and one final self-evaluation reviewing their effort, completed work, and self-assessed understanding to date. These surveys asked students to identify concepts they felt they understood, larger questions they either still had or had developed while learning other aspects, and how they felt they were progressing in the development of their portfolio. Students were also asked to give

themselves a letter grade based on their progress so far, the only times that actual scores or grades were brought up with their work.

As part of the final self-evaluation, students were asked to propose their final course grade based on their portfolio and efforts throughout the semester. The instructor then met with each student individually for five to fifteen minutes to discuss the breadth and depth of their demonstrated mastery as indicated by their final portfolio after it had been reviewed for correctness and completeness.

Analysis

In previous iterations of the process control course, students were assigned 29 homework exercises as part of the weekly assignments, 2 large exam exercises on the midterms, and the semester-long course project. In the Spring 2022 semester with the ungrading approach, across the 14 COs, students were provided 71 homework-level exercises to choose from on the foundational and intermediate scale, 11 exam-level exercises to choose from on the advanced scale, and the course project with assessment of four components associated with three COs. The significantly larger number of exercises was based on having more options aligned with each CO, as well as providing students with more flexibility in selecting exercises that they felt would better demonstrate their mastery.

From these options, students attempted an average of 36.2 foundational and intermediate level exercises, with an average of 31.8 exercises being correct in their final portfolio. Additionally, an average of 2.5 advanced level exercises were attempted with an average of 2.3 exercises being correct in the final portfolio. In all cases, students were on average attempting and correctly completing more exercises than had been assigned in more traditional assessment semesters. The amount of work completed varied widely, as demonstrated in Figure 1 and Figure 2.

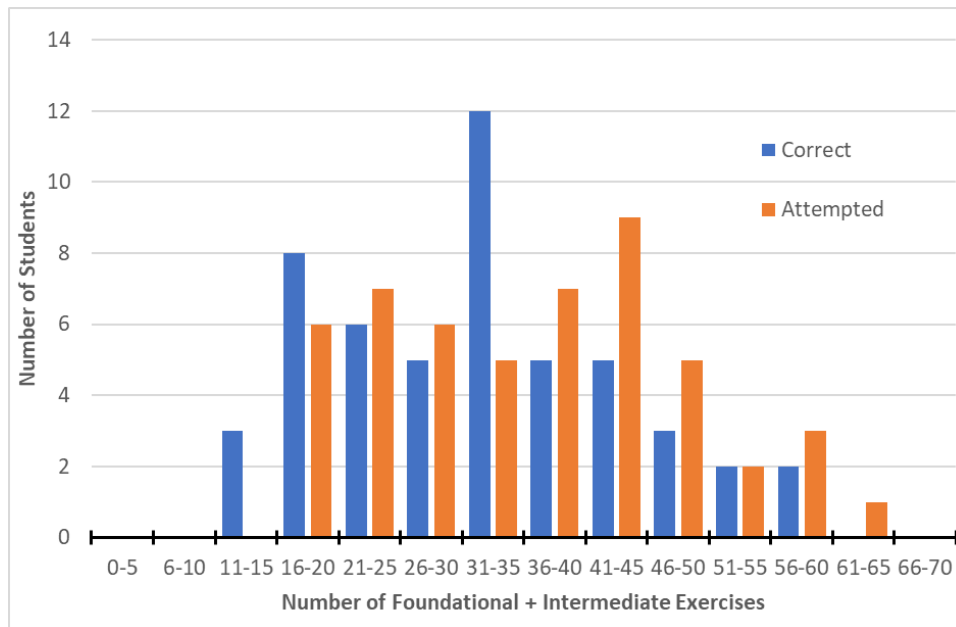


Figure 1. The amount of foundational and intermediate exercises attempted by students, as well as the number of these exercises that were correct at the end of the semester. For comparison, 29 exercises had been assigned during previous iterations of the course before ungrading techniques.

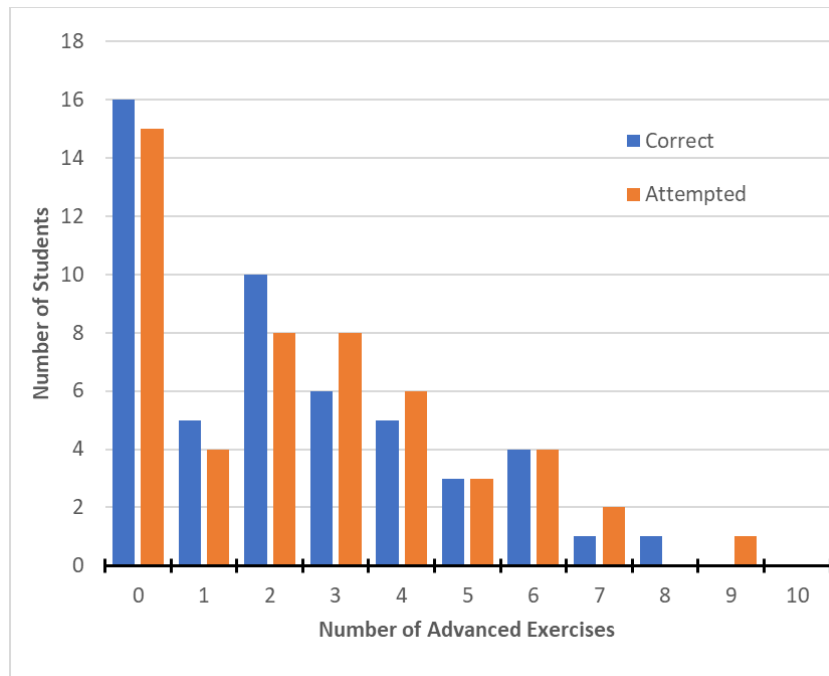


Figure 2. The number of advanced exercises attempted by students, as well as the number of these exercises that were correct at the end of the semester. For comparison, 2 exercises through midterm exams had been assigned during previous iterations of the course before ungrading techniques.

The increased number of exercises completed compared to previous semesters may be the result of several factors. First, this was the first experience all students in the course had had with ungrading and being allowed to develop their own portfolio, and as such were unsure how much work met expectations of demonstrating mastery. Several students would ask for a set number of problems that needed to be completed by the end of the semester in each CO, only to be assured by the instructor that the final number of exercises was up to them based on their own self-evaluation. This uncertainty drove some students to complete extra exercises just to reassure themselves. Additionally, the nature of traditional grading approaches led students to request a sense of how many average exercises their class was completing for each CO. Students would then respond to these provided averages by completing more work to help pull bring their own respective number of completed problems in line with the rest of the students, which would effectively increase the overall average and potentially lead to more work being completed in a somewhat ironic feedback loop.

The flexible deadlines did result in more work being generally completed near the end of the semester as opposed, but the nature of the course being delivered over 14 weeks while requiring 14 course outcomes helped to provide a general guide for students to completed their work. This is demonstrated for the completed work in the first three COs in Figure 3, as students had received all necessary instruction for CO 1 by the end of the first week, all instruction for CO 2 by the end of the second week, and CO 3 by the end of the third week. In all cases, there is a small portion of the class completing work associated with each CO after that week of instruction, followed by nearly 50 percent of total work completed for each CO having been submitted by the following week.

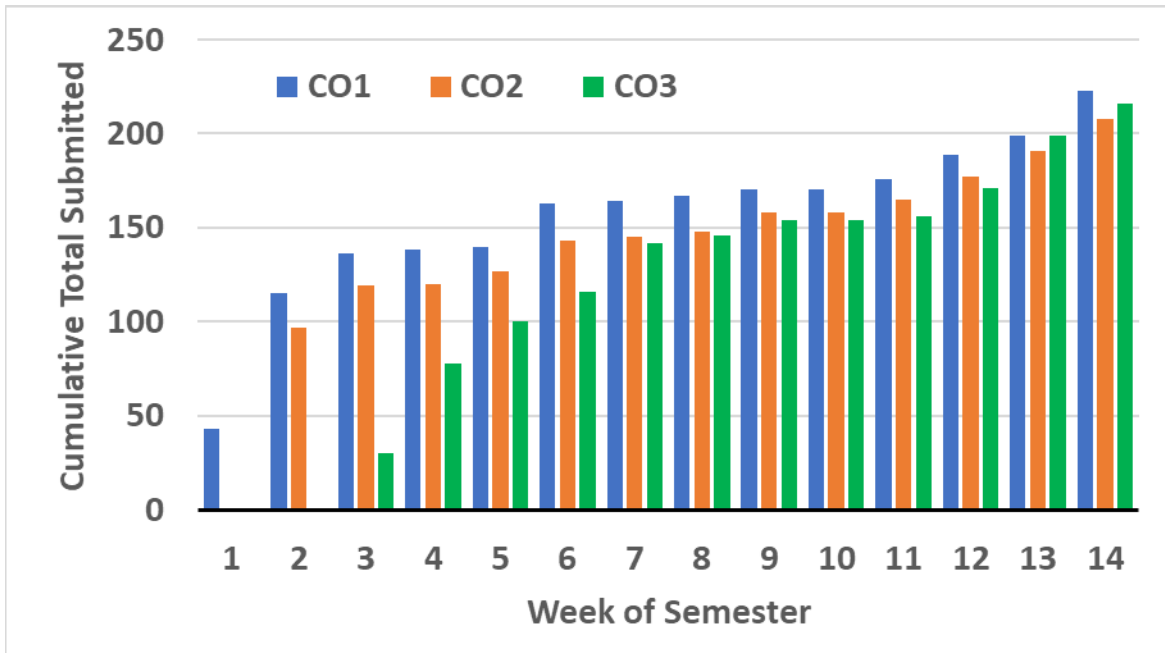


Figure 3. Cumulative exercises submitted by students for the first three course outcomes over the course of the 14-week long semester.

This overall impact can be more clearly observed by the cumulative total of all exercises submitted by the students, with a significant increase closer to the end of the semester as students worked to fulfill all COs for their final portfolio. This trend is demonstrated in Figure 4.

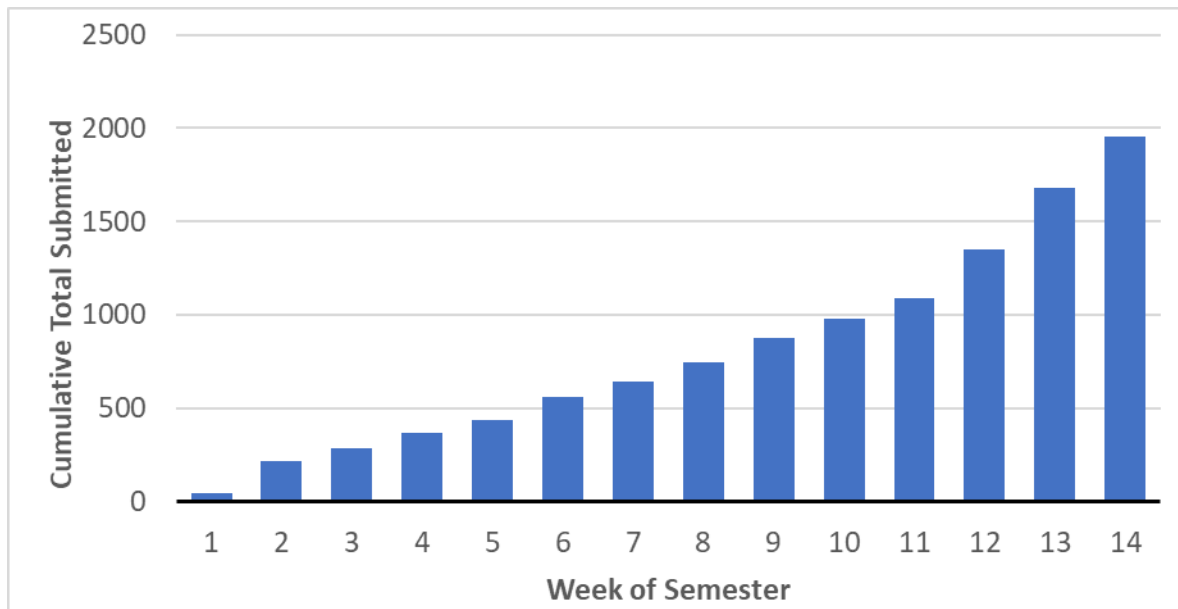


Figure 4. Cumulative exercises submitted by students over the semester.

Student Feedback

The self-evaluations throughout the semester as well as the final self-evaluations helped provide insight into students' perception of the ungrading approach. Overall, 94 percent of students felt they had sufficient opportunities to demonstrate their mastery through the exercises and project provided, and 88 percent of students felt they were able to focus more on learning in the course that semester than they had in other courses. Specifically, students cited the nature of the portfolio approach as a major reason supporting their ability to connect with the course content, with 42 percent of students stating that the elimination of exams as a reason they could focus more on learning.

With respect to the lack of deadlines throughout the semester, students were a little more critical, as 33 percent cited the lack of deadlines as being somewhat detrimental to their learning. Specifically, having the flexibility to procrastinate on completing work for their portfolio led some to wait until later in the semester to build their portfolio, thus driving them to somewhat 'cram' their learning in as they would have had to before an exam, and leading to less of a long-term connection with the concepts themselves.

The overall reported positive student experience with the ungrading approach was demonstrated through their feedback, with many students reflecting on how the approach to assessment allowed them to better focus on the course content as well as experience lower levels of stress during the semester:

- "I feel like I really learned in this course because I was challenging myself with solving the problems because I wanted to, not because I had to study for an exam. Having beginner, intermediate and advanced level problems also helped me gauge my understanding of the topic. The final group project was a big learning moment because we got to work with others who may have different ideas about how to design a control system."
- "As I kept working and fixing my errors, I began to grow my skills in the various CO and with the lack of exams and deadlines, I was able to learn and relearn stress-free."
- "I was able to focus more on learning in this course through the non-exam focused setup. It allowed me to consider the course outcomes and express my understanding in a flexible, low-pressure way. Exams have this tendency to make people think, "Oh, so I just need to pass, and then I can forget it." Course outcomes, as well as consistent feedback on course outcomes, makes sure that even the older topics covered stick in the mind."
- "I was not trying to get answers correct for a grade, but rather to understand the material better. I found myself completing extra exercises when I felt I did not fully grasp a course outcome, even though it was entirely optional which I think is because I wanted to understand the material and truly learn it."
- "Without having the pressure to study for an exam or quiz, I was able to dedicate more time into the course outcome problems and fully understand how to complete the problem. Whereas if I had taken an exam, I wouldn't have cared for the of why I got one problem wrong."

In individual meetings at the end of the semester, nearly all students encouraged the use of ungrading techniques in future iterations of the class, with some expressing their regret that they had not been exposed to similar approaches earlier in the education. On a related note, several students stated that they would have preferred being providing ungrading assessment previously to have better prepared them for the experience in what was for many their final semester of college.

Final Grades

Students were required to propose their own grade for the course as part of their final self-evaluation. Some other faculty, having been informed of the ungrading efforts being implemented, had expressed concern that this freedom would potentially lead many students to ‘grade-inflate’ and propose significantly higher grades than they were deserving of based on their completed work. The proposed grades are indicated in Table 1 with percentage of students in the class selecting each grade for themselves, and the concern of the other faculty could potentially have been justified, with 63 percent of students proposing a grade in the A range for themselves.

Table 1. Percent of students in the course proposing final course grades.

Proposed Grade	Students in Course
A	35.2%
A-/A	7.4%
A-	20.4%
B+/A-	9.3%
B+	3.7%
B/B+	1.9%
B	7.4%
B-/B	1.9%
B-	3.7%
B-/C+	0.0%
C+	1.9%
C	5.6%
C-	0.0%
D+	0.0%

After the individual meetings with the students, however, 56 percent of students stayed at the same grade as they had proposed for themselves. Only 11 percent of students had to be brought down to a lower final grade based on the instructor’s assessment of the breadth and depth of their portfolio and overall body of work; in comparison, the instructor used their reserved discretion to bring 28 percent of students up to a higher grade than proposed.

It should be noted that of the 54 students in the course, three students failed to complete their portfolio for personal reasons and eventually adjusted to an incomplete grade in the course. At the time of the proposed course grades, two of these students proposed the grade they intended to work towards once their portfolio was completed, while the other student proposed an incomplete in their final self-evaluation.

The overall performance of students in the course can be compared to the performance of students in the previous spring semester when the traditional grading approach had been implemented. Overall, given that students were completing more work than had been previously required and also had more work correct than had been previously assigned, a greater level of student mastery was demonstrated and thus the students in the course received higher grades as indicative of the work completed. This comparison is presented in Table 2.

Table 2. Percent of students receiving final course grades in traditional grading and in ungrading.

	Spring 2021 (Before Ungrading)	Spring 2022 (Ungrading)
A- or A	59.3%	68.5%
B or B+	27.5%	20.4%
C, C+, or B-	9.9%	3.7%
D-, D, D+, C-	2.2%	1.9%

Institutional Outcomes Resulting From This Study

One primary concern with implementing this ungrading approach was the time commitment of the instructor, particularly with respect to the effect of the minimal deadlines. Overall, the additional time committed was minimal compared to previous semesters with traditional assessment approaches, and significant time was saved as a result. TAs had previously graded all problem sets while the instructor graded any exams and projects. With the ungrading approach, the TA provided all feedback on weekly submissions, while the instructor reviewed the final portfolios, reducing the instructor's workload by nearly 30 hours over the course of the semester, while increasing the TA's workload by approximately 15 hours over the semester (which remained well below the expected amount of time of 20 hours per week that TAs were limited to in their work at Northeastern University). The instructor did need 10 to 12 hours prior to the semester to set up all CO exercises, although this was a one-time effort to do so. Additionally, by eliminating exams and eliminating review periods to prepare for the exams, using the ungrading approach opened up nearly 1.5 weeks of class time, which was devoted to additional in-class project work for the students to get ahead in their course project efforts and further improved the quality of the resulting final projects.

From the instructor's experiences, the ungrading approach was recommended to all other members of the chemical engineering faculty during the department's annual teaching retreat. Two other faculty members had similarly been experimenting with contract grading and mastery-based grading in their own undergraduate and graduate courses; the resulting positive experiences and encouragement to other members of the department led to other faculty adopting ungrading in their own efforts in the Fall 2023 semester.

Conclusions and Recommendations

Overall, using an ungrading approach in a chemical engineering course had multiple beneficial outcomes. The approach significantly reduced student stress by eliminating exams and allowing for enough opportunities for students to demonstrate their course mastery. In fact, through this approach, more student work was completed for assessment purposes and was completed correctly than in previous traditional assessment approaches. Instructor grading time was reduced and additional in-class time was opened up for other potential uses.

On the other hand, the limited deadlines may have been detrimental to the overall effort, and were to be the focus of improvement tweaking for future iterations of using ungrading in the course moving forward. Based on student feedback, soft deadlines were established in future course iterations, with students required to submit some exercises for feedback at least once every three weeks, and then further reduced to once every two weeks in response to more student experiences. Evaluation of the impact of the softer deadlines on student work and mastery is currently being analyzed. It should be noted that the approaches to deadlines are not a standard component of ungrading, but remain the one component that the author is most focused on working to improve for future iterations.

In general, both based on direct positive experience, student feedback, and resulting quality of student achievement, the author cannot recommend using an ungrading approach highly enough.

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