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Ungrading and Student Motivation: Assessing the Impact on Student Productivity and Allowing Room for Point Totals

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Abstract

Ungrading refocuses the emphasis of a course onto learning and the mastery that students should have achieved at the end of the course, as opposed to students focusing on achieving certain grades and defining their success on the grade. In general, grades are de-emphasized for greater focus on students learning, processing, and applying the instruction in the course, through means such as greater levels of feedback and discussion with each other and the instructor. Many approaches fall under the broader umbrella of ungrading, including contract grading, mastery-based grading, portfolios, and self-assessment, but the general approach allows an instructor to provide less stressful, more equitable assessment.

When flexibility is more centered at the core of the assessment approach, allowing students to adjust how they can prove their mastery, as well as the overall breadth, depth, and body of work of mastery to be showcased, changes can be made to the assessment system over time to provide better support for students of all backgrounds and enable their mastery development. In previous iterations of implementing ungrading, changes were made to deadlines based on student feedback to reduce the flexibility of the deadlines throughout the semester, which resulted in higher student productivity. Further suggestions for improvement included assigning a point total to each exercise to allow students to 'gamify' and better score their work as the semester went along. As this potentially introduced a larger change to how students might approach the course, it was worthwhile to evaluate what elements of the course design were connected to student motivation.

In the third iteration of implementing an ungrading portfolio approach into a process control course, students could self-determine the assignments they would complete and how many assignments to complete, with all student deliverables culminating in one portfolio of demonstrated work by the end of the semester, but now with a point total assigned to each exercise to partly gamify but primarily further delineate the depth of mastery shown by work completed. To evaluate the continuing impact of the ungrading approach as a means of course design, student feedback was assessed using the MUSIC model for student motivation, evaluating factors including empowerment, usefulness, success, interest, and caring as relevant to student productivity and motivating for overall effort (IRB approval #24-03-17). Students had been more highly productive with the ungrading approach compared to a traditional homework-and-exam semester; however, adding in a point score component opened parallels closer to the more traditional approach. The results of the ungrading implementation over three years, student feedback, and analysis of student motivation will be discussed in this paper.

Background

Alternative Assessment

A larger pedagogical movement towards alternative forms of assessment can currently be observed across disciplines and levels of education.[1] Multiple studies have implemented different approaches in integrating alternative assessment into modern course instruction, with a range of benefits being cited depending on the scope of the approach, commitment by the instructor, and buy-in from the student body.[2] Alternative assessment was specifically cited in the recent

Engineering Mindset report, which described necessary steps forward in strengthening and broadening engineering education, and will likely lead to further adoption.[3]

Alternative assessment itself is a response to larger concerns about traditional grading structures and the problems that are inherent in relying on standard letter grades. While the traditional structure was developed for the purposes of uniformity between institutions,[4] inconsistencies in how grades can be assessed and applied by different instructors reviewing the same work make the traditional grading system somewhat arbitrary and thus inaccurate and inequitable.[5-8] The dependence of assessment on a numeric scale has further implications on the nature of learning that students experience. If high grades are emphasized as the outcome of effective education, then students will focus more directly on identifying being successful in their learning as doing what is necessary to get a high score. However, if the learning itself can be emphasized by adapting the assessment to focus on students' developed mastery, then students will respond in their education by focusing on what they need to do to learn as a means of succeeding in their studies.[9] Adopting a better means of assessment will allow the evaluation of student performance to become more equitable and will improve the student learning experience itself; enabling students to succeed even when they come from different backgrounds and preparation,[10,11] or exhibit different levels of stress in response to intense assessment,[12] only further serves to enable students' deeper understanding and more accurate evaluation of their mastery.

'Alternative assessment' is a larger catch-all term for many different approaches. Similarly 'ungrading' references a specific approach that falls under the larger umbrella of 'alternative assessment' but is frequently being used as a catch-all term including alternative assessment itself. The three larger subsets of alternative assessment[13] include:

- Specifications-based grading,[14] by which grades reflect students' completion of work to certain specified levels, with achievable tiers for each learning outcome;
- Standards-based grading,[15] by which grades reflect students' proficiency in the learning objectives, and mastery defined by different tiers;
- Ungrading,[16] by which mastery and proficiency are the greatest emphasis.

Ungrading's name comes from a reduced emphasis on grades, but includes a range of possible approaches, including contract grading, self-assessment, peer-assessment, and portfolios.[17] These techniques can be used in other approaches, but within ungrading they are centered in the emphasis on learning and the partial to total de-emphasis of the final grade itself.

Overall, assessment techniques, regardless of the specific type, can be considered as falling along two different spectrums:[18]

- Assignment flexibility. The tasks that students must complete in order to demonstrate their learning or showcase their performance and mastery in the course may rely on a specific set of assignments to be completed, or may span all the way to students having complete flexibility such as in an open portfolio with open-ended options on work that can prove their mastery.
- Assessment flexibility. Traditional assessment may rely on a very specific rubric for work completed, but this spectrum may include mastery-based grading and using a scale describing student ability such as 'meets expectations' and 'needs improvement'; contract grading, in which student are assessed based on work completed to pre-specified amounts

or levels of completeness; and self-assessment, in which students define their own grade based on the learning and mastery demonstrated.

These spectrums can thus be visualized as in Figure 1. Traditional assessment approaches can be found at the more restrictive ends of both the assignment and assessment flexibility scales, while alternative assessment covers the much larger range of options as an instructor might reside further down either spectrum. For example, the author's previous use of open portfolios with self-assessed final course grades in an ungrading format would likely fit at the far top right of the Figure 1 plot.[19]

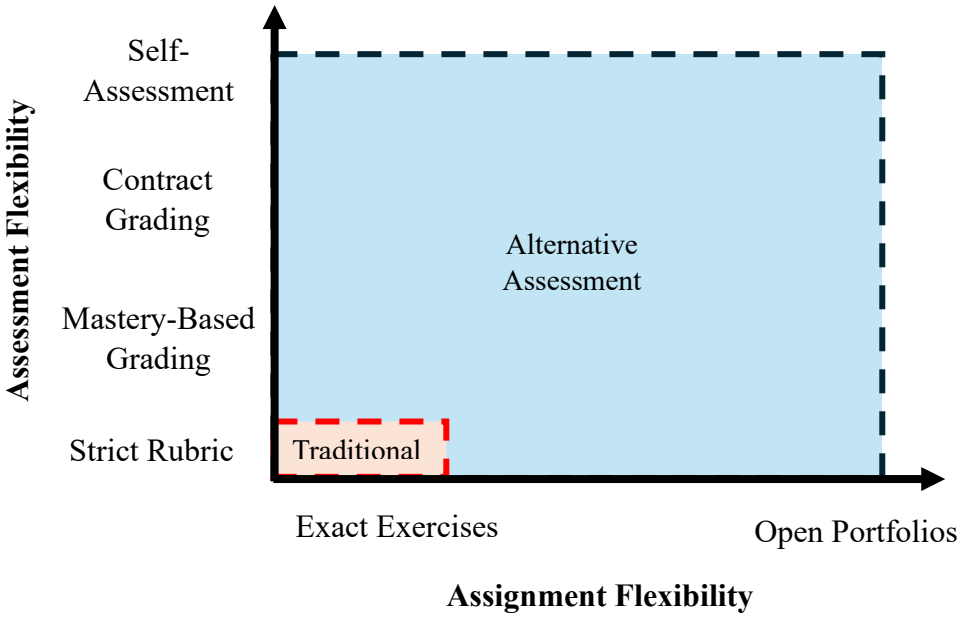

Figure 1. Depiction of forms of assessment approaches comparing flexibility in assignments and assessments. More traditional assessment is closer to the origin, while a range of approaches can be covered under the heading of alternative assessment.[18]

Whatever type of alternative assessment used and wherever on either spectrum that an instructor may reside, alternative assessment itself can be best summarized by 1) the emphasis on learning, not student grade or compliance; 2) grades that are delivered reflect on and allow for students to progress in their learning, meaning that grades are not reliant on singular efforts; 3) the assessment used provides multiple opportunities and methods for learning to be demonstrated; and 4) grades themselves are de-emphasized as compared to deep and meaningful feedback, so that students may grow and improve.

Early conclusions from alternative assessment techniques have summarized a number of reasons for adoption that are student-focused, including reduced student stress, more accurate and authentic assessment, increased responsibility for their grades, greater motivation to learn, and the bifurcation of grades from students' identity and their sense of self-worth (meaning students do not directly define their evaluation of themselves based on their grade as opposed to their understanding).[2] Additionally, early conclusions have suggested instructor-focused reasons for adoption as well, including saving instructor time in assessment, upholding higher academic

standards and discouraging cheating, and reducing conflicts between instructors and students because of the potential for multiple attempts and student growth.[18]

While alternative assessment is a growing movement, there remains opportunity to not only more readily apply these techniques in STEM courses in undergraduate courses,[16] but to also consider how it is best implemented in the overall course design. Instructional techniques including all forms of active learning are not restricted by the use of alternative assessment, and so the more beneficial aspects of various instructional approaches could be considered for how they could be integrated into working with the assessment structure itself. Further study into how well different instructional approaches can blend or support alternative assessment course design would be beneficial in helping to encourage broader adoption of alternative assessment techniques.

Gamification

While alternative assessment can define the structure of a course itself, there is no required instructional technique in association with the alternative assessment; as such, a strong assessment approach may still fail if the instruction itself does not promote student learning in an engaging, confidence-building way. One broader instructional approach in education that has shown promise in increasing student engagement and improving their self-efficacy is through gamification. Gamification, or the utilization of game-like mechanics like point-scoring, puzzles, trivia or other similar elements specifically in a non-game context, has been implemented in educational settings for many decades before the term gamification was even developed.[20] Because gamification effectively rewards positive behavior and actions, it has potential as a learning approach to encourage modes of thinking or problem-solving,[21] but it has been considered pedagogically based on game design theory, human behavior theory, and self-determination theory to show how specific gamified elements of instruction or course design can lead directly to positive impacts with students.[22] Positive aspects such as allowing students to make mistakes through trial and error to work towards problem-solving efforts,[23] allowing free-choice behavior so students feel less constrained and more empowered in their decision-making,[24] and engaging students through positive feedback as a means of a 'game reward'[25-27] have all indicated strong potential for gamified instruction as a means to supplement overall instruction.[28] Gamification can increase student engagement and motivation,[26] potentially provide active learning[29] that is necessary for successful equitable instruction in STEM,[30] and lead to higher academic performance.[31]

The potential benefits of gamification are particularly notable with respect to student self-efficacy, given the need to strengthen self-efficacy in students to help increase and diversify engineering graduates. As gamification allows for students to potentially benefit from trial and error learning as a result of their perceived higher likelihood of success, participation would thus allow for more mastery experiences and help strengthen self-efficacy.[20,32] Active participation in digital games and role-playing games has been shown to benefit self-efficacy, as students are able to consider the outcomes they have experienced and develop approaches to better solutions and behavior for them to follow in the future.[33] Intrinsically motivated students are more eager to learn, which in turn enables greater self-efficacy, and gamified learning has been shown to allow for such intrinsic motivation.[34] Additionally, gamification is based on the central conceit of the novel educational approach being fun, and a more enjoyable experience can result in improved performance and self-efficacy.[34]

Gamification can potentially be blended into an alternative assessment structure not only in instructional approaches but also in the assessment itself. While grades themselves may be de-emphasized, point totals could still potentially be used as achievable outcomes if the total score itself is completely separated from a specific outcome. Students could thus accumulate points based on the work completed as a by-product of completing exercises to demonstrate their mastery, similar to a high score in a video game where the emphasis is the progression through the levels and the score is a less meaningful description of achievement in the game. Given the potential benefits of gamification, there may be potential in using point totals to help students track their progress or focus on developing more complex mastery, while still emphasizing the learning achieved and de-emphasizing grades in a larger alternative assessment structure.

Motivation

This paper reflects the development of multiple years of implementing alternative assessment in a chemical engineering Process Control course marking considered study beyond its initial adoption,[19] and the attempt to introduce a gamified point total as a motivating factor for students. Ungrading in particular is the most open-ended of assessment structures and allows for more flexibility overall; ungrading likely has the most potential for integration with different instructional approaches and thus makes it a good candidate for working with gamification. This paper discusses the ungrading efforts used in the course, adjustments and improvements made to its implementation, integration with gamification through the form of point totals, and the resulting impact on student performance, student feedback, and instructor experience.

Iterations of Ungrading Implementation

Overall approach

Prior to the use of ungrading techniques, the Process Control course at Northeastern University was taught using more traditional assessment. Student were given eight weekly homework assignments over the semester with a total of 28 problems, had two required midterm exams and an optional third midterm (for students who had performed poorly on a previous exam and wanted to improve their overall grade) that contained two to four total advanced level problems, and were required to work on a semester-long group project designing and simulating a control system for a theoretical unit operations system.[35] Students had one opportunity at each problem, whether on problem sets or exams, and their final course grade was numerically evaluated based on performance for each assignment.

The ungrading approach used in this effort involved eliminating exams, quizzes, and other required assignments. This redesigning was in line with the broader goal of refocusing students from concentrating on their numerical grade and instead concentrating on how and how well they were learning. Students were instead tasked with developing a semester-long portfolio demonstrating the breadth and depth of their mastery over their entire body of work. At the beginning of the semester, all students were provided with exercises of various types, including student-developed ConcepTest questions,[36] mathematical analysis, and conceptual design, across all fourteen course outcomes for Process Control as defined by the Undergraduate Education Committee in Chemical Engineering at Northeastern. Exercises were broken down into three levels of difficulty, including Foundational, which was more introductory, focused on more basic math, identification, or definition; Intermediate, which involved applying concepts to more complex systems and beginning to design control systems both conceptually and mathematically; and Advanced, which

were equivalent to previous exam difficulty problems and involved rigorous application of both concepts and mathematical solutions. Students were provided with all possible exercises for all course outcomes at the beginning of the semester, which included 71 total Foundational and Intermediate exercises, and 11 Advanced exercises. Exercises were distributed unevenly across the course outcomes, with greater numbers of exercises associated with course outcomes that were more heavily emphasized in instruction. In addition to the portfolio, students would continue to work on the semester-long group design project.

In this approach, students could submit work each week from any course outcome, have it reviewed and returned to them with feedback on its correctness, and then have the opportunity to resubmit as many weeks as necessary until the work was marked correct. Students would thus know based on their work over the course of the semester where they were developing mastery and how well their portfolio was being assembled based on their demonstrated knowledge. Students were also required to submit intermediate self-assessments in the middle of the semester to reflect on their developed mastery thus far in the course and where they needed to further improve their understanding. At the end of the semester as part of a final self-assessment, students would propose their own final course grade, which would be reviewed by the instructor as part of their overall portfolio (along with the course project report and presentation). The instructor and the students would meet individually for 10-15 minutes to discuss the proposed grade, how well it reflected the demonstrated mastery, and a final course grade would be determined from there. In terms of time commitment, a teaching assistant was utilized in the review of weekly submissions, and their workload remained effectively similar to their grading of problem sets in the traditional assessment approach. Instructor time commitment was significant only at the end of the semester in reviewing student self-assessments and the full portfolios, and then meeting with each student individually; however, the instructor time commitment over the entire semester was significantly reduced by approximately 40 hours of grading in comparison to the exam-driven traditional approach previously used.

This series of ungrading techniques has been implemented for three spring semester iterations of the Process Control course beginning in 2022 for a group of 54 junior and senior students. The second iteration in spring 2023 was instructed to a total of 93 students across two sections taught by the same instructor, and the third iteration in spring 2024 was delivered to 61 students. Instruction was also conducted in fall semesters by the same instructor as the spring semester courses, but these classes were much smaller in size and usually involved students who were off-sequence in their instruction, making them more difficult to analyze as a whole; for consistency in this paper, only the spring semester students will be discussed and analyzed.

Iteration adjustments

Each iteration of ungrading led to adjustments to the broader mode of ungrading assessment in response to student concerns and instructor observations, in order to find an approach that best met overall needs and enabled greater student mastery. The first iteration represented the most open-form of ungrading, with not only the introduction of the portfolios with no defined total number of problems to complete, but also with no hard deadlines for work submission besides the end of the semester final portfolio. Students were given complete flexibility in terms of when they could submit exercises for review all semester long. The largest student concern, in addition to broader concern from other faculty members, was that the lack of deadlines was too flexible, with some

students reporting that they found the lack of required submitted work at intermediate points throughout the semester to be more challenging than regular deadlines and more overwhelming to their time management capabilities.

The second iteration sought to address the deadline flexibility concern, with exercises now required to be submitted at least every other week. Students now had flexibility available to them if tasks external to the course became more difficult, but now also had some restrictions to ensure that they practiced good time management and maintained a steady development of their mastery in the course. The largest concerns from students were reflective of a theme previously expressed, in that the openness of the portfolio made it difficult to determine how many exercises students would need to complete. This had been purposely left open to allow students to develop and demonstrate their mastery in ways most accessible to them; for example, requiring three exercises per course outcome might drive one student to complete three foundational level problems compared to another student that completed a combination of three intermediate and advanced level exercises. The latter student would clearly have developed a deeper mastery in the course, while the former student may have focused solely on the work required and not pushed themselves to further their understanding by establishing their foundational level capability and then attempting more difficult exercises beyond that.

As such, the third iteration of instruction sought to address this open concern about how many exercises were necessary for the final portfolio to indicate mastery with breadth and depth, without taking away students' empowerment in the exercises selected and difficulty level completed. The element of gamifying the course through the introduction of point totals for each exercise was thus introduced in the complete set of exercises provided at the beginning of the semester. Higher point totals were introduced for intermediate and advanced level problems; lower point totals were assigned to exercises with more basic definitions or repetition of discussion from lecture. For example, a point total between 5 and 8 points might be assigned to a foundational level exercise, between 10 and 20 points might be assigned to an intermediate level exercise, and between 25 and 40 points might be assigned to an advanced level exercise, also accounting for the number of parts to each exercise. Students were thus potentially encouraged to attempt certain exercises with a greater degree of difficulty or required a more rigorous application of conceptual and mathematical understanding, and still maintained their autonomy in terms of the exercises they could select to complete and how many exercises they could complete.

Point totals were also assigned to the course work associated with the group project, depending on how the quality of the deliverables were evaluated on a scale of Foundational, Intermediate, and Advanced level of demonstrated mastery. Given that this work was completed over the course of the entire semester, these point totals were somewhat larger in comparison to that of individual work submitted in the portfolio, and were somewhat de-emphasized in consideration of the full performance by both students and the instructor. In general, assigning a higher point total to Intermediate and Advanced level exercises was also designed to encourage students to strive to develop deeper levels of mastery as well.

Student Performance

Impact of deadlines

Student work could be submitted weekly during the first 12 weeks of the semester for review. With each adjustment to the structure of the ungrading approach, particularly with respect to the intermediate deadlines for work, students would submit exercises with different levels of consistency over the course of the semester. This variation is reflected in Figure 2, highlighting the percentage of students who submitted work either neither week, one of the two weeks, or both weeks over each two-week period in the semester.

Requiring work to be submitted at least once every two weeks significantly helped to increase the rate of work submitted, with students submitting at least some work each two-week period increasing from approximately 60% to 88% with the introduction of intermediate deadlines in the second iteration. By introducing point totals, students began to submit work even more consistently, as the submission of work both week increased by an average of 16% in the third iteration of the course; however, the some students also recessed in their course activity, with the student submitting no work either week increasing from 12% to 17%.

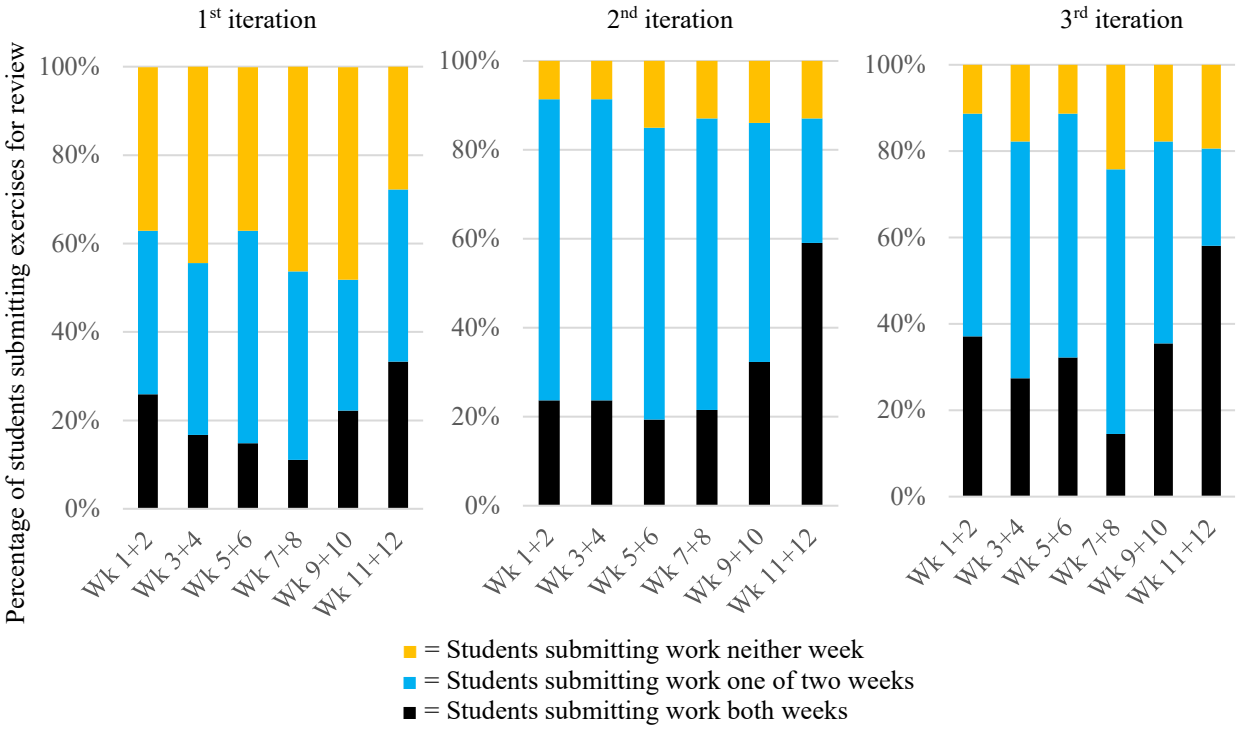

Figure 2. Percentage of students submitting work with different rates of consistency over the course of each semester of instruction.

Overall work submitted

Before the ungrading approach was implemented, students were tasked with 28 problem set exercises equivalent to Foundational and Intermediate exercises, two to four Advanced-level exam problems, and the course project; with the ungrading approach, students had a total of 71 Foundational and Intermediate exercises and 11 Advanced exercises to select from across the 14 course outcomes to build their portfolios. As can be observed in Figure 3, students began to

complete more work on average than was assigned in the traditional approach, with the amount of work completed correctly each week gradually increasing at a higher rate with the submission of corrected work alongside new completed work at later periods in the semester.

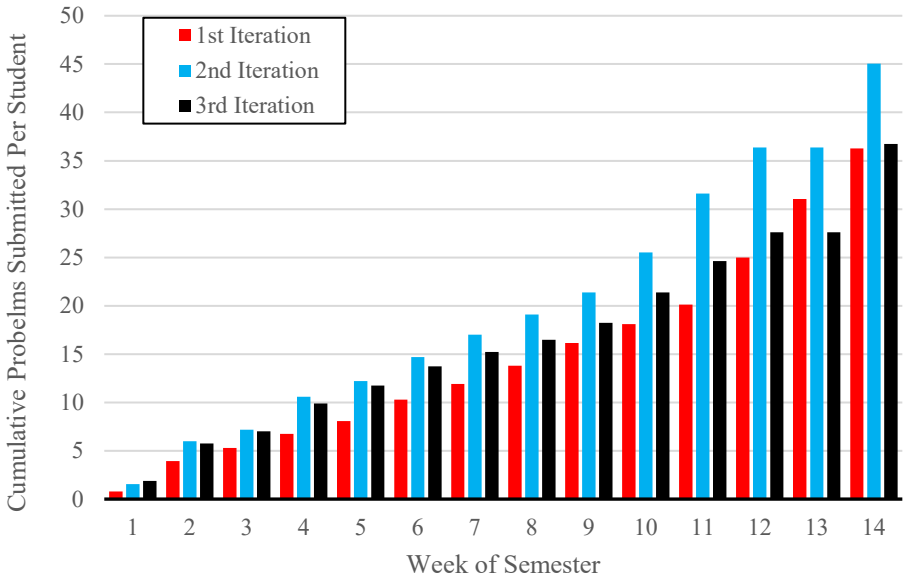

Figure 3. Average correct exercises completed by each student over the duration of the semester for each iteration of the course.

Of particular note is the changes in total correct exercises completed by students on average each semester with respect to the small changes in the ungrading structure. By introducing ungrading, students had an average of 31.8 Foundational and Intermediate exercises correct, compared to the 28 assigned in the traditional approach, along with 2.3 Advanced exercises. By introducing more coursework submission deadlines, these averages increased to 35.1 Foundational and Intermediate exercises and 4.2 Advanced exercises correct. With the implementation of point totals, students still completed a lower but still significant amount of work, with an average of 29.0 Foundational and Intermediate exercises correct out of 36.9 exercises attempted; however, students attempted the highest number of Advanced level exercises, with 4.1 average exercises correct of 6.3 attempted. These numbers are summarized in Table 1.

Table 1. Average exercises correct of those attempted by students in each iteration of the course.

	1st iteration		2nd iteration		3rd iteration	
	# of exercises correct	# of exercises attempted	# of exercises correct	# of exercises attempted	# of exercises correct	# of exercises attempted
Foundational + Intermediate exercises (71 available)	31.8	36.2	35.1	40.1	29.0	36.9
Advanced exercises (11 available)	2.3	2.5	4.2	4.8	4.1	6.3

Even with the implementation of point totals, students' final course grade was still determined through their self-assessment, proposed grade, and discussion with the instructor. As high point totals could still potentially be achieved through completing all the Foundational and Intermediate exercises even if a limited number of Advanced exercises were attempted, a broader consideration of the student portfolio was still necessary. Students that had limited or no examples of mastery in a course outcome would not be able to get a straight "A" in the course, for example; students who showed a clear Intermediate-level of understanding but attempted a limited number of overall exercises might not have a complete body of work to justify a higher course grade, either. Students also were eager to share an honest perspective in assessing themselves, as previously noted often suggesting lower grades than what their work was likely deserving of.[19] The impact of considering students' full portfolios even in light of the point totals led to large ranges of points achieved with respect to each final course grade, as observed in Figure 4.

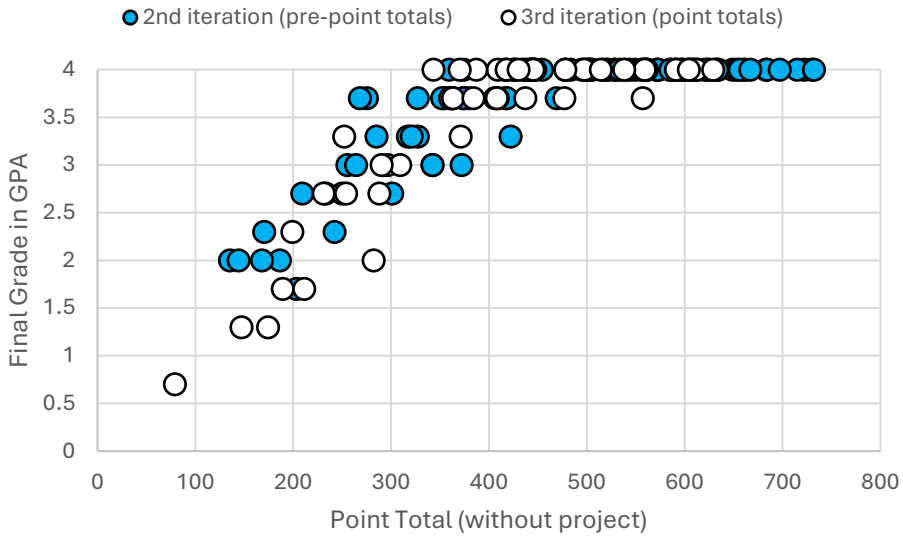

Figure 4. Final total points for each student, with theoretical totals for students in the 2nd iteration of the course and actual totals for students in the 3rd iteration, compared to their final course grade plotted on a 4.0 GPA scale (A=4, B=3, C=2, D=1, F=0).

Because of the somewhat heavy weight of the points assigned to the course project, the impact on total points accumulated by each student was less insightful when factoring in the project, effectively serving to mainly shift the total point totals for all students by a similar amount, acting similar to a curve being applied to an average exam grade.

One would expect that a higher point total would correlate to a higher grade in the course, even with needing to consider a students' full portfolio. This general expectation held true, as can be observed in Figure 5, with the theoretical scores of students from the previous iteration provided for comparison.

Overall, students did receive higher course grades than had been given out in the traditional assessment system prior to the ungrading implementation. However, as students were both attempting and completing correctly a higher number of exercises than the traditional approach, were clearly demonstrating their mastery with both breadth and depth across the established course outcomes, these higher final course grades were deservedly earned by the demonstrated learning students had done. While some instructors might be concerned at a high percentage of grades being B level or higher, as 84% of the students in the third iteration of the course did (72.6% with A or A-), if students demonstrate broad mastery on an Advanced level, then they should be rewarded with a grade appropriate in recognition of their growth, learning, and achievement.

Figure 5. Average point totals per final course grade, for students in iterations both before (theoretically achieved) and after (actually achieved) implementing the point total system.

Student Feedback

Students contributed a large amount of feedback at the end of each semester as part of their final self-assessment. Within this feedback were several open-ended survey questions seeking their opinion on the assessment structure and its impact. In general, students have responded positively to the ungrading system, with 69 to 88 percent of students across all three iterations expressing that they were better able to focus on their learning given the de-emphasis of grades as compared to their mastery development. In particular, a large number of students cited a lack of exams as a better reason for their focusing on learning; as one student reported in the first iteration of the assessment system:

> "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."

The number of students that have cited the lack of exams has decreased steadily over the past few iterations of ungrading. There are many possible reasons why this decline may be the case, but one probable answer is that ungrading and alternative assessment are becoming more familiar to students, and they have begun to experience similar approaches in some of their other courses prior to this experience in Process Control. Specifically in the Chemical Engineering Department at Northeastern University, 90% of the core required courses have now had some form of alternative assessment implemented in the past three years. As such, students may now be taking a reduced number of total exams, and so are not as relieved by the elimination of exams. Overall, nearly all students felt that the ungrading system provided them with sufficient opportunities to prove their learning and mastery, with fewer students expressing concern about the flexible deadlines serving as a detriment to their learning. This feedback is summarized in Figure 2.

Table 2. Student self-assessment feedback on their experience with the ungrading system.

	1st iteration	**2nd iteration**	**3rd iteration**
Were you able to focus more on learning in this course?	88%	69%	77%
No exams cited as reason for better focus	44%	34%	24%
Lack of deadline/structure cited as detrimental to learning	33%	11%	16%
Sufficient opportunities to demonstrate mastery?	94%	98%	98%

Students offered a large range of positive feedback for their experience with the ungrading system. From the third iteration, students cited feeling more valued, experiencing less stressed, and having better focus on their learning:

- "The way I tackled the HW assignments was different compared to previous classes (less looking up answers when stuck when there's a hard deadline/submission is graded)"
- "I feel that I have been able to isolate my focus on understanding course material rather than achieving a high grade."
- "I actually felt valued as a person and not just a number. It made me feel more comfortable reaching out for support and asking questions because I didn't feel dumb for having questions, which made me care more about the material. It was much more motivating and engaging than the traditional class structure because everything felt more individualized to how I learn best. This structure sets students up for success to learn and prove mastery in ways that they excel best, instead of testing how well they can conform to the traditional model."
- "I struggle with severe anxiety which has been debilitating for me in normal exam situations. A lot of my previous classes I would get discouraged with my ability to take exams and would compare myself to other students. I genuinely felt more engaged within this course and confident in my abilities because there was no possible way for me to feel as though someone was doing "better" than me."

Students also provided feedback through a series of questions associate with the MUSIC model for student motivation in which MUSIC stands for eMpowerment, Usefulness, Success, Interest, and Caring.[37] The model helps determine what components of the educational approaches taken will lead to increased student motivation and thus lead to increased student learning. The MUSIC model helps to guide by which aspect that motivation is achieved: empowerment, based on the amount of control students believe they have on their learning; usefulness, based on students understanding their learning is valuable; success, based on students believing they can succeed in the course if they put in effort; interest, based on students finding the concepts and the course enjoyable; and caring, based on students believing the instructor cares about their learning. Focusing on these components comes from several motivation theories, including self-determination theory, self-efficacy theory, expectancy value theory, and interest theory.[38-41] This model has been previously successfully applied to educational studies for engineering students.[42,43] It could be expected that students in an ungrading system would recognize high levels of empowerment in their ability to select their own exercises; of additional focus would be whether students also report high levels of motivation from perceived opportunity for personal success, in that the system works well for them to grow and learn.

Students in the third iteration of the course were provided the MUSIC model questions, with their responses falling on a range of 1 to 6, with 6 representing 'strongly agree', 5 representing 'agree', 4 representing 'somewhat agree', and 3 to 1 providing a similar range for disagreement. Their responses broken down with respect to each MUSIC model component can be observed in Figure 6. High levels of agreement were observed for nearly all components, with the strongest element being the perception that the instructor cared about the students. A high level of agreement for all components reflects student perception that all components of motivation were indeed present in their learning experience; this provides a strong signal of recommending ungrading and alternative assessment as a whole in further course instruction.

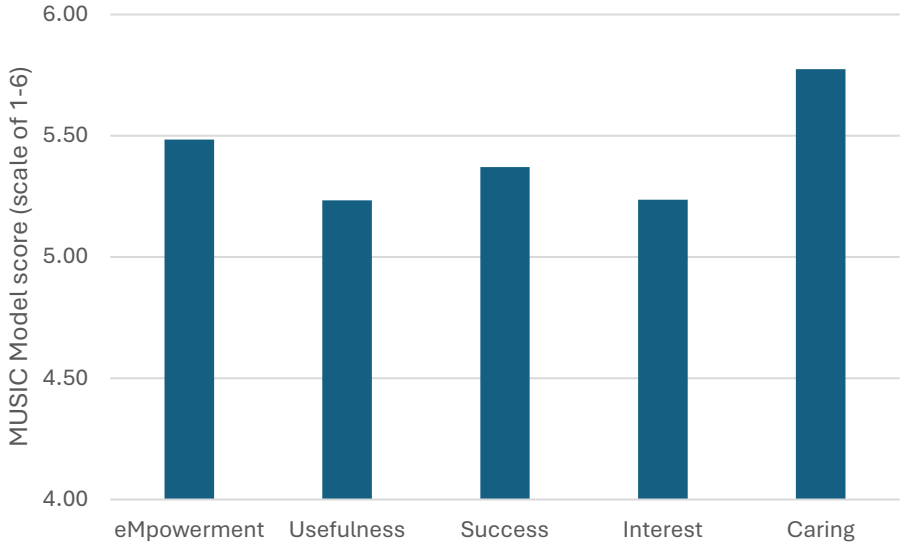

Figure 6. Average student responses in the third iteration of ungrading broken down on the MUSIC model scale.

Overall, students did not provide any direct feedback on the implementation of the point totals. However, the large increase in Advanced level exercises completed does suggest that their personal approaches were impacted by the higher point totals and altered their decision making in the exercises they selected to complete and work through to complete correctness.

Instructor Reflection

From an instructor perspective, implementing the point totals had the opposite effect of the ungrading assessment approach. Previously, student portfolios had to be assessed based on both an overall perspective of the breadth, depth and full body of work, in addition to a closer consideration of the exercises selected within each course outcome. Without a rubric providing a specific numeric grade, the ungrading approach would drive the instructor to more carefully review and evaluate the demonstrated student mastery. This effectively provided a more insightful final assessment of each student. However, introducing point totals created the opportunity to summarize all student work by a singular number, adding all corrected work together. The objective to focus on students' overall mastery became much harder to review with the availability of a numeric assessment of all work.

Effectively, while the gamification may have provided a positive motivation for students, it had a negative impact on the overall assessment process by enabling a limiting of the instructor's perspective. Point totals may have promoted more advanced problem-solving and application of concepts and theories, but it also restricted the final assessment review by allowing for a return to a 'grading view' tendency.

Conclusions and Future Work

Over a multi-year process in a Process Control course, ungrading has been found to be effective as a means of enabling higher levels of student mastery, better focus on learning, and lower levels of student stress. While alternative assessment can take on many forms, the significant benefits for the student learning experience and overall academic performance should encourage its broader adoption through techniques that work best for the individual instructor. Student response has reflected high levels of motivation with respect to their perception of multiple motivating factors, but in particular their perception of the instructor's care for their success and achievement. In integrating alternative assessment with different teaching approaches, gamification may allow for a means to encourage more complex problem-solving, but should be implemented in some form that does not reduce the instructor's assessment of student work to the traditional numeric-driven perspective.

In order to address the student concerns about the openness of the portfolio approach, with the lack of precise clarity about just how many problems of what levels should be completed, the ungrading approach will be implemented again in a fourth iteration of the course instruction but with an alternative to the point total gamification technique. It may be possible to induce the same level of motivation in students through open guidance similar to standards-based grading and contract grading, by defining 'novice', 'basic', 'proficient', and 'exemplary' levels of mastery (or some

other scale) based on general number of exercises and level of exercises completed correctly. Further work will investigate implementing such guidance in an open ungrading format while still allowing for students to be empowered in their portfolio development and mastery achievement.

One additional interesting point to consider is the differences in implementation, student experience, and achieved mastery in an alternative assessment approach as compared to an assessment approach that allows students to submit corrections on exams. Effectively, the overall principle is the same in that students receive feedback on their work and are able to resubmit documentation of their mastery over the concepts being assessed; however, the format is distinctly different given resubmitting corrections on exams are specifically with the purpose of gaining more points on the exam and thus achieving a higher grade. In terms of potential impact, the associated benefits in terms of refocusing student mindset towards developing greater mastery may be lost with the exam-focused form of feedback and resubmission, as students may once again be more focused on their score as opposed to their learning. Studies investigating the impact of exam resubmissions have found some benefits in student motivation,[44,45] so there is the opportunity for a particularly useful study contrasting alternative assessment with exam resubmission to investigate the impact on student motivation, self-efficacy, and perceived experience, Being able to determine the scope of the differences could have a significant impact on educational approaches with respect to encouraging instructors hesitant to change who would prefer to maintain the traditional exam-style approach to assessment. Future work will also include effort in other courses to compare the two approaches and their resulting impacts.

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