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# Infinite Resubmissions: Perspectives on Student Success and Faculty Workload

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## 1 Abstract

A commonly used college grading model relies on assignments and assessments that are graded on a points (0-100) scale. Some students will then spend time to revisit the assignment, investigate their mistakes, and possibly seek help from the instructors, but this is not always enforced, and many students will likely not do so. If an instructor were to require students review the past assessments and associated rubrics/feedback, it would contribute to the students' growth but could take significant faculty time and effort. Pedagogical models, such as competency-based or mastery-based assessment, give students multiple opportunities to prove expertise over the material, while providing transparent grading and feedback. Encouraging students to focus on improvement rather than grades does require a considerable investment from the instructor, but it can better motivate students and scaffold their educational growth.

Three existing undergraduate courses were converted from a traditional (0-100) to competency-based grading, including one course that incorporated attributes of gamification. The assessment scheme and associated rubrics included four competency levels: beginner, developing, competent, and proficient. The courses, all within Electrical and Computer Engineering, include two junior programming courses and a specialized junior-level technical elective. As part of the new course models, the students were allowed to resubmit their work as often as necessary to achieve an assessment of competency or proficiency. Students could not pass the courses without achieving at least competency in each level, and their letter grade was determined by how many topics in which they achieved proficiency. Thus, it forced students to revisit their quizzes, exams, and assignments and resubmit (and improve) work until they reached a satisfactory assessment level.

In this work, we will discuss the pedagogical details of the courses and the assessment model and analyze the impact of the "infinite resubmission" policy on student feeling of success, student grades, instructor perspective on student engagement and growth, and faculty time and effort. This will include both qualitative and quantitative analyses for the three different courses, comparing and contrasting what was successful and what was not, as each course had different concepts, assessment strategies, class sizes, and delivery modalities.

## 2 Introduction

Many engineering and computer science courses follow the following model: present students with new material through lectures and/or activities, assess their understanding of said material through quizzes, exams, and assignments, provide a grade (possibly with feedback), and repeat. Some faculty may also encourage engagement with the material with detailed feedback and repetition, to further ensure the student understand their own mistakes and grow from those mistakes, as will be presented in Section 3.

In a traditional grading structure, assessments are graded (0-100), weighted (*e.g.*, 30% for exams, 20% for homework, etc.), and then translated into a letter grade. There is increased movement to incorporate new grading policies into courses, primarily in the form of competency-based grading (or similarly mastery-based, contract, standards-based, or micro-credential grading), which focus on the students' achievement of particular standards or competencies, described in detailed rubrics. The grades in these models are not purely percentage or points and rather are labeled with specific levels of understanding. But in order to ensure students the best opportunity to achieve those competencies (which translate later into a letter grade), it is critical to (a) give strong feedback and (b) allow students to attempt a particular learning objective more than once. This repetition could be repeating the same concept in different ways or revisiting the original question/assessment with a different approach and more guidance.

This feedback cycle could be viewed as an impediment to widespread implementation of competency-based grading, as it requires instructors to have multiple assessments and provide fast and specific feedback. This could become significant undertaking for the instructor and has likely dissuaded adaptation into some courses. With a better understanding of the time commitment and possible avenues for implementation, more instructors could be compelled to try.

In this work, an instructor in the field of Electrical and Computer Engineering converted three courses to competency-based grading and allowed unlimited resubmissions for all quizzes, exams, and homework assignments (only final projects were exempt from resubmission). Data were gathered regarding the number of resubmissions, the faculty time grading, and the impact of the infinite resubmission policy. In two semesters, these data are compared for three different courses, as well as compared to previous courses using the more traditional grading structure.

Results show the policies of infinite resubmissions, flexible submission deadlines, and competency-based grading were overwhelmingly successful, as determined by student feedback and faculty observation. The new model requires dedicated time on behalf of the instructor, in terms of planning and grading, but the results indicate it is worthwhile. With some revision, the time could be kept to a minimum while maximizing student engagement and growth.

It is worth mentioning that these courses were all taught during the COVID-19 pandemic of 2020 and were done with synchronous, virtual methods. The courses did not need physical space, and online videos are available even during in-person semesters. That being said, there may be some impact to the students' positive or negative reactions. The impact of the virtual modality will largely be ignored for the paper.

This work was reviewed and approved by Wentworth Institute of Technology's Institutional Review Board for human subjects in research.

## 3 Literature Review and Related Work

**Resubmissions and Multiple Attempts:** There are numerous previously published works addressing a policy of allowing students to submit incorrect or incomplete work multiple times [1, 3, 9, 20, 21, 23, 25, 29, 32], but each varies in its focus or implementation. Moore and Ranalli tracked the faculty time and impact for a mastery-based approach to homework, allowing two resubmissions per student [25, 29], which is especially relevant to our work presented here, as we will also discuss faculty time, although with more than 2 submissions. Several other studies discuss limited resubmissions, while others had a more unlimited approach [1, 3, 23, 32]. A series of papers studied the effects of allowing retakes of quizzes and exams, tracking the student time, faculty time, quiz implementation, and overall impact [5, 9, 11, 12, 16, 20, 21, 22, 24, 26, 31]. In each of these cases, there is a lack of insight into the impact of unlimited resubmissions, both for student and faculty time and effort.

**Competency-based Grading:** Allowing students to resubmit work or attempt a learning objective more than once is a common facet of competency-based grading as well as similar grading policies (mastery-grading, micro-credentials, standards-based grading, contract grading) [1, 2, 3, 4, 6, 7, 14, 18, 19, 25, 27]. These policies aim to reinforce a detailed list of learning objectives, and thus as part of the process, students are encouraged to revisit topics that they had not successfully grasped earlier. This requires either multiple assignments/assessments for each learning objective or multiple attempts to the same (or similar assignments).

These grading schemes are increasingly popular, especially in Engineering and Computer Science courses, so only a subset of existing works is presented here.

**Automatic Grading and Feedback:** In order to allow resubmissions, it is imperative to provide students with feedback as quickly as possible and with enough guidance to correct the students' thought process for the next attempt. Several previous studies have investigated the effects of and the mechanisms to deliver rapid and specific feedback [21, 27, 28, 30, 32]. In the work presented here, there is a mix of auto-grading and manual instructor feedback, supplemented by published rubrics for each learning objective. An auto-graded quiz structure was used, similar to other works [20, 21, 30], which then led students to more traditional assignments, which were graded by the instructor.

One of the largest issues with feedback, in particular with allowing multiple attempts, is faculty time and effort [6, 25, 27]. While some previous works have addressed the time commitment, there is still work to be done. In our work, we focus on the time commitment for infinite resubmissions.

With multiple attempts or allowing multiple assignments to address a single competency, students are provided with opportunities to make mistakes and not be penalized for them. This concept is not intended to train professionals that mistakes don't have consequences. On the contrary, in a classroom where the goal is to allow growth and development of the students, the resubmissions allow students to identify their mistakes while in a safe environment. In addition, it promotes the idea of having the students fix their own mistakes, rather than leave them unaddressed.

**Gamification:** The general design of one of the courses here borrowed from common tactics in gamification. Gamification refers to incorporating elements from games into the structure of a course. In the presented work, a leaderboard, leveled accomplishments, "quests," and achievement/awards were used. There are myriad publications discussing gamification and its impact on the faculty instructor and the students, in terms of learning, engagement, enjoyment, and more, including several key papers and review studies [13, 15, 17, 22]. The impact of the gamification is not going to be thoroughly evaluated in this paper, but as it was part of the course structure, it is worth including in the literature review.

## 4 Course Details

The practice of allowing infinite resubmissions was implemented across three courses, all of which were junior-level computer engineering. In total, this included around 70 students, with several students withdrawing partway through the semester.

### 4.1 Curricular Design Comparison

**Original course structure:** Each course had been taught at least twice with a more traditional grading structure. This included weekly in-class quizzes and assignments, all graded within 3-4 days of the due dates and returned with detailed feedback for the individual students. If a student missed a quiz, the grade was a 0. For assignments, students could submit late assignments for up to a week, with a 15% deduction for each day it was late. Assignments could not be resubmitted. Course grades were a weighted scale of quizzes, assignments, exams (if applicable), and a project (if applicable).

**New course structure:** The general structure of quizzes and assignments (typically weekly) was maintained. However, quizzes were moved to a learning management platform, with most quiz questions being auto-graded. A quiz grade of 90% was required in order to release the assignment associated with that chapter or topic. If a student scored less than a 90%, they would be required to retake the quiz. If they achieved a 90% or higher, the assignment was released. Quizzes were open note and not timed, instead they were intended to give students reinforcement of the basic lecture topics. The actual score was not factored into their course grade. Previous work evaluated how students approach retaking quizzes and describe the impact of quiz resubmissions [9].

Assignments were all posted in the beginning of the semester, with due dates serving as a guiding suggestion and no late penalty being applied. They remained hidden until quizzes were completed satisfactorily, as described above, but students could see them upon passing a quiz, regardless of the date. This allowed students to work at their own pace, with some scaffolding to guide their progress. Part of the flexible deadlines was because of the remote learning model, in order to give students more breathing room, but it resulted in interesting results for our discussion and evaluation.

Assignments were scored on a 4-point competency-based scale (0 = beginner, 1 = developing, 2 = competency, 3 = proficiency). Students were provided with feedback and a score typically within

48 hours of the submission (not the due date). They could then resubmit any quizzes or assignments as often as necessary to reach their desired level with similar feedback timing.

In two of the courses, the number of 4s (proficiency) would dictate the final letter grade. For example, if there were 10 assignments/rubrics, 10 proficiency scores was an A, 9 was a A-, etc. In the remaining course, the total number of points was averaged to create a final score.

There are aspects of competency-based grading, gamification, and more within the new structures. While we will discuss these structures as part of the courses, this study will focus on the resubmission policy.

### 4.2 Course Details

**Object-Oriented Programming:** This course comprises the bulk of the students assessed in this study. In the Fall of 2020, 54 students were enrolled (two sections) in this junior-level course, all in majors related to electrical and computer engineering. The lecture topics included pseudocode and programmatic thinking, search/sort algorithms and program efficiency, basic data structures, C++ syntax and concepts (*e.g.*, conditionals, loops, variables, memory, functions, objects, inheritance, STLs), and Python and Java comparisons. It is a 4-credit course, with 2.5 hours of lecture and two hours of lab. It includes small and large-scale assignments, quizzes, and an optional project. The lectures followed a flipped model, with prerecorded lectures and live activities.

**Applied Programming Concepts:** Applied Programming Concepts is a junior technical elective, intended as a follow-up to the above Object-Oriented Programming course. The latest section of the course had 18 students. Applied Programming Concepts covers databases, programming language comparisons, advanced data structures, algorithms, UML documentation, testing, version control, and large-team programming. It is a 3-credit course, with one hour of lecture and four hours of lab, focusing on real-world hands-on programming. Students had weekly quizzes and assignments, as well as a project.

**Hardware Security:** Hardware Security is a junior-level technical elective, intended for electrical and computer engineering majors. The course typically has 15-20 students, with the latest instance only have nine (scheduling conflicts prevented more students). This course covers topics in adversarial modeling, cryptology, side-channel analysis, Hardware Trojan Horses, and more, all related to hardware cybersecurity. Similar to previously discussed courses, students had to complete quizzes and assignments. Hardware Security has a project and an exam, as well. The project is chosen by the students with guidance from the instructor, and could hardware, software, or a combination of both. The exam was also subject to multiple submissions, with an 80% being required to pass, similar to an exit exam. This course's details have been discussed in previously published work [8, 10].

### 4.3 Administrative Considerations

At Wentworth Institute of Technology, there are no teaching assistants, and thus all grading was done by the faculty instructor. Course sizes are typically 20-30 students, with a three-course faculty load each semester. If one were to implement this in large courses with multiple graders, consistency in feedback would need to be a focus.

If one were to implement this in their own courses, they must make sure the final grade policy is compatible with the school's overall policy. In the courses discussed here, the syllabus had a direct mapping of the competency-based grading outcomes to a final university-wide grading scheme.

**Note regarding 2020 courses:** This work was completed during the 2020 COVID-19 pandemic. The original versions were taught using in-person lectures and labs, supplemented in most cases with on-line recorded videos of lecture material. For the new version, all lectures and labs were remote, using digital conferencing software. All times were synchronous, using videos to supplement or review the live content. It is unclear how the pandemic impacted the course outcomes, so this work will focus primarily on the infinite submissions policy, which can be largely decoupled from the course modality.

## 5 Evaluation Procedure

To evaluate the restructured submission policy, the following questions are being explored:

1. How often did students resubmit?
2. When did students submit, given the flexible deadlines?
3. How much additional grading time was required from the instructor?
4. How much additional preparation was necessary by the instructor?
5. Did students benefit from the policy?
6. How did it change the aggregate grades of the classes?
7. What were the student's perceptions of the policies?
8. What are the faculty perceptions of the policies and suggestions moving forward?

The first two questions can be answered using data tracking of submissions to the learning management system. The investigator collated and analyzed the number of submissions and the timing of the submissions.

To answer the question of faculty time, the faculty member measured their own time for grading and estimated the time for additional preparation prior to the semester.

In terms of grades, the investigator tracked the grades across course sections, including years where the more traditional submissions policy was used.

For perceptions, the students were given an end-of-semester survey with a variety of questions (Likert scale, open-ended) and the results were gathered and analyzed in the next section.

## 6 Results and Discussion

In order to assess the various attributes of grade resubmission policy, data were gathered via student assignment tracking (including time of submission, number of resubmissions, grade impact) and a survey.

These data are presented to answer the questions proposed in Section 5. As a reminder, the data come from three courses: ELEC 3150 (Object-Oriented Programming, 51 students), ELEC 3225 (Applied Programming Concepts, 18 students), and ELEC 4025 (Hardware Security, 9 students). Given the small sample sizes for the latter two courses, some of the discussion will focus only on ELEC 3150, which had significantly more students.

### 6.1 Students resubmissions

To track how often students took advantage of the resubmission policy, the instructor aggregated the LMS data for both submission frequency and time/date. Figure 1 describes the number of quiz attempts, and Figure 2 shows the number of resubmissions for each of the three courses.

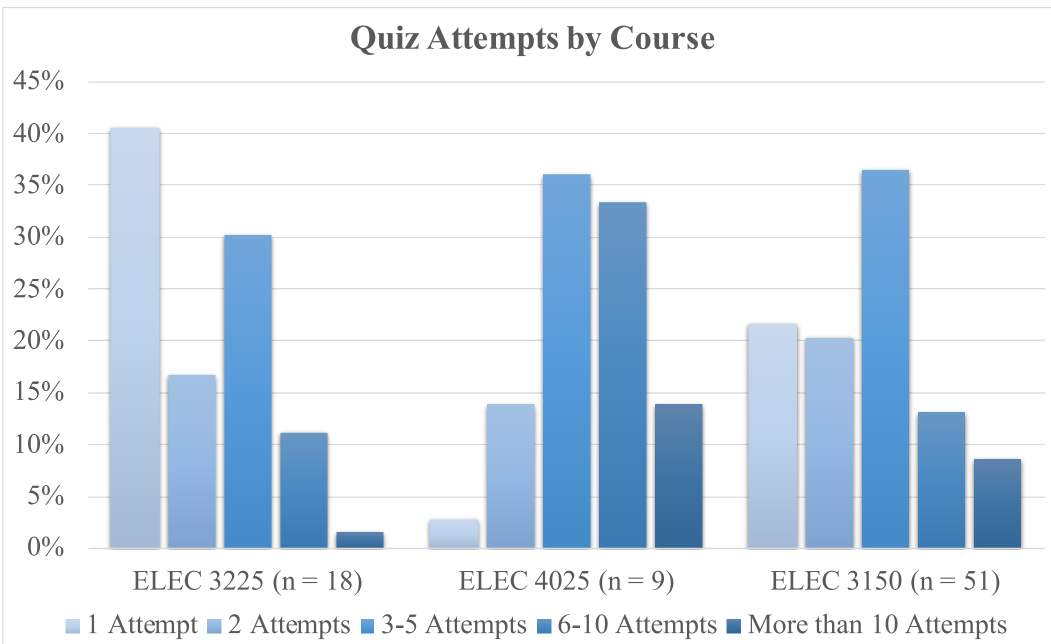


Figure 1: Number of quiz attempts needed, per course, represented as the percentage of students. The number of students per course is also listed (n).

**Quizzes:** Quizzes were mostly automated, with a large percentage being graded by the LMS. This means multiple attempts were mostly negligible for faculty time, although not for student time. Students were allowed to retake them as often as they needed to attain the 90% or higher, although, because a pool of random questions was used, students did not always get the same questions. In Object-Oriented Programming, the questions followed this ”large pool” model, while in the other courses, students would get the same questions on each attempt.

The number of quiz attempts varied significantly across the courses, and internally to the courses the attempt number varied across topics. For all the courses, the average number of attempts was high (3-6) with a high standard deviation (3-5).

It is worth noting that in ELEC 4025 (Hardware Security), there were often 1-3 questions that required hand-grading by the instructor. Students received a 0 on those problems by default until the instructor could grade them. Many students did not check to see if their answers were graded automatically, and thus many times they tried multiple times unnecessarily. This inflated the number of attempts shown.

Because the quizzes were automated, students were able to reattempt at will, so some used brute force, trying a question's different options repeatedly until they got it right. This means that students may not have made a concerted effort and rather decided to try over and over one answer at a time. It is recommended that instructors consider this in creating quiz questions. For example, by creating a large pool of questions that are randomly chosen, it makes it harder for students to attempt the same question repeatedly. This eliminates "guess-and-check," but requires more questions. Further, using fill in the blank, multiple selection, or short answers instead of multiple choice or true/false can eliminate random guessing. This is not a new insight, but it warrants emphasis [29].

For ELEC 4025 (Hardware Security), there was a cumulative exam that students were required to achieve an 80% to complete the course. Of the nine students, five needed only one attempt, three needed two attempts, and one needed more than two attempts. The other courses have no large exams, and thus there is no basis for comparison.

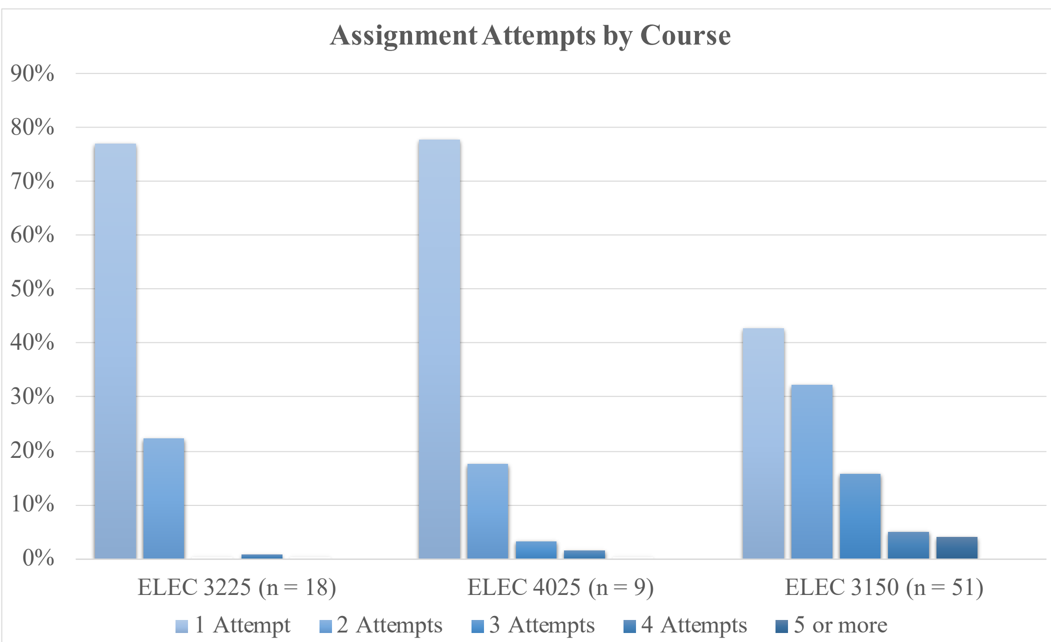


Figure 2: Graph of number of resubmissions for all classes. The number is normalized to the number of total students that submitted. If a student did not submit anything, they were not counted in the total number of students.

**Assignments:** As Figure 2 illustrates, for ELEC 3225 and ELEC 4025, 99% and 95%, respectively, of students attempted an assignment one or two times. Feedback was given, and in each case, the student found that feedback critical in guiding them to improvement.

For ELEC 3150 (Object-Oriented Programming), 75% of students submitted one or two attempts, with an additional 16% needing a third attempt (for a total of 91% so far). If a student did not submit an assignment, they were left out of the calculation.

Further, 2.5% of all resubmissions were on the first assignment. This assignment was based on flowcharts and pseudocode, which is somewhat subjective and harder to test prior to submission. Students made incremental improvement based on instructor feedback, often requiring multiple iterations. Other assignments were based on actual code implementation, which students could compile, run, and test independently.

Finally, 5% of submissions that were resubmitted three or more times can be attributed to a small cohort of students. These students used the submission site as more of an ”ask for help” mechanism, less than a way to finalize completed work. While this was useful as a way to provide a means of engagement, it does somewhat corrupt the data as a pure means of measuring resubmissions.

Given these data, an instructor could infer that giving more than 1-3 attempts is unnecessary and limiting the number could help scaffold students. On the other hand, as most students did not use more than 3 attempts, providing students with the safety of unlimited attempts could give them peace of mind (as we will see from the qualitative comments) without overburdening the instructor. We will discuss instructor time later in this section.

**Deadline flexibility:** As part of the infinite resubmissions policy, students were allowed to submit assignments any time through the semester without penalty. This was true until the final week, when a hard deadline was enforced. Figure 3 shows the number of submissions for each week of ELEC 3150. The other courses had too few students to draw any significant conclusions. There are two classifications of assignments here. The first is a small assignment that is not fully graded and does not require or allow resubmission. They are a means of practice only. While feedback is provided, it is more limited in its length and the assignments are shorter.

Suggested deadlines were posted weekly on the course site, approximately one assignment per week. As such, one should expect that the submission rate should be approximately 7% per week. This is shown as the dotted line in Figure 3. As may be expected, students did not always meet these suggested deadlines. Early in the semester, students showed evidence of activity and engagement, with a noticeable decline in the middle of the semester. Week 11 had a significant increase in submissions, most likely due to a soft deadline for project permission. In week 11, students had to have a grade of “competent” or higher in all assignments to be allowed to complete the project (which was the only way to go up to a grade of A- or A). This encouraged students to submit assignments similar to a traditional deadline.

The most noticeable increase (about 31% of all submissions) happens in weeks 13 and 14. This is because of the final deadline for the semester, as people either completed assignments for the first time or resubmitted assignments one last time to increase their grade. Future iterations of the

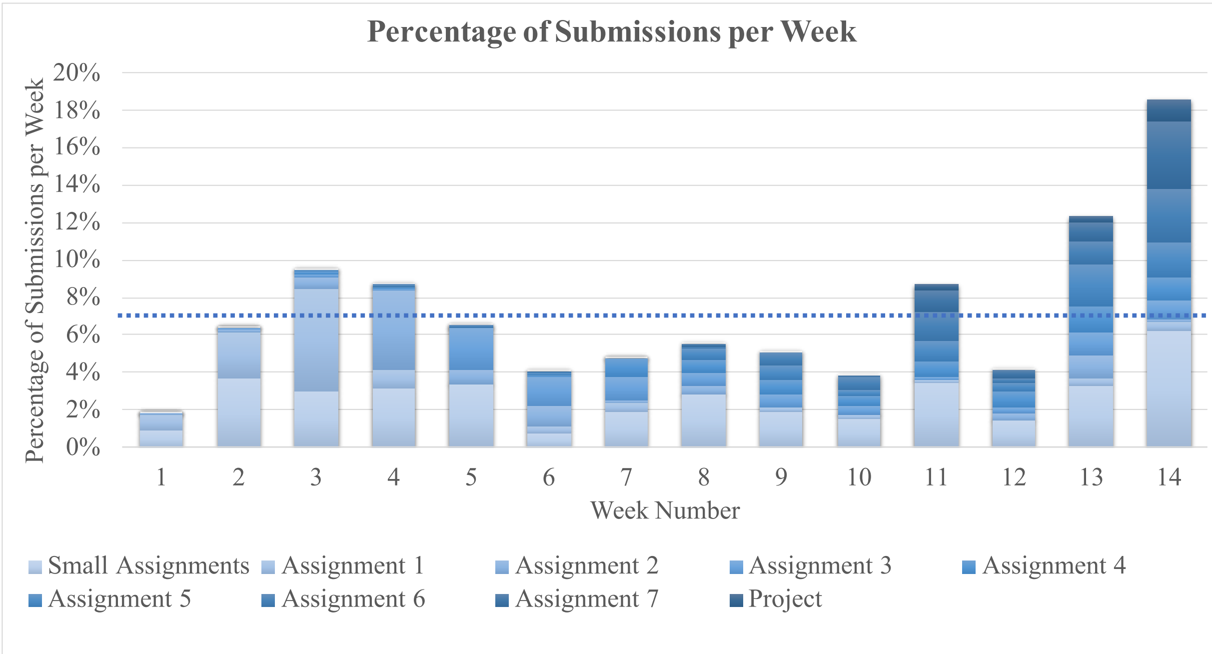


Figure 3: Student assignment submissions by week (only ELEC 3150). This includes all submissions and resubmissions. Small assignments are grouped together, while larger assignments are given more detail. The dotted line represents the expected average of submissions based on suggested deadlines (7%).

course have already sought to include more direct motivation for students (late penalties, for example) in order to spread out the time requirement of the instructor.

### 6.2 Instructor time

**Grading and Feedback:** A key component of the submission-feedback-resubmission iteration is the instructor's timely and facilitative feedback to the student. This requires time and effort on the part of the instructor. The course sections evaluated had on average around 20 students, with the instructor having three course sections. This technique would be much more difficult in larger classes (especially without teaching assistants). In general, instructor feedback was provided within 24 hours of submission, sometimes as quickly as an hour, depending on the time of submission. Since all assignments could be submitted at any time, it did require the instructor to give feedback on any assignment on any day.

On average, the grading time for resubmitted work was less than the first submission. This echoes the work by Moore and Ranalli, which pointed out resubmission added 23% of faculty grading time [25]. To gauge the faculty time here, the instructor measured all grading for the final three weeks of the semester (around 35% of all submission grading). Results are shown in Figure 4. On average, resubmissions took 78% of the time of the grading of a first submission (1:34 minutes compared to 2:01). Of all submissions to large assignments (the only kind that allowed resubmission), 51% were first submissions, with 49% of all submissions being resubmissions. As such, 49% took an additional 78% of the original grading time. On average, the instructor for this

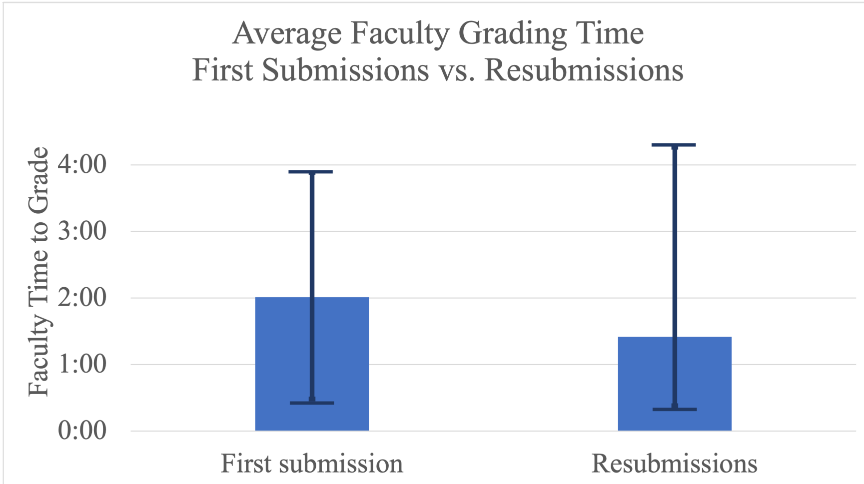


Figure 4: Comparison of faculty time (in minutes) spent grading an individual assignment, first submission vs. subsequent resubmissions. The bar chart represents the average, with the error bars showing the minimum and maximum times.

course spent effectively added 75% of their time original grading time. This may seem significant, but it does depend heavily on the rubrics and grading style. For example, in this course, the instructor added approximately 8 hours for the entire semester. With firm deadlines, this would be less than an hour per week. The instructor in this case put in significant effort in the formation of the course materials to decrease the time it took to grade, and the course material was conducive to faster grading.

The data are not disaggregated to track the time for each resubmission individually and thus the second vs. third timing is unavailable. However, it is possible that resubmissions that come later in the semester may be further removed from the instructor's memory, as the initial round was graded earlier. In this study, the instructor created a robust key and rubric, which facilitated faster grading and limited this issue.

If another instructor is interested in similar structures or policies, it is recommended that clear keys and rubrics are created to facilitate quick but detailed feedback. Note that the feedback given was not directive but was intended to guide the student towards finding the correct answer on their own [32].

**Preparation:** Prior to the course starting, there was significant overhead to creating the course materials. This included new programming labs, key creation, and the formulation of detailed rubrics for the course. Each of these would be similar to if one were to create any new course materials, so it is only a significant undertaking if you cannot reuse existing material. Otherwise, it would be similar to creating any new course. The primary component of the increased time was in recording lectures, since the course was switching to a flipped model.

The additional time in preparation helped reduce the time necessary for grading, as assignments were designed to be "quick" to grade. The development of strong keys and rubrics were seen as upfront costs.

### 6.3 Student grade impact

There are two points of discussion regarding student grades. The first is regarding how the assignment resubmissions may have had an impact on the students' final grades. Figure 5 graphs the number of resubmissions by the grade group (plus and minus grades are dropped here for simplicity).

It is worth nothing this course took place during the COVID pandemic, and many students had trouble adapting to the new learning environment. This may account for the larger than usual number of failing grades, but future work could explore this model in a more traditional (non-pandemic) setting. We also limit the discussion to the larger course only (ELEC 3150) as the grades in the other courses were typically high, and those course sections were small.

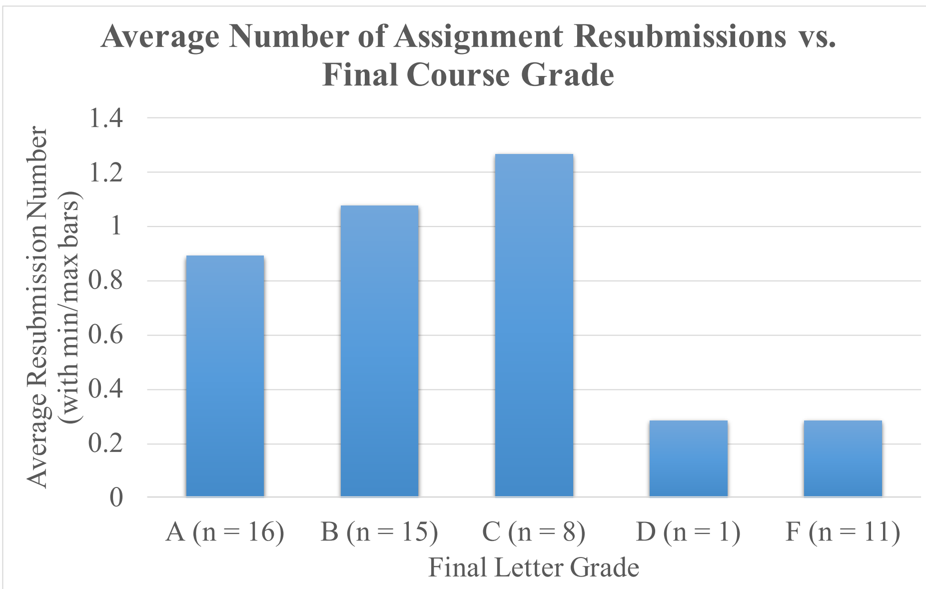


Figure 5: The average number of assignment resubmissions compared to the students' final grades. With the grade, a number of students who received that grade is included. Only the ELEC 3150 course is reported here.

**Resubmissions vs. grade:** Figure 5 shows that students who received an A used resubmission less often than their peers (averaged 0.89 resubmissions per assignment), with those receiving a C having the largest number of resubmissions (averaging 1.27 resubmissions). The students who received Fs had very few resubmissions, but they also had very few initial submissions. The sample size is not high enough to gain deeper statistical insight; however, from the faculty observation, resubmissions for those students who received an A were typically simple fixes while the resubmissions for the students who received a C were often much more involved, requiring more work on both the part of the instructor and student. This feedback-resubmission cycle often resulted in feedback being overlooked or misunderstood, hence the need for multiple resubmissions.

One question that arose after the courses' completions was how the resubmission policy affected student's first attempt. The worry is that students would submit a purposely incomplete version knowing it was just a placeholder or an attempt to gain feedback without putting in initial effort. The individual grades were not recorded longitudinally through the courses for each resubmission, so no quantitative data exist. However, from the instructor's experience, there were students who did take advantage of the system in that way. The goals of the resubmission policy were to increase engagement and lower stress, not just assess a student's understanding at a given point in time. As such, the students that did hand purposely incomplete assignments were given feedback, although sparser than their peers' feedback. If a student did this more than once, the instructor warned them that resubmissions would be denied if an initial effort was not evident, which fixed most cases. In the recommendations subsection below (Subsection 6.5), the authors will provide suggestions to avoid this problem in the future.

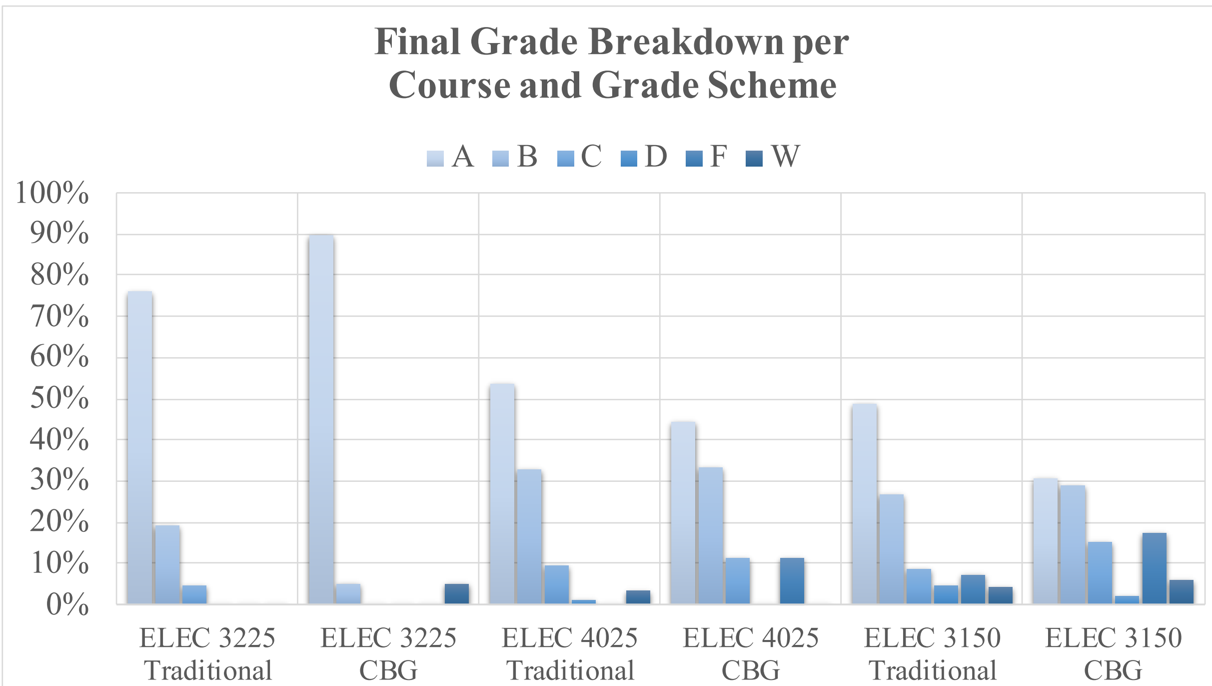


Figure 6: Final grades for traditional course (using no resubmissions and a more traditional grading model) compared to the new course model (resubmissions, flexible deadline, competency-based grading).

**Grade impact of new model:** To investigate the impact the new model had on student grades, Figure 6 shows the grade breakdown for previous years and the past semester (with infinite resubmissions), as percentages of all students to take the course. Grades marked with "CBG" represent the sections using competency-based grading and infinite submissions, while the "Traditional" has a more standard grading structure with firm deadlines and no resubmissions. For ELEC 3225 and ELEC 4025, there was minimal difference between the grades from one semester to the next. Those courses also tend to have mostly high grades, historically.

The grade comparison is not directly correlated with the number of submissions, because the traditional model had a different final grading scheme, different deadlines, and the no resubmissions. However, the assignments were largely similar, so one can use this in part to

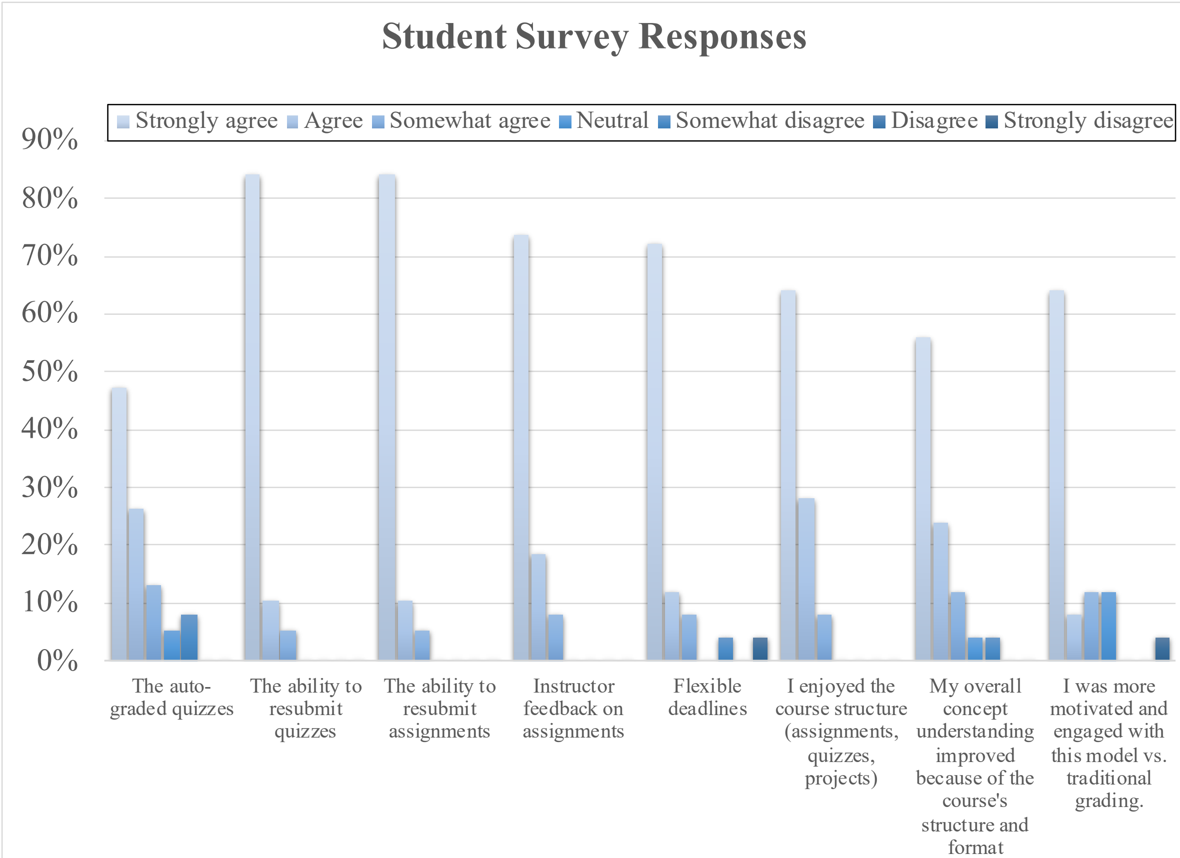


Figure 7: Survey Results for questions regarding the class policies.

assess single submission vs. infinite resubmission grades. This can't be done on individual assignments but can be done in the aggregate.

For ELEC 3150, the largest changes happened for A and F. The percentage of As dropped from 49% to 31%, while the percentage of failing grades increased from 7% to 17%. It is believed that, in large part, these grade differences were related to several novel aspects of the past year (COVID pandemic) and are outside the scope of this paper. Anecdotally, students commented to the instructor that their failing grades were primarily a result of the difficulties of remote learning and/or the pandemic. This hypothesis is further supported by the increase in DFW grades across multiple classes, regardless of modality and content at the university.

It is also possible that the freedom of deadlines contributed to a lack of time management structure for a subset of students. This is in contrast to the students who would have otherwise fallen behind and failed because of past missed, incomplete, or incorrect submissions. A deeper look into the students who failed showed a general lack of submissions through the entire semester, so it can be concluded that the alternative structure had a somewhat limited impact on the final grading outcomes in the aggregate view, with some students improving and some declining through the course.

### 6.4 Overall qualitative perceptions

**Student perspectives:** To get the students' perspective, they were given an optional survey. Out of 78 students, 38 responded. Figure 7 shows part of the results. In this part of the survey, students were asked if they agree/disagree on which aspects of the course helped them learn. The ability to resubmit both quizzes and assignments was overwhelming noted as a helpful aspect, with no responses indicated other than positive. Similarly, instructor feedback on assignments, a key component to a successful resubmission model, was noted as a positive.

The final question is geared to compare the more traditional model (0-100 scores, weighted categories for final grade, no resubmission) compared to the implemented competency-based grading model (1-4 scores, equal weighting for all learning outcomes, includes resubmission). As the figure shows, 64% responded "Strongly Agree" when asked if, "I was more motivated and engaged with this model vs. traditional grading." A total of 84% had an affirming answer to that survey question, and only 4% had a negative response.

Open-ended questions were also given in the survey. Below are some representative quotes from the student responses, regarding the flexible timeline, resubmissions policy, and related topics. Grammatical errors are not corrected from the original response.

> *"It was very rewarding having a course that was paced by my own work ethic. I especially liked that my grade was representative of what I genuinely know by the end of the course as opposed to what I remembered the day I submitted the assignment."*
>
> *"I like how the professor graded my work and gave me detailed feedback and allowed me to resubmit because that encouraged me to meaningfully try again and resubmit."*
>
> *"The ability to make multiple attempts at assignments and quizzes took the stress for the most part off of the grading and allowed me to focus more on learning the material without adding too much to the workload."*
>
> *"being able to fix work until you can fully understand it is a good thing however i think it makes me lazy"*
>
> *"I really liked that, personally I don't think I submitted more then [sic] 2-3 times, but every time I did resubmit I learned a concept I was getting wrong. If I didn't get the feedback I did in-between it would have been hard to work out the fix, but we had that."*
>
> *"I loved it. In real engineering work chances are you never really get it right the first time and so being able to go back to make it better is all part of the optimization process"*
>
> *"I appreciate it, but think it can be used an excuse to make assignments quite difficult."*
>
> *"I liked this policy a lot. This placed more of an emphasis on understanding and*

*without the pressure of getting a bad grade. It allowed me to, without stress, learn the course material and hand it in. If I did not understand something or misinterpreted a concept, the assignment would be returned to me and I would be given another chance to learn what I did not understand. There was no fear in receiving a bad grade, which allowed me to learn much more than I otherwise would have if that pressure was looming over me."*

**Faculty perspectives:** There were a number of issues that arose as the resubmission and flexible deadline policies were put in place. First is in regard to the type of feedback necessary. The instructor must be able to provide quick feedback that guides students towards fixing their mistakes without explicitly and directly saying *how* to fix the mistake.

This fairly constant feedback cycle did increase time for the instructor, as discussed above. The main reason that the instructor was able to maintain this feedback level was because they had purposely completed all preparation for the semester before it started. All lectures, assignments, and assessments were complete prior to the first day. Without this level of preparation, it would likely have been overwhelming to give consistent feedback in a timely manner (usually within 24 hours).

The constant "availability" of the instructor, in terms of providing feedback, did lead to some abuse of their time. This availability was partly a result of the quick response to submissions. Several students took full advantage of the feedback loop, submitting incomplete work and hoping the instructor comments would fix their issues. The feedback provided, however, only gave guidance, not answers. This led to frustration from the student and took more instructor time. It is a positive thing that the students were engaged in the course activities, but clearer definitions of the policy are required to ensure it is not taken advantage of.

In a similar area of policy "abuse," the lack of deadlines did hurt several students. These students did not pay attention to the suggested deadlines, and instead pushed their work to future days. This eventually hurt some of the students, but it is possible these students would have struggled with deadlines early on also. It is recommended to have some incentive for submitting assignments on time, perhaps as part of their final grade or instituting a late penalty. These are common practice in many classrooms and should be considered as orthogonal to the resubmission policy.

One may believe that given the policy of resubmission, students would be less likely to cheat. This hypothesis would be based on the idea that students would have no reason to copy code if they could have extra chances. Unfortunately, this was not the case, as over a dozen academic dishonesty cases were identified and adjudicated. These were almost all within a week of the final deadline, implying that it is the *deadline* and not the actual work that had the largest impact on cheating. More formal investigation is necessary to determine if the resubmission policy directly leads to new avenues of cheating (for example, a student getting feedback, then passing it along to peers).

To address possible cheating, the instructor used past techniques to identify any infractions. This included comparing assignments for similarities to determine if code was being shared by students (as is common in most courses) and using both random and targeted web searches to find solutions that students may have found online (as is also common). Since submissions could come in at any time of the semester, the faculty did these types of checks when a large number of submissions were done (usually around a suggested deadline) or when there were particular anomalies in the submission (*e.g.*, when a student used a concept or syntax that wasn't shown in class). These techniques for catching academic honesty violations are not novel, and any instructor that implemented this technique would need to similarly be vigilant in their grading.

Overall, from the perspective of the instructor, resubmissions are extremely useful to guiding students. As an anecdote, there was a student who early on fell behind and struggled. They frequently met during office hours and used resubmissions to get higher grades. In the end, their grade was very high, and they displayed high proficiency in all topics. In a more traditional classroom without resubmissions, their early assignments would have decreased the overall course grade to the point of failure. Instead, the students seem to engage and are better for it. The conclusion overall then is that these resubmissions encourage participation and continued improvement. Of course, careful definition of the parameters of the policy are required to ensure that they aren't abused and loopholes aren't created.

## 6.5 Recommendations and Insights

### Key recommendations

- *Carefully consider the number of resubmissions.* It is recommended to have at least 1-2 resubmissions available, but the data presented show that even if infinite are available, most students won't use more than three. A possible solution being developed is to allow one resubmission automatically, and students can earn more through their progress from the first to second submission.
- *Have an incentive to maintain a deadline*, but not strict enough to discourage a student from catching up. A complete lack of deadlines may lead students to procrastinating to the point of failure. But student feedback showed that some flexibility helped with their mental state and stress levels, allowing them to balance their mental health and education.
- *Prepare as much ahead of the semester.* Because the in-semester time will be more dedicated to instructor-student interaction and grading, it is critical for time management to limit mid-semester preparation for the course. It is recommended all quizzes, assignments, and lecture planning are complete before or early in the semester.
- *Use auto-grading, but not always.* The auto-graded quizzes helped to reinforce basic lecture topics without instructor grading. However, the instructor-graded assignments helped make feedback personalized and facilitative, better guiding the student to their individual mistakes.
- *Create keys and rubrics.* As with any competency-based model (or similar models), rubrics are critical for student success. But in this case, the key result of the rubrics was to let the instructor grade quickly and consistently. If possible, putting the rubrics directly into the course website or LMS will help grading and transparency.

- *Clearly define all policies.* Students will either intentionally or unintentionally find loopholes in the policy or misconstrue the policy. Clearly define the parameters of resubmission and any expectations.
- *Ask the students to submit resubmission reports.* This requirement helped the instructor to quickly note if the student has made the necessary changes and understands why they were necessary. It could be as simple as a few short descriptive sentences.
- *Give clear feedback, but not answers.* Facilitative feedback can lead students to fixing their mistakes, but if the instructor gives the correction directly, students will grow from the resubmission [32].
- *Create "student success" and soft skills rubrics.* In subsequent versions of these courses, the instructors added (but have not fully assessed) rubrics regarding a student's effort and success. These include timeliness, report writing, and consistent effort. These provide students with incentive to put in their full focus and attention into each assignment, and not purely rely on the resubmission policies to increase their grade. Early indicators show this helps with motivation and helps reward students putting in early and consistent effort. It similarly creates disincentives for finding loopholes in the grading scheme. Rubrics for these should be clearly stated along with the technical rubrics.

## 7 Conclusion

Allowing students to infinitely resubmit assignments for improved grade and no penalty improves their satisfaction, their learning, and in some cases their stress levels. Faculty must dedicate both some upfront time to prepare course materials specifically designed for the new structure and must dedicate in-semester time to fast and clear feedback.

This paper details the student impact, the time and energy from the faculty perspective, and gives details as to how three Electrical and Computer Engineering courses were adapted to the new model. The results show that the infinite resubmission policy helped students manage their own education, choosing their grade goal, grow in their understanding without fear of making mistakes, and eased stress levels. By combining auto-grading, facilitative feedback, and clear policies, students can gain the most out of their course. Faculty effort is required, but careful planning can minimize the impact on faculty time.

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