WIP: Exploring Strategies that Allow Multiple Attempts on Formative Assessments in an Introduction Programming Course

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Abstract

For some faculty, it is an ongoing challenge to design assignments and course policies that motivate students to focus on the learning that can come from overcoming challenges. For many students, when the stakes are too high or their time is too strained, productive activities are bypassed for strategies that more quickly get to an answer without necessarily exercising critical thinking skills. A variety of approaches have been taken to encourage students to productively struggle on formative assessments and then reflect on their results to further enhance learning [1], [2], [3]. These strategies often come with a tradeoff.

The purpose of this work is to share additional strategies where students have been given multiple opportunities to complete formative assignments with the hope of finding a balance where students feel motivated to put enough effort into the 'productive struggle' and problem solving to learn the material.

Specifically, this paper presents variations on an approach where students were given multiple opportunities to complete their lab assignments and weekly homework assignments. While the summative assessments in the class, like quizzes, midterms, and final exams were preserved as single-attempt assessments, the initial exposure to material included activities that allowed students to take multiple attempts at learning the material.

This work-in-progress paper shares the details of the structure of the assignments and initial results from applying these approaches in an Introduction to Programming for Engineers class at a two-year college.

Introduction and Previous Work

When considering student success, a common goal for educators is to provide meaningful activities that support learning and help their students achieve the specific Student Learning Outcomes (SLOs) for their course. Many strategies can be used to motivate students to perform these formative assessments; but, historically, one lever that a faculty member can easily adjust is the grade percentage assigned to this work. When the weight of these assessments is too low, or even removed, students can feel justified in prioritizing other work – especially when their time is limited. Students, especially Engineering students, have increasingly more demands on their time and have been spending less time outside of class than previous generations. This has resulted in some wondering if too much homework is being assigned.

When the weight of formative assessments is too high, students can succumb to pressures to "do well" and sometimes eliminate or shorten the productive struggle that strongly supports learning. This 'time in the trenches' is especially important when learning programming. Unfortunately, some students will take the opportunity to cut corners – especially if the course infrastructure does not disincentivize it. In today's world, there are increasingly many avenues to do so through websites like Chegg, CourseHero, and generative AI sites like ChatGPT. In some courses, due to time demands, students are literally put in the position of having to decide between taking the

longer amount of time to learn the material and doing it quickly, which at time includes using outside (disallowed) resources to 'earn' a higher grade.

The motivation for this paper comes from previous work that shared strategies to take pressure off of formative assessments by lowering the emphasis on getting the right answer. Some approaches have been taken to motivate students to spend more time on formative assessments and then further enhance learning through reflection [1], [2], [3]. Other strategies [4], [5] lean on the benefit of flexible deadlines and regrading policies. It has been shown that struggling students specifically spend an increased amount of time engaging with material when opportunities to reflect are presented [2]. The overarching goal in these approaches was to have students emphasize their 'productive struggle' and avoid sprinting to an answer through alternative, and sometimes disallowed, methods. One strategy included a follow-on assignment where students were encouraged to thoroughly review solutions and reflect on their previous knowledge gaps. The follow-up assignment allowed students to truly identify the material that they missed and understand what they did not originally comprehend.

This work-in-progress paper considers multiple options that have formative assessments graded in a more effort-based manner. Specifically, the number of opportunities that a student has to complete this work has been adjusted to eliminate the pressures that are generally associated with graded work. Two minor adjustments on the approach are shared for consideration by faculty looking for ways to deemphasize the grade in formative assignments like labs and homework while encouraging students to perform important iterative reflection on their assignments. In one version, the follow-up homework assignment was extra credit and, in the other, this additional assignment was considered a required assignment that allowed them to earn back lost points.

For each version of the course discussed in this paper, lab assignments could be revised as many times as needed to achieve full understanding. Further, upon submission of their homework assignments, students were given a full solution set. Building from previous work (where it was called Dual-Submission or Student-Revised Homework), students were then given an additional assignment where they were asked to grade their own work, correct any problems they missed, and then reflect on what they did not initially understand and have now learned through the review process.

The course discussed in this work is an Introduction to Programming for Engineers class taught at Mission College, a two-year college in Santa Clara, California. Students reflect a diverse population in race, experience, income level, and major. Over the last five years, the class has an 89% pass rate amongst students that finish the class with 44% receiving an A, 29% receiving a B, and 16% receiving a C.

Course Details

The Introduction to Programming for Engineers course is a 1st year course that teaches C++ and covers hardware in the form of an Arduino. The grade is made up of multiple components including:

- Attendance/Participation 5%

- Labs 8%
- Homeworks (and Updated Homeworks) 12%
- Quizzes 10%
- Midterm 1 15%
- Midterm 2 15%
- Final Project 15%
- Final Exam 20%

The final project is a "robot" that is designed from the circuit and Arduino material learned in the course.

Material is offered in the text, but first covered in lecture. Lab assignments each week offer a first look at the material covered in lecture for the week. The weekly Homework assignments follow the material of the lab. Upon completion of the homework, the Course Management System (Canvas) releases the HW solutions for that week along with the corresponding Updated Homework assignment and the Quiz for the week. The idea is that students see the material in lecture, then in lab, then in the HW, then in the Updated Homework, then in the quiz, and finally in the exam at the end of the Module. Thus, a diligent student that isn't doing any studying outside of the required material would still see the most important material five times in low-stakes formative assessments before being tested on a higher-stakes exam.

The grade breakdown reveals that Labs and Homework assignments are still worth 20% of the overall grade; however, these activities are presented in a way that allows students to multiple attempts that can result in full credit.

Lab Specifics

The Lab assignment each week provides an initial, low-stakes look at the important material from the week. Students are given 2-3 hours of class time each week to work on these lab activities. Students are encouraged to collaborate with their peers and ask questions to the embedded tutor or the professor. Upon completion of the lab activities, students are required to demonstrate their programs. During this demonstration, students are asked additional questions about their work and asked to update code in real-time to confirm that they truly understand their code and can modify it. In cases where students need more time, they are allowed to complete the lab assignments outside of class and can either email the code to the professor or demonstrate the work in a future class session.

If a demonstration or submission reveals a gap or does not work in some way, the student is given partial credit and as many opportunities as needed to revise the program. Lab assignments can continue to be submitted through the end of the semester. While some students accept a partial credit score for a lab task here and there, an overwhelming majority of students iterate on their lab assignments until full credit is earned.

This iterate-until-correct opportunity is intended to create a mindset that promotes productive struggle. Students are encouraged to ask questions during lab and this can carry over to their approach on the homework. The culture of the course is that the professor is a coach that is helping

students take on the material and the corresponding tasks cultivating an ‘us vs. the material’ mindset instead of a ‘students vs. professor’ mindset.

Homework and Extra Credit Reviews vs. “Updated Homework”

Homework assignments follow directly from the Lab assignment that was “due” earlier in the week. If a student follows the schedule, they have four days after completing the lab to complete their weekly homework assignment. While some previous work has encouraged an effort-based grading of the initial homework submission, the assignments in this class have still been graded for correctness, work shown, and overall quality. From 2019 to 2023 (eight semesters), students were then offered a weekly extra credit assignment where they could take the provided solutions and grade and correct their own work and reflect on what they did not previously understand. Students could earn back half of their lost points from the corresponding homework assignment through this extra credit assignment (EC).

In Fall 2024 and Spring 2024, the second assignment was changed from being extra credit to being a required “Updated Homework” assignment (UHW). UHW assignments were graded out of 20 points; however, a student could also earn back any lost points from the corresponding HW assignment (which would be graded after the UHW was submitted). Doing so has the effect of the work being graded based on effort despite each assignment being graded for correctness.

Example 1: Assume HW3 was worth 100 points and due on Sunday, 2/18 while UHW3 was worth 20 points and due one week later on 2/25. If a received an 80/100 on HW3 but then corrected everything and reflected on all of the gaps in their original work would receive a 40/20 on the UHW3 assignment; thus, resulting in a total of 120/120 on the combination of the two HW3 assignments.

Example 2: If a student performs ‘perfectly’ on the original homework assignment and earns 100/100, they can earn 20/20 through a relatively short UHW reflection. This would result in the same 120/120 points as in the previous example.

Example 3: If a student does not submit the original homework assignment and earns 0/100, they can earn 120/20 through an exhaustive UHW reflection. This would result in the same 120/120 points as in the previous examples. Allowing this is a tradeoff that is intended to support student learning with greater flexibility. In these cases, the reflection is strongly taken into account in grading. It should be noted that this is rarely attempted and most students that miss assignments are the same students that do not later prioritize the UHW assignments.

Results and Some Successes

While the overarching goal of the work is improved learning outcomes, an initial goal was to encourage students to engage in reflective work. Students were categorized by how often they completed this secondary work: 9 or more submissions (out of 12) was considered *regular*, 4-8 submissions was considered *occasional*, and 3 or fewer submissions was considered *rare*.

In the four years that students were offered this secondary assignment as extra credit, Fall 2019 to Spring 2023, 35% of students regularly submitted it, compared to 17% who did it occasionally, and 48% who rarely submitted.

	A	B	C	DFW
Regularly	49%	25%	29%	23%
Occasionally	10%	33%	29%	13%
Rarely	41%	42%	43%	64%
Number of Students	63	24	21	39

Table 1: From Fall 2019 to Spring 2023, the percentage of students who submitted the extra credit work regularly (9+ times out of 12), occasionally (4-8 times), and rarely (0-3 times) throughout the semester based on their final exam grade: A, B, C, or someone that received a D, an F, or withdrew before the final (D/F/W).

As one may expect, the regularity of performing these secondary assignments was correlated to their performance in the class. As Table 1 shows, 49% of students that earned an A on their final exam had submitted the secondary assignment regularly. Interestingly enough, 41% of these students seemed to not feel the need to do so. The differences between the B and C students was not significant. Not surprisingly, students that did not do well on the final had not taken the opportunity to do this extra credit work as often – 64% of these students rarely (or never) did the extra credit work.

In Fall 2023, when the secondary assignment was modified to be a required Updated Homework assignment, 71% of students did the assignment regularly with only 18% doing it rarely. All students that received an A or a B on the final had regularly submitted their UHW assignments. Even the D/F/W students had an even split between regular, occasional and rare submitters.

One thing considered in this work is that the infrastructure (based on the examples provided above), is that a student could opt to not do the first assignment and then make up for it entirely in the Updated Homework. A student that did this would routinely get well over 50 points on the 20 point UHW assignment. In 148 UHW submissions, only 8 received more than 16 extra credit points. 9 had such a limited reflection, that the initial 20 points were not earned. Between those extremes, 131 students got the full 20/20 UHW points and the additional 0-15 points of extra credit to balance lost points on the original HW.

Challenges

Unfortunately, the data is not significant enough to make strong conclusions about the impact of changing the Extra Credit to a required Updated Homework. Table 2 shows the homework-only grade for the eight years where the secondary assignment was extra credit compared to Fall 2023 when it was required.

	A	B	C	D/F/W
Fall 2019-Spring 2023	84	24	16	23
Fall 2023	10	3	0	5

Table 2: Number of students with A, B, C, or D/F/W homework-only grades during the two periods of time: (a) the eight semesters where the secondary work was extra credit and (b) Fall 2023 when the secondary work was required as an Updated Homework assignment.

The Homework-only grades of A and B were actually the same percentage. It is concerning that the number of D/F/W was actually a higher percentage in Fall 2023. This could have been because the Updated Homework was considered intimidating. With small numbers, it is hard to know for sure.

So far, significant final grade changes have not been observed.

Another downside of the described model – specifically with the labs – is that students who fall behind will often prioritize the longer and slightly more valuable homework assignments and will sometimes skip the labs with the thought that they will complete them later. The flexible deadline fails to motivate some students to complete the labs in a timely manner.

Conclusion and Future Work

The primary goal of this work-in-progress paper is support (new) faculty who seek strategies that can enhance the way their students engage in formative assessments. By sharing experiences with two different approaches – and highlighting previous work – the hope is that those looking to incorporate reflection into their course have a few new ways to consider.

The fundamental conclusion, however, is that this is still a work in progress. The strategies employed accomplished the goal of increasing reflective activities by the students. However, there are too many factors to draw a significant conclusion from these results. To some degree, this work leans on the efforts of others that share that reflection pays dividends and the goal here is to increase reflection. Thus, the work will continue with an emphasis on these reflection assignments. Future work will include surveys to glean more of an understanding of how the students approached the UHW assignments and how useful they felt the secondary assignments were. Another area that could be explored is adjusting the weights of these reflective UHW assignments to further incentivize effort in this all-important area.

References:

[1] Bierman, E., Wood, T., Plumblee, J. (2019, June), Student and Faculty Perspective and Survey Results on an Innovative Homework Process Paper presented at 2019 ASEE Annual Conference & Exposition, Tampa Bay, Florida.10.18260/1-2—33290

[2] Jay, J., & Dodd, D. (2022, August), Efficacy of the Dual-Submission Homework Method Paper presented at 2022 ASEE Annual Conference & Exposition, Minneapolis, MN. 10.18260/1-2—40641

[3] Hume,, R. A., & Biggerstaff, A., & Williamson, E. B. (2023, June), The Efficacy of Student-Revised Homework Assignments in an Introductory Engineering Course Paper presented at 2023 ASEE Annual Conference & Exposition, Baltimore , Maryland. 10.18260/1-2—44449

[4] Bhatt, I., Alford, L., Begley, L., Hosseini, R. (2023, June), Piloting a Flexible Deadline Policy for a First-Year Computer Programming Course Paper presented at 2023 ASEE Annual Conference & Exposition, Baltimore, Maryland. 10.18260/1-2--43892

[5]K. M. Nickels and M. Uddin, “The impact on student learning of resubmission of work and flexible deadlines,” in 2003 GSW, 2021.