

Labor-based Grading in Computer Science: A Student-Centered Practice

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Abstract

Innovation in teaching in STEM fields was explored widely during the COVID pandemic in 2020. This paper describes the adaptation of labor based grading for computer science courses. Labor based grading has been developed for language and writing courses by shifting the grading focus from summative exams to formative and reflective assessments. The method was tested in several computer science courses with two different instructors during the 2020-2021 academic year. Students were surveyed to understand how they perceived grading methods in the course and their own level of anxiety. A total of 69 students completed the survey where 84% reported the method reduced anxiety (4 or 5 on a Likert scale). The study found that labor based grading was an effective way to reduce student anxiety, reduce academic integrity issues, and improve student motivation.

Introduction

The COVID-19 pandemic resulted in rapid changes to many aspects of higher education in STEM including the delivery of material, assessment of work, and all communication moving online. These changes upset the status quo and exposed problem areas in our traditional approaches to teaching and led us to explore a method known as labor-based grading. Labor-based grading is a methodology where student grading is focused on the level of effort they put forth in the course, rather than subjective assessment of their work by the instructor.

One problem with traditional grading is the usage of high-stakes, time-pressured assessments like exams. Pre-pandemic it was common for our courses to rely on 2-3 highly weighted in-person exams. After moving courses online during the pandemic the path of least resistance was to move these types of evaluations online. Online exams pose greater challenges as students have greater temptation and access to means of misconduct. The tools available to instructors to combat these challenges are unfortunately time-consuming and inadequate. We needed to find a way to motivate students to focus on their own learning, rather than just obtaining a specific number of points.

This challenge was the catalyst to look for new methods of grading, though there were other drawbacks of the quality based grading that we also wished to overcome. Traditional grading has been shown to propagate biased and colonial structures [1]. The focus on single submission evaluations like exams caused a great deal of anxiety among students of all skill levels and contributed to greater errors and stereotype threat [2]. Finally, assigning a one-dimensional score to a student's work is necessarily subjective and invites application of unconscious and conscious biases in grading. While these other drawbacks existed prior to the pandemic, their importance was often overlooked or underestimated.

Labor-based grading had already been applied with success in writing classrooms by Inoue [3]. Among the benefits to students observed in these classrooms; decreased anxiety in learning and assessment, greater engagement with and retention of the material, increased agency for students in their learning path, greater community building among and between students and instructors, and greater emphasis on the benefits of reflecting on one's learning.

Once our team tested labor based grading in our classes, we found immediate benefits. We designed a survey to help us understand a few key research questions.

1. Does labor based grading enhance the learning experience for the students? (improved engagement, improved environment, learning community)
2. Does labor based grading reduce student anxiety?
3. Does labor based grading improve academic integrity issues?

Background

Labor based grading is one example of a broader category of tools that are part of a shift towards “ungrading” [4]. Traditional grading is based on the idea that there is one correct response, often that of the dominant culture or viewpoint. Traditional grading systems rarely value the time and work invested in gaining knowledge, which may be very different for each student. Other grading models like mastery based grading [8], specification based grading are also alternatives to the traditional model.

In contrast to traditional grading, labor-based grading rewards students for investing time and effort to gain new knowledge or skills. The method has been well documented by Inoue [3] as a method for building equity and inclusion in the classroom. The method typically has several parts: the assignment structure or process; the time spent on the assignment; the quantity of work; and the due date for the assignment [3].

Labor-based grading is distinct from standards-based grading. Standards-based grading has been explored by a range of scholars, often with a focus on higher education applications [5]–[8]. This method is focused on assessment of student skills on specific learning objectives or topics. Often students have multiple attempts to demonstrate mastery of a specific topic or learning objective.

Most of the prior work in the literature on labor-based grading is focused on applications in writing or literature courses as shown in Table 1. While labor-based grading has consistently been shown to be valuable for students, the method has not been explored by STEM faculty prior to this work. Cowan provided a summary of student perceptions on grading and grading contracts that includes insights about how faculty might navigate transitions to new grading [9].

In the context of COVID-19 and the transition to online courses, the research team adopted labor-based grading in part to reduce student anxiety and cheating. The relationship between cheating and student anxiety has been explored by prior researchers [13], [14]. No prior works were found that explored labor based grading in STEM fields, or computer science. The present work is a unique contribution to the literature in this context.

Table 1. Summary of prior literature that focuses on labor based grading methods.

Author/Citation	Year	Class Context	Summary
Medina [10]	2018	English	Social justice pedagogy and grading contracts.
Inoue [3]	2019	English	Equity and inclusion in the context of labor based grading.
Gomes et al. [11]	2020	English	Student and faculty narratives about grading contracts.
Shubert [12]	2021	English	Pandemic based adoption of contract grading.
Present work	2021	Computer Science	Adaptation of labor based grading contracts to computer science applications.

Methods

Classroom Changes

Prior to adopting labor based grading, we used an assortment of traditional lectures with a heavy use of whiteboard, flipped classrooms, and active learning in our classrooms. The assessment methods used were individual or pair oriented without any focus on building a community based learning environment. There were two to three exams typically administered and contributed to a significant portion of the overall grade. As a result of implementing labor based grading, we instead created a learning community of three or four students to a group. The members of each group worked together on homeworks and during live lectures when exercises were assigned to reinforce learning. This improved student engagement in a virtual environment where students were isolated from each other. Students that had to work during the pandemic due to their family situation watched recorded lectures asynchronously to complete the learning logs. The labor based learning supported synchronous and asynchronous students during the pandemic while we were in virtual classrooms. The labor based learning translated well during more recent terms into the in-person learning environment allowing the instructor to accommodate students that tested positive for the virus and to continue their learning without being in the classroom.

Labor-based grading guarantees to any student that completes the assigned labors honestly, faithfully, in a reasonable time, and with a reasonable number of errors, the grade of B (3.1 on a 4 point scale). Grades higher than a B can be achieved through the completion of extra labors that expand the learning goals of the student or support the learning goals of others in our community. Grades lower than B are awarded to students that struggle to meet all the completion criteria for assigned labors, but are still able to complete them with additional help or time.

Labor-based grading replaces point based grading with a completion metric. In addition, all graded labors are equally weighted under this model. For an assigned labor to count as complete, the student must

complete it by following the instructions honestly and faithfully, but they do not need to complete the task perfectly. While this introduces a quality based metric, the bar for completion is typically lower than the bar for a perfect grade in the quality based system. This more forgiving metric is paired with the opportunity to resubmit incomplete work with corrections after it has been graded.

Assigned labors are graded in one of five categories: complete (on-time), complete (late), complete (missed), incomplete, and ignored. The categories of incomplete and ignored count as major strikes against a student and in most cases these are not permitted if a student wishes to achieve a good (and in some cases passing) grade. Completed labors are further categorized based on when the labor was completed. If it was completed satisfactorily before the assigned due date it is counted as on-time. If it was submitted after the due date but within a permitted late submission period (e.g 1 week) the labor counts as late. Finally, if it was completed after the late submission period it will count as missed. Allowing late and missed work helps alleviate out-of-class challenges faced by students that may cause them to miss an assigned labor, but more commonly they are used by students to submit corrections of work they have misunderstood the first time around.

Late and missed work are excused up to a maximum number that depends on the specific course and the amount and challenge of assigned labors. Incomplete labors are less likely to be excused but in some courses (in particular those with challenging material) we have excused a small number of incomplete labors as well. We have never excused ignored labors as ignoring assigned work is extremely detrimental to student learning.

The following methods were used to implement labor based grading:

1. Contracts: We created a collaborative labor based learning contract [Appendix A] to get students to understand this model and to get buy-in. It is modeled after the labor based grading contract [3] for writing courses tailored to work for STEM students. We experienced difficulty in getting student input and feedback on the contract initially, but we have now refined it over many iterations. The contract outlines the type of grading and what is expected of the students during the course.
2. Learning logs: The students were allowed to write learning logs reflecting on their learning experiences both in and out of the classroom. Two types of logs were used. The first type was a reflection on their learning based on the homeworks or projects that they did. The second type was a learning log in lieu of attending a live lecture or watching an asynchronous lecture. Students submitted weekly logs for the asynchronous learning and biweekly logs for the homeworks or projects that they completed. The logs were graded by the instructors for completeness. The struggles portion of the log format was used to provide additional resources or supplements. The instructors provided samples of good learning logs to help students with the content and writing. The format for the learning log can be found in Appendix C.
3. Peer Assessment: Students worked in learning groups and met weekly to engage in learning activities and problem solving. These sessions were documented to reflect on the learning that took place within the group. Students came together to discuss the grading and comments provided by the instructor and to learn from each other. The learning groups worked together on peer assessment to critique each other's work and to learn from each other.

Student Survey

To better understand the possible benefits for students, we developed a survey in Qualtrics to ask students about their experiences with labor-based grading. The survey was approved by the Institutional Review Board, and distributed to students that had completed any of the five courses that had used the methods in computer science in the last year. The survey was distributed via email by a different faculty member (not an instructor in computer science) to reduce power perceptions for students.

The survey had several questions to encourage students to provide feedback on a Likert scale. The question included a mix of labor-based grading instructional methods and more traditional classroom elements. An example is shown in Figure 1, where students were also asked to provide an essay response about learning methods with examples.

	Very Helpful	Somewhat helpful	Moderately helpful	A little helpful	Not helpful at all	Not Used in this Course
Midterms and final exams	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quizzes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Learning log/learning journal/reflections	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Class polls	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discussion board	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discord	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Homework problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Learning groups/group work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other <input type="text"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 1. Example of a Likert question on the student survey. After this question, students were asked an open-ended question, “Did any of these methods significantly enhance your learning in the class? If so, please share an example of how it helped.”

The survey included open-ended questions for students to share an example or narrative. Questions were structured to allow students to share in many ways. “Did any of these methods significantly enhance your learning in the class? If so, please share an example of how it helped.” We also asked students how labor-based grading affected their anxiety levels in the course.

Results

Classroom Structures - Instructor Reflection

Prior to adopting labor-based grading techniques our grading methods were typical of those used in most STEM classrooms. Assignments, projects, quizzes and exams were graded using numerical points

converted to percentages and then combined in a weighted average. Innovation within this model was limited to adjusting the weights of assigned work, updating rubrics or changing the kinds of work assigned. Instructors used a mix of exams, homeworks, projects, quizzes, labs, participation polls all with individual focus in core courses. In elective courses, group projects were used without any accountability for individuals and the projects were broken down into multiple parts over the quarter. Grading leaned heavily on exams in most of the courses. Participation was used up to 20% of the grade to encourage engagement during lecture. In courses with large enrollment, working in pairs on homework assignments was used in some courses.

Due to the pandemic, we moved to remote teaching where all exams were administered online. Online testing with no proctoring and access to online solutions and classmates invalidated the old methods of assessment. We experimented with creating multiple versions of the exams where the students took them synchronously. This kind of testing where there could be loss of internet connection and the creation and management of multiple versions of the tests caused a lot of anxiety for the students and the instructors. Equity issues related to mental illness and language barriers surfaced due to the online testing model. We questioned whether the old model of testing was really an effective model for measuring student learning.

We found that implementing labor based grading reduced student anxiety in learning and assessment. Students had more buy-in into their own learning and built a community among students and professors. There was increased student engagement and improved retention of the materials. Reading the student reflections in their learning logs helped us provide additional resources and a better understanding of where students struggle. During the pandemic, we could use early intervention as a result of the improved interaction between students and professors.

We were able to get timely and constructive feedback from the students from the reflective assignments to improve and adjust instruction. The most important improvement was the absence of academic integrity violations as students tend to cheat when they are short on time or when they don't understand. Our instruction shifted from sage on stage to student centered teaching. We were able to intervene early in the core courses when students were not engaged or stopped submitting reflective assignments to improve retention. The quality of questions that the students asked improved as they were allowed to engage and interact with each other.

When students submit regular reflective assignments we now benefit from regular directed feedback. The learning logs and reflections allow instructors to monitor student success with material on a week-to-week basis and with a personal touch. If most students are reporting problems with the week's material, the instructor can respond immediately with more instruction or resources. If individual students are struggling with a concept or with out-of-class challenges the instructor can provide individually focused support. This can result in greater retention of material for individual students, as well as greater retention of students in the course and program.

While it is helpful to students for instructors to get this regular feedback, it also provides help to instructors in designing or redesigning their courses. Feedback offered at the end of the quarter in the form of standardized student surveys can often be very high-level. Feedback offered in the form of free reflections is often honest, personal, and detailed.

Grading efforts are changed as well. Instead of focusing on justifying a particular point score for a solution, you can focus on advice for improvement. There is no need for subjective rubrics, the evaluation of complete/incomplete is often immediate, which opens more time to give direct, focused feedback to each student.

These techniques are student centered, putting the focus on student learning, as well as placing more of the responsibility in the hands of the student. In addition, the techniques emphasize communal learning over individual learning, meaning students rely more on one another for support, which reduces instructor workload and improves the quality of queries students pose.

Survey Results

A total of 69 students completed the survey from the five courses, but many of the students had completed more than one course. They represented 26% of the possible 268 respondents (not counting overlaps). Most of the responses (58%) were from students that had taken a more recent spring course.

Students were asked how helpful specific class methods were for helping them learn material in the course. Learning logs/journals were given high marks by the students, as were the learning groups as shown in Table 2. Both of these methods are key elements of labor-based grading. Students were also asked to share examples of how the learning methods helped them. A word cloud summary is shown in Figure 2, where group work is again highlighted.

Table 2. Summary of student responses to the prompt, “How helpful were each of these methods for helping you learn material in this class?” with Likert options from 1 to 5. Items associated with labor based grading are shown in bold.

Class Methods	Mean	Standard Deviation	Number of Responses (N)
Midterms/Exams	2.47	1.14	19
Quizzes	1.75	0.90	57
Discussion board	2.33	1.35	46
Learning logs/Journals	2.21	1.31	66
Class polls	1.63	1.05	46
Discord	1.49	1.02	51
Homework	1.47	0.78	62
Learning groups	1.70	1.10	66
Other	1.56	1.26	9

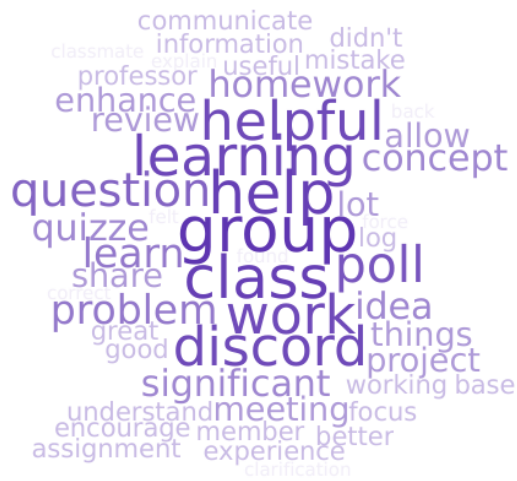


Figure 2. Student response summary for, “Did any of these methods significantly enhance your learning in the class? If so, please share an example of how it helped.”

Students were asked about how the labor-based grading had affected their anxiety in the class and pressure they might feel to cheat. As shown in Figure 3 and Figure 4, the students expressed the strongest agreement with reduction in anxiety. 84% responded with a 4 or 5 on the Likert scale for reduction in anxiety.

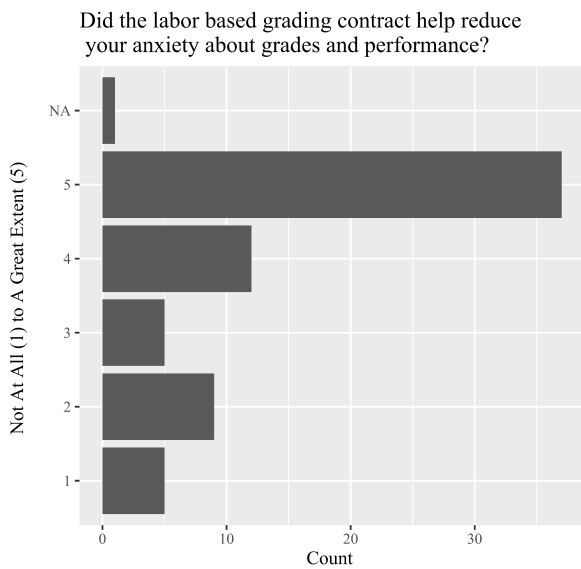


Figure 3. Student response summary for, “Did the labor based grading contract in this class help reduce your anxiety about grades and performance?”

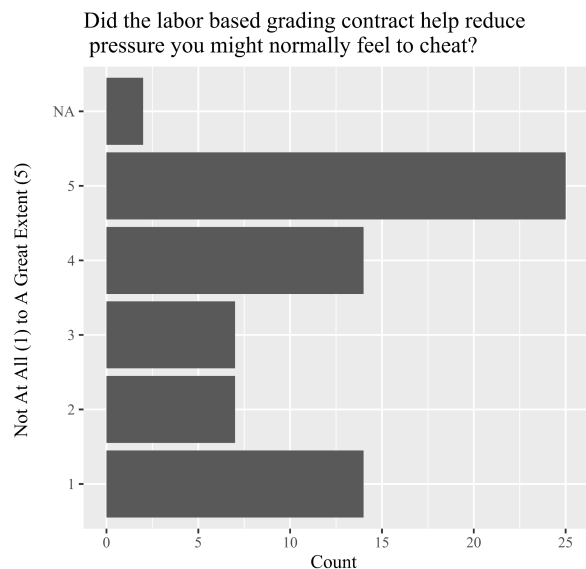


Figure 4. Student response summary for, “Did the labor based grading contract reduce pressure you might normally feel to cheat?”

Students also indicated that they felt a reduction in pressure to cheat, with 58% selecting the strongest Likert values. The mean was 2.57 with a standard deviation of 1.57. The student reaction was not as strong as the reduction in anxiety. This makes sense, many students wrote in the comments that they did not normally feel any pressure to cheat, so there was no change for the new grading method. However for students that might normally feel pressure to cheat, the reduction could be significant.

Student Comments Summary

Student comments were very insightful about how they perceived the change in the course. A summary of student responses by question are shown below.

Question: Do you have an example of how your anxiety level in this course might be different than other science courses you have taken?

- “Whenever my imposter syndrome took hold and I was feeling like a failure and anxious over new material because I struggled with the previous section, I would remind myself about the labor based grading contract and it did help a bit.”
- “Typically exams are very high stress for me. I tend to struggle with the time constraints and the necessity to perform, likely owing to my generalized anxiety disorder and OCD (diagnosed while deployed to Afghanistan).”
- “I feel a lot of pressure during exams because I am trying to maintain a (roughly) 4.0 GPA to help my odds of getting into grad school. On many exams, even missing a single question on a single exam can be enough to make a 4.0 nearly impossible to obtain. This class moved the measure of my performance from how well I "learned" the assigned material to how deeply I explored the course topics on my own in a semi-structured environment. I found it to be a very rewarding experience, and it helped boost my confidence in my skills as a computer scientist, since I was forced to apply them in new ways that I may not have in a more "traditional" setting.”

Question: Do you have an example of how the pressure to cheat in this course might be different than other science courses you have taken?

- “There was no pressure to cheat because we just had to do our best in order to succeed. It made people collaborate more and help each other out with answering questions since there wasn't as much pressure.”
- “I spent more time trying to understand and reviewing concepts than just trying to get correct answers.”

Question: Do you have anything else you would like to share with us about the grading and assessment process in this class?

- “I am extremely grateful for the passion that instructors experimenting with labor-based grading have for my learning. I feel that the degree of work required in a labor-based course is the same if not more than a course with a more conventional style. This being said, labor-based courses have encouraged me to step out of my comfort zone with my responses to questions, and I no longer

obsess over the small technicalities of specific problems and instead focus on the core ideas of concepts presented.”

- “By far the best class I’ve ever taken and I would take any course regardless of content if a labor based contract was implemented. Because I know that I would learn at my absolute best when I don’t have to worry about potentially failing a course if something went wrong during a exam/quiz/assignment.”
- “I deeply hope that labor based grading is the future. It allows students to focus on doing the work rather than on the grade. In all my experiences with it, my peers and I have always agreed that it probably results in a more effective learning environment in every way.”

Conclusions/Discussion

We are further shaping our pedagogy based on our experiences with labor based grading and are pleased with the current implementation. This model helped transition into the back to the classroom teaching in recent terms where the principles can still be applied for improved engagement and retention.

Research Question: Did labor based grading enhance the learning experience for the students? (improved engagement, improved environment, learning community...)

Student survey responses confirm that they believe this grading method allowed them to shift away from a focus on collecting points and focus instead on learning. They reported that the learning groups offered significant benefits, and they believed the learning logs/journals were also helpful for the course. Instructors observed that students demonstrated increased agency for their own learning and significantly increased engagement.

Research Question: Did labor based grading reduce student anxiety?

Student comments and responses overwhelmingly confirmed that this grading method reduces anxiety. The majority of students agreed or strongly agreed that the method had reduced anxiety. Faculty observed the same reduction in anxiety, and confirmed it with review of student comments. This finding is important since reducing anxiety and supporting mental health in students is important to crafting student-centered classroom practices.

Research Question: Did labor based grading improve academic integrity issues?

Student responses about academic integrity were not as clear as those about anxiety, but it is clear that many students do believe this method of grading reduces student cheating. Instructors observed that the reduction in anxiety and the contract for grading shifted the focus to learning so effectively that little incentive for cheating remained for students.

Our research team has found labor based grading to be a useful and effective method for shifting the balance in our classrooms toward “ungrading”. Labor-based grading provides a flexible structure for aligning traditional grade scales with a learning focused approach. The frequent feedback in learning

journals provides a way to reflect and improve classes quickly, while also offering metacognition benefits to students.

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Appendix A: Labor-based Grading Contract

OVERVIEW

- Your **labors** will be graded as **complete (on-time, late, missed)**, **incomplete** or **ignored**.
- If you **complete** all assigned **labors** in this course you will earn a **base grade** of 3.1.
- Your **base grade** may drop to 2.1, 1.1 or 0 if you accumulate too many **late, missed, incomplete** or **ignored** labors (the details can be found in the Grading Matrix document).
- You can earn 0.3 boosts to your grade by completing **extra labors** (the details can be found in the Extra Labors document).

GLOSSARY

- **labor** - an assigned work like a programming assignment, math assignment, written assignment, quiz or survey
- **base grade** - your grade before applying boosts from extra labors
- **complete** - you have followed the instructions on your labor and not made any major mistakes
- **on-time** - your labor is complete and was submitted before the due date
- **late** - your labor is complete and was submitted within seven days after the due date
- **missed** - your labor is complete and was submitted more than seven days after the due date
- **incomplete** - you failed to follow the instructions or made major errors in your labor
- **ignored** - you did not submit your labor
- **extra labor** - an optional labor that if completed will boost your final grade

CONTRACT

You are guaranteed a base grade of 3.1 if you meet all of the following conditions.

- **Participation.** You agree to participate in all course activities including:
 - Reading course syllabus and other documents and watching course welcome videos.
 - Attending all lectures or viewing all lecture videos.
 - Staying on the weekly pace to the best of your ability.
 - Attempting and completing all assigned labors.
 - Attending all learning group meetings.
 - Reading and/or asking questions in the Discord discussion board.
 - Seeking help from your peers and instructor when you are stuck.

We all may miss an obligation from time to time, but in such cases we should make up the labor as soon as possible. If you are anticipating missing an obligation it is a good idea to reach out to your learning group and instructor to alert them and ask for support.

- **Sharing and Collaboration.** You agree to work cooperatively and collegially with your classmates. You agree to listen and respond to your classmates with honesty and compassion during discussions in and out of class.

You agree to meet every week with your learning group and to meet your weekly obligations to your learning group to the best of your abilities. You agree to review the work of your group mates with compassion and a genuine aim to help them improve their understanding

and skills. You agree to listen with compassion to your group mates' suggestions and recommendations to improve your own work.

You agree to ask questions of your learning group when you are stuck or don't know how to get started on a labor. You agree to help your learning group with their learning challenges whenever you can by helping them improve their understanding.

- **Complete/Incomplete Labors.** You agree to turn in complete work, which means making an honest attempt to solve every problem assigned and to follow the labor instructions for each assignment faithfully. Your solutions *do not* need to be perfect for your work to count as complete. We all make mistakes and this is a common way we learn. In the event that you have submitted work that has been graded incomplete you are able to resubmit it with corrections. If you correct your errors your incomplete work will be upgraded to complete (though will count as late or missed as normal).

Labors may be considered incomplete if you fail to follow all instructions faithfully. Make sure you put aside time to review the labor instructions before you complete your assignments, and review them again after completing to make sure you have followed them properly.

You are permitted some number of incomplete labors (the exact number is in the Grading Matrix document).

- **On-Time/Late/Missed Labors.** You agree to complete all of the labor instructions for each assignment to the best of your ability and at the pace of the class. If you complete your labor before the due date your solution will be graded **complete** and **on-time**.

If you manage to complete your labor after the due date, but within seven days, it will still count as **complete**, but will also count as **late**. You are permitted some number of late labors (the exact number is in the Grading Matrix document).

If you manage to complete your labor more than seven days after the due date it will still count as **complete**, but will also count as **missed**. You are permitted some number of missed labors (the exact number is in the Grading Matrix document).

- **Ignored Work.** You agree not to ignore any work expected of you. Ignored work is any work unaccounted for in the quarter. Accumulating any ignored work will keep you from meeting our contract expectations and will jeopardize your base grade.

Grading Matrix

This quarter you will be asked to complete 37 mandatory labors. You are expected to complete the labors on-time. You are permitted to complete some labors late or missed (see the Labor-based Grading Contract for more details). Below is a table that shows the maximum number of solutions you may have in each category in order to achieve the base grade indicated.

Base Grade	Late	Missed	Incomplete	Ignored
A (4.0)	4	4	2	0

B (3.1)	4	4	2	0
C (2.1)	6	6	4	0
D (1.1)	8	8	6	1

Note: The 4.0 and 3.1 rows are identical because to achieve a 4.0 you must first satisfy the conditions of a 3.1 and then complete the requisite number of extra labors.

Note: Incomplete and ignored extra labors do not count in this calculation. Late and missed extra labors only count in this calculation if you also have earned credit for them.

Appendix B: Learning Logs

The format for the learning log is as below:

Start date:

Start time:

Resources used:

Struggles:

Wins:

Distractions:

End time: