

Mandatory or Voluntary Course Work in Introductory Programming Courses?

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Abstract. Which approach, mandatory or voluntary weekly labs, is more conducive to student learning? We conducted a quasi-experiment in a bachelor level programming course (CS2) at the Department of Informatics at the University of Bergen. The course had maintained consistent structure, content, and faculty for the past two iterations, with one key distinction: in 2022, the weekly labs were made mandatory (n=265), whereas in 2021 they were voluntary (n=311). We compared student performance, retention, stress levels, and satisfaction between the two iterations.

Our findings revealed that in the semester with mandatory labs, students demonstrated significantly better performance on an end-of-term assignment that was nearly identical for both iterations of the course. We also observed a slight increase in the retention rate for students who participated in the final exam, but this difference did not reach statistical significance.

Regarding stress and workload, we employed a mixed-methods approach, utilizing both qualitative and quantitative data collected through surveys to gauge students' experience with mandatory versus voluntary assignments and how it impacts their workload. The responses revealed that students who had not experienced mandatory assignments expressed concerns about being overwhelmed with workload. However, students who had actually gone through the mandatory workload found it manageable and even viewed it as a positive aspect of their overall learning experience in the course.

Finally, we compared the end-of-term anonymous course evaluations between the two years, and found no statistically significant difference in course satisfaction between the two iterations.

Keywords: Mandatory vs Voluntary · Introductory Programming · CS2 · Didactics · Scholarship of Teaching and Learning

1 Introduction

As instructors we wish for students in our courses to work consistently throughout the semester, engaging in learning activities for every part of the curriculum. However, this goal is not easily achieved. Students often procrastinate their efforts until the crucial moments of the course: before graded assignment deadlines and the final exam. In order to mitigate this, a course instructor could decide to make the weekly labs in their course mandatory. But is introducing more deadlines actually benefitting the students?

According to John Biggs, the quality of learning is low under extrinsic motivation, such as having labs be mandatory. In his *What the student does: teaching for enhanced learning* [1] he states:

“Often, attempts to create a felt need to learn, particularly through ill-conceived and urgent assessments, are counter-productive. The game then becomes a matter of dealing with the test, not with engaging the task deeply.”

A better option is catering to the students’ *intrinsic* motivation, Biggs argues, where the student is motivated by the enjoyment of and interest in doing the course work itself. This form of motivation drives deep learning and yields the best academic work [2, chapter 3].

The terms *intrinsic* and *extrinsic* motivation are terms we find in the expectancy-value theory of motivation [3]. According to this model, anyone who engages in an activity needs to both value the outcome (subjective task value) and also expect success in achieving it (expectancies for success). Subjective task value is divided into four types, including the aforementioned intrinsic and extrinsic motivations. Extrinsic motivation occurs when students perform the task because of the value or importance they attach to what the outcome brings; for example, if a student engages in a learning activity because they want a good grade. Intrinsic motivation, on the other hand, occurs when someone performs a task because they are interested in the task itself; for example, if a student engages with the course material due to the intellectual pleasure of problem solving and exercising their skill, independently of any rewards that might be involved.

In the programming course which is the subject of this study, we expect the vast majority of students to have at least some intrinsic desire to learn the material, since it is either one of the most central courses in their study, or a course they chose voluntarily. However, we recognize that our students also have many other tasks that they for various reasons are motivated to perform. We therefore wish to motivate our students through our course design as well.

While intrinsic motivation is more conducive to student learning, it is not easily achieved. It is hard to create course materials that induces such motivation in all students. Meanwhile, providing extrinsic motivation to students *is* easy; forcing students to complete course work by having the labs be mandatory amounts to extrinsic motivation, and costs essentially nothing in terms of instructor time (at least when the labs are graded automatically).

To study the effects of mandatory versus voluntary labs we conducted a quasi-experiment in the course *Algorithms, Data Structures and Programming* (INF102). The course had the exact same curriculum and held a very similar structure for two consecutive years: fall 2021 and fall 2022. The only major difference was that the weekly labs were voluntary in 2021 and mandatory in 2022. To assess the differences in student learning we compared the two student groups. Onward, we will refer to the semester that had voluntary weekly labs in 2021 as *semester (i)* and the semester which had mandatory weekly labs in 2022 as *semester (ii)*.

1.1 Research questions

To assess the benefits and drawbacks of having mandatory weekly labs we asked the following research questions:

- **RQ1:** Does having mandatory weekly labs affect student performance?
- **RQ2:** Does having mandatory weekly labs affect student retention?
- **RQ3:** Does having mandatory weekly labs affect student stress?
- **RQ4:** Does having mandatory weekly labs affect course satisfaction?

2 Related work

There have been several studies investigating the effect of introducing different extrinsic motivators to university courses, such as tasks that contribute to the final grade of the course and mandatory homework. It is, however, impossible to draw any one conclusion across all the studies, as they show greatly varying results. On the one hand, there are studies that show improved engagement and performance in summative assessments throughout the course when introducing such motivators:

- Shaker, Brignell, and Pugh [12] conducted an experiment on incentivized engagement among second-year undergraduate students enrolled in a Statistics and Engineering module. In this study, students were encouraged to participate in a weekly reading activity, where engagement did not contribute towards their grades during the first half of the semester, but did so in the second half. The findings revealed that incentivization effectively increased the engagement levels of students who had previously shown lower engagement with the reading activity. Moreover, for those students who exhibited lower engagement and subsequently performed less satisfactorily in summative assessments, the introduction of incentives led to an improvement in their overall academic performance. However, the effect of incentivisation appeared to be neutral or even negative for the groups who were already performing well, although this could potentially be linked to the student's motivational style.
- Holden and Burazin [8] support the theory that mandatory activities have performance boosting effects. In their study, they found that in a university mathematics service course, students performed 6% better on tests if they had mandatory assignments compared to if they had voluntary assignments and the offer of extra office hours to get feedback on these assignments.

Some studies only support the theory that extrinsic motivators contribute to increasing engagement, and not performance; Gutarts and Bains [4] found in their study that students in a university calculus course tend not to finish assignments unless they are graded, but found no significant difference in test scores between the group with mandatory assignment compared to a group with weekly (ungraded) quizzes. There are also studies that undermine the positive effects of extrinsic motivators:

- Haugan, Lysebo and Lauvås [6] argues that mandatory coursework assignments should be eliminated, and find that voluntary formative assessment through peer review yields better results in terms of time spent studying, grades and failure rates.
- A similar result is found in a later study conducted by Haugan and Lysebo [5]. Here, the mandatory activities in the course were replaced with four voluntary activities: planned lectures, weekly homework with clear expectations regarding learning outcome, planned groups where students could receive help with the homework, and a peer assessment at the end of the lecture to receive feedback. Some students were chosen as interviewees, with a prior knowledge test having been conducted to ensure a diverse group. Many of these students reported higher, as well as intrinsic, motivation, although this could be coloured by the fact that most other parallel courses heavily relied on mandatory activities, and that these students were tired of this structure. The fail rate of the subjects in the study were also significantly reduced, although this could be accounted for by a number of other factors as well. It is, however, promising that students with low prior knowledge who still performed well on the final exams reported that they greatly enjoyed the course structure. These students especially reported that the voluntary nature of the course activities made it possible for them to prioritize tasks in a way that was not possible in other courses.
- Another study that finds mandatory assignments to negatively affect performance in students is by Peters, Kethley and Bullington [11]. They conducted a quasi-experiment in an undergraduate business management course where some sections in their course had graded assignments contributing to 15% of their final grade, whereas the other sections received the same problem set as a voluntary practice problem which did not contribute to their final grade. They found that students who had graded assignments performed significantly *worse* than their ungraded counterpart on the final exam, in particular on the qualitative questions on the exam.

3 Background

3.1 Course structure

At the Department of Informatics at the University of Bergen the course *Algorithms, Data Structures and Programming* (INF102) is the third introductory course following *Introduction to Programming* (INF100) and *Object-oriented programming* (INF101). INF101 and INF102 collectively covers the curriculum of what is traditionally referred to as CS2 [7]. INF102 awards 10 ECTS credits and is one of three courses taken in the third semester for most students at the department.

The course had a very similar structure in semester (i) and semester (ii). Each week is composed of two lectures and one group session where 20–30 students gather and can get help with course work from group leaders.¹ The curriculum has remained the same for both years. The only difference lies in the course work:

- **Semester (i)**
 - Fall semester of 2021
 - 1 mandatory (auto-graded) first lab.
 - 4 *voluntary* labs (auto-graded but not contributing to final grade).
 - 2 manually graded assignments. Students must pass with at least 6 out of 15 points in order to take the exam, and the grade of each such assignment contributes 15% of their final grade in the course.
 - Final exam.
- **Semester (ii)**
 - Fall semester of 2022
 - 1 mandatory (auto-graded) first lab.
 - 6 *mandatory* (auto-graded) labs. Students must pass at least 5 out of 6 of these labs in order to take the final exam, but otherwise they do not contribute to the final grade.
 - 2 manually graded assignments. Students must pass with at least 6 out of 15 points in order to take the exam, and the grade of each such assignment contributes 15% of their final grade in the course.
 - Voluntary ungraded mock exam (this contained the same questions as the exam from semester (i)).
 - Final exam.

The content of the labs were slightly different, but covered the same aspects from the curriculum both years.

4 Methodology

To answer the research questions posed we have collected and analyzed the following data. For **RQ1** (“*Does having mandatory weekly labs affect student performance?*”) we collected and compared the results of assignment 1 and 2. We also held a mock exam in semester (ii) with the exam tasks from semester (i) to compare the two groups.

For **RQ2** (“*Does having mandatory weekly labs affect student retention?*”) we compared the number of students that participated in the course at the start of the term and how many took part in the final exam, for each semester. Here we consider a student as a participant of the course if they handed in the first (mandatory) lab. The task was simply to submit their username using the software tools utilized in the course. Ample technical help was available if someone had any issues they needed to resolve. Hence, no student who seriously intended to participate in the course would fail this lab. If a student signed up to the course, but did not hand in this lab we consider them as non-participant who was not actually intending to partake in the course.

¹ A group leader is a student studying a bachelor or masters, who has a paid part time position in a course which they finished one or more years earlier.

For **RQ3** (“Does having mandatory weekly labs affect student stress?”) and **RQ4** (“Does having mandatory weekly labs affect course satisfaction?”) we employed a mixed-methods approach, utilizing both qualitative and quantitative data collected through surveys to gauge students experience with mandatory versus voluntary labs and how it impacted their workload. We had two separate surveys for semester (i) and semester (ii), each tailored to the respective course setup. In addition, the department administration issues a standard end-of-term course evaluation which asks the students about course satisfaction. We compared responses for the two semesters. All surveys were administered in Norwegian, and both survey items and their responses cited here have been translated to English by the authors.

5 Results

5.1 Student performance

Assignments The students had three course activities that were evaluated and counted towards the final grade: assignments 1 and 2, and the final exam. The student scores on the assignments from the two iterations of the course are found in Table 1.

Table 1: Sample size, mean and standard deviation of the assignment scores. Maximum score was 15 on both assignments.

Assignment 1	Semester (i)	Semester (ii)	Assignment 2	Semester (i)	Semester (ii)
n	256	224	n	226	203
Mean	9.995	11.364	Mean	12.226	12.788
Std. dev.	2.746	2.742	Std. dev.	2.806	2.295

The mean score of both assignments was higher in semester (ii). However, assignment 1 was regarded by the course instructors as slightly easier in semester (ii) than semester (i). Hence, the improvement in mean score may be caused by the difficulty of the assignment rather than an improvement in student learning.

For assignment 2 this was not the case. The assignment was very similar to the year before (only a few changes to the assignment text). While the improvement in score was lower than that of assignment 1, an independent two-tailed student t-test showed significant difference, $t(427) = -2.257, p = 0.024$.

Mock exam To assess the difference in performance on the final exam we had the issue of the exam tasks being different for the two semesters, and that they might not have been the same difficulty. In an attempt to do a comparable end of term assessment of student performance we held a mock exam for the students in semester (ii) with the same questions as the exam from semester (i). The idea was to compare the two student groups by looking at their performance on the same exam tasks. Usually all previous exams in the course are made available to the students, but this time the exam was not published. The mock exam was held one week before the final exam, with the same conditions as the year before.² We only looked at the auto graded tasks of the exam. The first six tasks were multiple choice and completion tasks. These were graded with the exact same rubric both semesters. We added a question where we asked the students if they had seen these exam tasks before, in the case that some older students had sent them their exam. All those who responded “yes” were omitted from our data set. The results are shown in Table 2.

² Amount of time, access to aids, exam distribution application and rules for communication (only with course instructor and exam guards).

Table 2: Mean results of final exam in semester (i) (n=210) and mock exam in semester (ii) (n=95).

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Total
Final exam (i)	2.8	3.1	2.0	2.7	2.2	7.9	20.7
Mock exam (ii)	2.2	2.1	1.3	2.5	1.5	5.5	15.5

The mean score for each task (apart from task 4) and the total score was lower in semester (ii). This could suggest that these students learned less than the semester (i) students. However, this might not be the explanation. The mock exam took place a week prior to the official final exam. Based on our past observations, it has been noted that the seven days leading up to the final exam can result in substantial learning for students in any course. Furthermore, the difference in diligence exhibited by students when approaching a practice exam as opposed to a real examination is a significant factor that should not be overlooked. The time spent by each student per task was collected through the exam distribution application.³ For the mock exam in semester (ii), students spent an average of 44 minutes on the multiple choice tasks whereas for the final exam in semester (i) students spent 62 minutes.

Following this observation we have to discard the mock exam as a measure of student performance between the two iterations of the course.

5.2 Student retention

For the two semesters we collected data on how many signed up to the course and how many participated in the final exam. In addition, we have numbers on how many submitted the first weekly mandatory lab. These numbers can be found in Table 3.

Table 3: Student retention (submitted something on the final exam).

Semester (i)	n	%	Semester (ii)	n	%
Signed up to the course	325	–	Signed up to the course	284	–
First lab	311	100	First lab	265	100
Submitted final exam	207	67.5	Submitted final exam	192	72.5

As stated in the methodology we consider a student a participant of the course if they handed in the first lab. This lab was mandatory in both semesters. The difference in retention between the two years was 5 percentage points, losing 32.5% in semester (i) and 27.5% in semester (ii). However, using Chi-Square test of independence (without continuity correction) this difference was not significant, $\chi^2(1, N = 576) = 2.334, p = 0.126$.

5.3 Student experience and stress

To gauge the student’s experience with having the weekly labs be mandatory and what effect it had on stress, we issued a survey for both groups. The surveys contained many of the same questions, with some being tailored for the assignment scheme of that year. Each survey asked questions about the work load and general experience with the course. The students of semester (ii) received the survey two weeks before their final exam. The students of semester (i) received the survey one year after completing the course.

³ Inspira: <https://www.inspera.com/>

Table 4: Answers to the prompt from semester (i) (n=15) and semester (ii) (n=56).

“I want weekly labs in INF102 to be mandatory”

Semester (i)	n	%	Semester (ii)	n	%
(1) Disagree	4	26.6	(1) Disagree	1	1.7
(2) Somewhat disagree	5	33.3	(2) Somewhat disagree	6	10.7
(3) Neutral	3	20	(3) Neutral	7	12.5
(4) Somewhat agree	2	13.3	(4) Somewhat agree	8	14.2
(5) Agree	1	6.6	(5) Agree	34	60.7
Mean score	2.4 / 5.0		Mean score	4.2 / 5.0	

Both semester (i) and semester (ii) were prompted with the statement *“I want weekly labs in INF102 to be mandatory”* (results in Table 4). Semester (i) students had mostly a negative attitude to this statement, receiving a 2.4 out of 5.0 mean Likert scale score. In contrast, students in semester (ii) had a very strong positive attitude, yielding a mean Likert scale score of 4.2.

Table 5: Answers to the prompt from semester (i) (n=15) and semester (ii) (n=56).

“The workload in INF102 affected my efforts in the other courses this semester”

Semester (i)	n	%	Semester (ii)	n	%
(1) Disagree	2	13.3	(1) Disagree	13	23.2
(2) Somewhat disagree	4	26.6	(2) Somewhat disagree	7	12.5
(3) Neutral	3	20	(3) Neutral	8	14.2
(4) Somewhat agree	3	20	(4) Somewhat agree	20	35.7
(5) Agree	3	20	(5) Agree	8	14.2
Mean score	3.0 / 5.0		Mean score	3.1 / 5.0	

Both student groups were prompted with the statement *“The workload in INF102 affected my efforts in the other courses this semester”* (see results in Table 5). The two groups had similar attitude distributions on this statement, both having close to the same mean Likert scale score.

Table 6: Answers to the prompt from semester (i) (n=15).

“If the labs in INF102 were mandatory, it would be too much work.”

Semester (i)	n	%
(1) Disagree	0	0.0
(2) Somewhat disagree	3	20
(3) Neutral	4	26.6
(4) Somewhat agree	4	26.6
(5) Agree	4	26.6
Mean score	3.6 / 5.0	

The students in semester (i) were prompted with *“If the labs in INF102 were mandatory, it would be too much work”* (see results in Table 6). They lean towards the opinion that it would be too much work (mean Likert scale score of 3.6) even when they only had 4 labs instead of the 6 that semester (ii) had.

When asked *“why/why not do you want weekly labs in INF102 to be mandatory?”* we received a number of positive responses from the students of semester (ii):

Answer: Agree.

I want them to be mandatory because it is very easy to fool yourself into thinking you know an algorithm, but fall short when you actually implement it.

Answer: Agree.

It helps you keep up with the curriculum.

Answer: Agree.

I want them to be mandatory because if they weren't, you often forget to work on them if, for example, you have a submission in another course. You thus get more motivation to start earlier with tasks, in addition to getting consistent learning every week.

Answer: Agree.

Compulsory weekly assignments are good motivation to work steadily with the course all the way through. This is good as long as the assignments are not too extensive/difficult, so that it does not interfere with other courses being taken in parallel. More extensive/difficult assignments should be part of the assignment that counts towards the final grade. I think the course instructors found a good balance there.

We also received some more negative responses:

Answer: Disagree.

I enjoyed the labs but the fact that they are compulsory made them stressful, and sometimes my focus was into passing them (because it was Friday already) not in implementing the best solution. I think that making them optional but graded (at least with 1 point each), most of people will still do them but without feeling "I can't take the exam if I don't pass it".

Answer: Somewhat disagree.

A lot of work leads to a lot of stress and the fact that the work does not always bring good profits. Very strict requirements for rigid automatic tests which mean that if you have not understood 100% of what is being asked about/how the lecturer intends for you to solve it, it just doesn't work and you don't pass the compulsory course. Support that it should be mandatory but I think it should be in a different format.

Answer: Somewhat disagree.

It affects other work. For instance reading and acquiring knowledge in other ways. Often it has just become "firefighting", meaning that you have to rush to finish in order to then start mandatory studies in another course. Which I don't think leads to good learning.

Table 7: Answers to the prompt from semester (ii) (n=56).

"Mandatory labs meant that I did not have time to do other reading/work in INF102."

Semester (ii)	n	%
(1) Disagree	21	27.5
(2) Somewhat disagree	6	10.7
(3) Neutral	10	17.8
(4) Somewhat agree	13	23.2
(5) Agree	6	10.7
Mean score	2.6 / 5.0	

The students of semester (ii) had a mixed attitude to the statement *"Mandatory labs meant that I did not have time to do other reading/work in INF102"* (results in Table 7), having a mean Likert scale score of 2.6.

5.4 Student satisfaction and time usage

The administration at the Department of Informatics at the University of Bergen issues an end of term evaluation in all courses for the students to fill out. In this evaluation the students are asked to self-report their average time spent on the course per week (Table 8), as well as grading the instructors (see Table 9) and the course as a whole (see Table 10).

Table 8: Average time spent per week.

Semester (i) (n=40)	10.5 h/week
Semester (ii) (n=41)	12.7 h/week

Table 9: Answers to the prompt from semester (i) (n=40) and semester (ii) (n=41).

“What grade would you give to the teacher(s)?”

Grade	Semester (i)	Semester (ii)
(5) A	22	23
(4) B	13	13
(3) C	2	5
(2) D	2	0
(1) E	1	0
(0) F	0	0
Mean score	4.31	4.41

Table 10: Answers to the prompt from semester (i) (n=40) and semester (ii) (n=41).

“What grade would you give the course?”

Grade	Semester (i)	Semester (ii)
(5) A	14	16
(4) B	21	17
(3) C	4	6
(2) D	1	1
(1) E	1	1
(0) F	0	0
Mean score	4.12	4.12

With the Mann-Whitney U two-tailed test we found no statistical difference in either evaluation of teachers ($z = 0.142$, $p = 0.888$) or course ($z = -0.088$, $p = 0.928$). Qualitative responses to *“What did you like the most about the course?”*, *“What did you like the least about the course?”*, *“Do you have suggestions on how the course can be improved?”*, *“What did you like the most about the course?”* and *“Feedback on organized practical teaching”* yielded a mixed bag of both positive and negative comments for both years. We received no outlying responses that indicate a preference between the two semesters.

6 Discussion and conclusion

Our analysis of the mandatory assignment scheme has revealed positive effects on the majority of the students, with no apparent negative consequences. Specifically, we observed an improvement in performance during semester (ii) on the second assignment, indicating an enhancement of learning outcomes in comparison to previous iteration of the course. However, a potential concern arises when the same assignment is used consecutively over multiple years, as it increases the risk of plagiarism. Three students in semester (ii) were caught engaging in plagiarism by using the sample solution from the previous year. Consequently, their submissions were excluded from our data set. While the extent of plagiarism occurrences remains unknown, it is essential to acknowledge this issue. It is worth noting that the second assignment was also utilized in 2020, one semester prior to semester (i). Although no instances of plagiarism were detected among semester (i) students, the same possibility of sample solution sharing existed, posing a similar risk as in semester (ii).

We observed no significant difference in student retention rates, indicating that the implementation of the mandatory assignment scheme did not lead to an increased percentage of students dropping the course.

The survey responses from semester (ii) regarding the student experience with the mandatory assignment scheme were predominantly positive. The majority of students agreed with the statement *“I want weekly labs in INF102 to be mandatory”*, with several qualitative responses highlighting the belief that it serves as an effective means to maintain consistent work throughout the semester. Regarding concerns about being overworked due to the assignment scheme, these students expressed a neutral attitude. They did not perceive it as significantly impacting their efforts in other courses or their ability to engage in additional reading or work within the course.

The students in semester (i) exhibited a more negative attitude towards the mandatory work. They disagreed with the statement *“I want weekly labs in INF102 to be mandatory”* and concurred with the statement *“If the labs in INF102 were mandatory, it would be too much work”*. However, it is important to consider certain factors that may have influenced these responses. Firstly, the sample size was small, consisting of only 15 students. Additionally, the survey was administered one year after the completion of the course, which might have resulted in differing opinions compared to when they were actively taking the course. While these responses may not be fully representative of the entire student group, it is worth noting that when comparing them to the responses from semester (ii), they indicate a fear among students of being overwhelmed with excessive workload. However, upon actually experiencing the assignment scheme, students in semester (ii) found it to be beneficial for their learning.

There was no discernible difference in course satisfaction between the two iterations. In both years, the majority of students expressed high satisfaction with both the course instructor and the course overall. As with retention, the inclusion of additional mandatory course work did not result in a reduction in course satisfaction.

We see that students spent on average 2.2 hours more on the course per week in the semester when assignments were mandatory. We know that how much time one spends on a subject is one of the most important factors for academic success [10]. We deem it likely that the performance increase we see in semester (ii) is explained by this difference.

From these results we postulate a use for mandatory weekly work for certain students. Biggs [2, chapter 3] asserts that extrinsic conditions often result in low-quality learning by promoting a shallow approach. What type of approach to learning the students adopted during this semester, shallow or deep, was not clear from the data collected. Nevertheless, there has been a noticeable improvement in student performance. Following Expectancy-value theory [3], if anyone is to engage in an activity they need to value the outcome. While some students may possess intrinsic motivation, others may lack this driving force for engagement. Having predominantly an extrinsic motivation where the reward is far in the future may be a particularly poor form of motivation, which may easily lead to procrastination. Consequently, the mandatory assignment scheme was introduced as an inexpensive measure to support our students with limited intrinsic motivation. By incentivizing students who are otherwise disinclined to work, external rewards may foster their

engagement. In light of the findings of Shaker et al. [12], we postulate that the increase in student performance we have registered is found in this group of students.

6.1 Weakness

A weakness of this quasi-experiment lies in the variation of how the course is taught each year. As mentioned, there were a lot of aspects of the course that remained the same between the two semesters, such as faculty, structure and content. However, every year there are minor changes. We find these in how the course material is presented in lectures and assignments. Slight alterations to the slides and presentation in lectures, as well as changes to exercises is something that will always happen in new iterations of the course. Small changes are always made in an attempt to better the learning experience. These minor changes could contribute to the differences between the two groups presented in our results. As these are minor changes we do not have a comprehensive overview of them, and cannot attribute any positive or negative effects of them to our students.

In our statistical analysis, we have not taken into consideration the differences between our student bodies. A finer analysis would factor in differences such as pretest scores, age, math experience, academic family background and so on. These factors can impact a student's motivation and ability to perform well in a given course.

6.2 Further work

Although no apparent negative effects were found in our selected measurements, we did observe certain negative reactions which we wish to mitigate. In the responses to the semester (ii) survey on course experience 5 out of 47 students mentions stress in regards to the assignment scheme:

"I enjoyed the labs but the fact that they are mandatory made them stressful..."

"A lot of work leads to a lot of stress..."

"...Then the course quickly becomes more stressful and confusing, rather than fun and instructive."

"I felt that the lab between the two assignments was a little unnecessarily stressful..."

"...often we have mandatory assignments in other courses at the same time, so it would be less stressful if the labs didn't have a deadline."

As a higher level of stress lowers the academic achievement of students [9] it is very much in our interest to mitigate this effect. Although the number of students reporting stress is fairly low it is important to aid the students that struggle the most. To get the benefits seen in this study, but avoid increased stress we intend to try an alternative assignments scheme on the next occasion. This suggestion comes from a student as a response to the semester (ii) survey.

I think that making them optional but graded (at least with 1 point each), most of people will still do them, but without feeling "I cant take the exam if I dont pass it."

The plan is to have every weekly lab be optional (except the first lab as it is necessary to distribute the later assignments) and award 1% for each passed, amounting to 6% of the final grade. With this structure we hope to induce extrinsic motivation by having external reward, but mitigate the feeling of stress by having them be optional.

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