

Validating a Data-Driven Approach to Scheduling Office Hours

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Abstract

In this complete evidence-based practice paper, we will present our analysis of student use of office hours in a large introductory computer programming course and how we have used this data to best staff office hours for this large course in a way that is accessible and beneficial to our students.

For students beginning their foray into the wider world of engineering, hands-on programming experience is invaluable to developing an intuition for technical problem solving. As such, ensuring that resources like office hours are as accessible to the student population of a first-year programming course as possible is imperative, especially in larger courses where instructor-student interaction becomes limited.

We teach a large required introductory programming class (course name ENGR 101) at the University of Michigan. The class is a prerequisite for several upper level engineering courses and is a required course for incoming engineering students. This course has approximately 400-800 students depending on the semester. With log files from our departmental office hours queue system, we were able to determine that there were surges of attendance in office hours at points during the semester that aligned with project due dates and checkpoints. Using this information, we formed an office hours schedule that prioritized the times that students were more likely to attend by adding extra shifts in the three days leading up to a project deadline. The purpose of this paper is to document these data-driven changes that were made to shift scheduling and report on the impact that these changes had on graded assignment performance.

In a course with projects as the primary assessment of progress, there are a number of metrics that define project performance. These include the number of submissions to our autograder, the time taken to complete an assignment, and the overall final score. We aim to analyze these metrics as compared to those from the previous semester where the office hours schedule was unchanging week-to-week. Further, we plan to investigate the relationship between consistent office hour attendance and project performance using attendance data from the past two semesters. We hope to better understand the impact that good office hour attendance habits have on improving project performance and encouraging students to engage more with the programming assignments.

We hope to validate the changes to our shift structure through the overall performance results from the Fall 2024 semester. Based on our results regarding project performance as a function of office hour attendance, we will discuss recommendations for office hours shift staffing.

Introduction and Motivation

When holding a large course where instructor-student interaction is limited, staff office hours are a crucial component of the resources students have available to them. As such, it is a duty of the course to provide opportunities to attend office hours that are accessible to as many students as possible. In the CS1 course in question, fall semesters see enrollment of approximately 700; winter semesters see enrollment of approximately 400. The course typically has 18-25 student staff composed of both graduate student instructors (GSI) and undergraduate instructional aides (IA). By contract GSIs can work 20 hours a week and IAs can work 10 hours a week. With lecture sections of ~ 350 students it is not possible for the two instructors to interact closely with each individual enrolled in the course. This is why it is crucial to maximize the availability of contact hours for student staff.

Motivation to Investigate the Impact of Office Hours on Student Outcomes

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Previously, the scheduling of course office hours only relied on the availability constraints of the student staff. The number of office hours held in one week was calculated before the start of the semester. The calculation for this was done by setting the goal at one office hour shift weekly per five students enrolled. The course makes use of an online queue system for office hours. The online queue system logs interactions of students with the queue such as timestamps of when the student joins and leaves the queue as well as which staff member removed them from the queue after they were helped. As detailed in our pre-semester staff training, student staff in office hours are not to take more than five minutes assisting one student on the queue. This time restraint becomes especially salient when large numbers of students attend office hours at one time.

The course has two instructors who hold office hours in addition to the student staff, which make up two hours a week. The professor office hours are not included in this analysis, as attendance to those is quite limited and as they do not make use of the queue there is no timestamp data like there is for the larger staff office hours. Notably, we do not host virtual office hours for our course. While this was offered as an option in the past due to the COVID-19 pandemic, we have moved the majority of our asynchronous assistance to the platform Piazza, where students can ask for assistance outside of office hours and receive guidance and clarification from student staff.

It is also necessary to define what type of assistance is available at our staff office hours. Before the start of the semester, the staff receive guidance about what assistance is or is not acceptable in office hours. The students are already receiving guidance from the autograder in the form of error messages and what test cases are being failed by the project code. Often, the assistance required in office hours relates more to explaining what the error messages mean, working with students through logic using tools explored in the course, and debugging problems that occur in student code. It is advised that student staff give pushes in the right direction where possible, and follow a set of structured debugging steps that the students are also provided with where necessary. Office hours can also be used for assistance understanding aspects of the project specifications and course guidelines.

Related Works

Several works prior to this paper have noted that office hours can have a measurable impact on student performance outcomes. Finding a definite correlation between use of office hours and improvement of student grades is a topic of interest to many educators. Current research has used graded homework as a metric of assessment [1]. Other papers covered the difference between the impact seen within in person and online office hours in the aftermath of the COVID-19 pandemic. A number of these relied on student surveys to describe the office hours experience [2]. We look at the attendance data via the queue; while we may lose out on the subjective review of office hours, we do have more detailed information about our students' use of the time, as well as logs of how long they are on the queue. Other works have begun practices to require attendance in office hours [3] after failure on course assessments, and observed a statistically significant improvement in the students' grades on the retake of the failed assessment. The paper describes the mandatory office hours as beneficial to the creation of a strong student teacher bond. Other authors have attempted to increase student attendance at office hours by using a 'flipped' model, where office hours are not held in an office but rather in a high-traffic area that is accessible to the students [4] It is worth noting that we do have our own room for office hours located in the primary engineering library on campus.

In Mogadishu universities, Somalia, a study found a positive correlation between attendance and engagement in office hours with an increase in student grade performance [5]. The study posits that office hours facilitates an environment for students to focus on their studies and receive support on areas of weakness. Another university in Florida has changed the environment of office hours to reduce the perceived barrier of communication in a larger course [6]. Office hours also can have a reputation of only being for use in 'emergencies' as another study [7] puts it, whereas in Florida and Somalia the impact of office hours was found to be better with students repeatedly engaging. The problems faced here are some that our staff have dealt with as well—students have reported intimidation by long wait times for assistance. Other courses have changed the physical space to make office hours more convenient [8]; while we attempted to expand our space through use of multiple rooms, this was too confusing for the students and student staff and we had to return to the original configuration.

Student staff have for many semesters reported a significant increase in office hours attendance leading up to a project. The act of student procrastination in itself is not novel— even without our analysis of the queue, it could be easily assumed that more students would require help around deadlines than usual. This paper is also driven by understanding what those peaks in attendance mean for the student staff working office hours, aiming to reduce the load placed on student staff by overflowing office hours. Furthermore, the changes in office hours scheduling allowed for less office hours to be scheduled during non-deadline weeks of the semester, meaning that student staff had less office hours time overall. This allowed more of their time to be spent on preparing for lab, course improvement, asynchronous assistance, and other endeavors. The focus of this paper is to determine the impact that this increase of office hours had on student course success and grades by student attendance population. Notably, we do not offer online office hours for our course.

Methods

The data collected encompasses the past three semesters worth of queue data for the course. Prior to the Fall 2023 semester, students were not required to sign on to the queue every time they attended office hours. Data from the Fall 2023 semester is used in this analysis, though as that was the start of the implementation of required sign-ons, use is slightly lower as students and staff became used to the changes to workflow. In total, this amounts to data from 1941 students across semesters.

Prior to the Fall 2024 semester, office hours were held with an invariable schedule week to week. In Winter 2024, there were 28.5 office hours per week, staffed by 3 graduate student instructors or instructional aides per hour. In Fall 2023, there were 31.5 hours held staffed at the same rate. Previously, we had included in each of the student staff's assignments 1 extra hour of office hours duty during the two days before a project due date on Tuesday. With the number of staff, this amounts to approximately 22 of extra office hour shifts in a week. The number of needed office hours were calculated by estimating the number of students who would attend office hours in a week, aiming to provide enough office hours and shifts on Piazza (an asynchronous forum platform) that 5.5 students of the total enrolled would be accounted for with every shift scheduled.

In the Fall 2024 semester, the standard weekly number was set at 30.5 in addition to the 1 flexible hour staff had been assigned. Initially, these were also planned to take place in a different location so as not to overwhelm the normal office hours room. The standard room can only accommodate close to 30 people at a time and during periods of high office hours attendance can lead to overflow into the hallways surrounding the office. However, this caused confusion both for students and staff, and after the first project this was modified such that all of the office hours were held in the original room with the extra staff. The end result was that in a normal week, staff would hold 30.5 of office hours; on the Sunday, Monday, Tuesday leading up to a project, the number of office hours available would jump from 15 hours to 20 hours. The students were alerted to the extra availability through a post to the course website and announcements made by course instructors on the class Canvas page.

After the semester concluded, the log of queue attendees was downloaded from the queue and analyzed, along with the project grade and style data from the Autograder.

Analysis

The analysis following uses data from the Computer Science departmental queue system as well as gradebook data from our course from the Fall 2023, Winter 2024, and Fall 2024 semesters. The queue attendance log is referenced with the assignment calendar to determine the number of attendees in the days leading up to a project. Further, the final course grade spread is shown compared to the number of logged office hour attendances during a semester. Finally, average project grades and individual project grades are plotted to determine if increase in office hours increased the overall project performance. This paper focuses on the impact of office hours on projects as projects are the most heavily weighted of our course's assignments; they are also the most versatile in terms of creative requirement on the student's part, and in this sense can be

thought of as a measure of their ability to engage with the course material they have been presented. Further, as there are numerous avenues for students to attain credit in our course, our course and project grades are quite high on average.

Analysis and visualization of this data was conducted in Python. Some further analysis was completed in Excel. It is notable that the data from the Fall 2023 semester may be partially incomplete, as it was the first semester that the queue process was required; it is still used in this analysis with that understanding, as the Fall semester numbers are better for comparison due to the scaling up of the course during this period.

Using the queue log data, we identified a set of ‘peak’ days that experienced a surge of office hour attendance. These ‘peak days’ are defined as the two days preceding the project deadline as well as the day of the project deadline. It was also observed that surges in attendance appeared around our project checkpoint (a deadline one week into the project duration where the students are expected to have approximately half of the project deliverable completed. These surges are not included in this analysis, though we hope to investigate those in the future.

Results

In this section, we report the results of our analysis of the office hours queue data and the project scores.

Office Hours Visits and Time Spent

In total, there were 2,419 visits to office hours in the Winter 2024 semester. Per day, there were an average of 33.3 office hour visits. On the days identified as peak days, there were on average 68 visits to office hours per day. In the Fall 2024 semester, there were 3,186 visits total, with 40.2 per day on average and 103.3 per peak day on average.

Figure 1 shows the frequency of student visits to office hours across the three semesters. The plot is divided by frequency of visits per individual student.

The number of student visits per day of office hours is plotted in Figure 2. The difference between peaks is due to the changes to the overall course schedule between semesters.

Note: Figure 2’s graphs are using the number of total student visits, rather than unique student visits; if a student logs on to the queue twice in one day, this is counted as two visits to office hours. Conversely, Figure 1 uses counts of unique student visits.

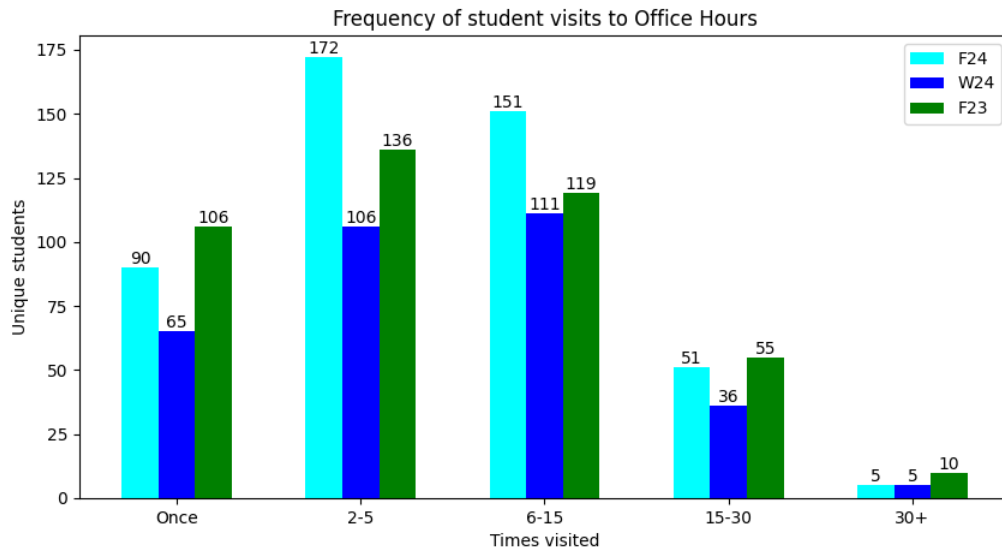


Figure 1: Frequency of Student Visits to Office Hours. As can be expected, the majority of students attending office hours are only attending 1-5 times per semester. Attendance beyond that point becomes rarer.

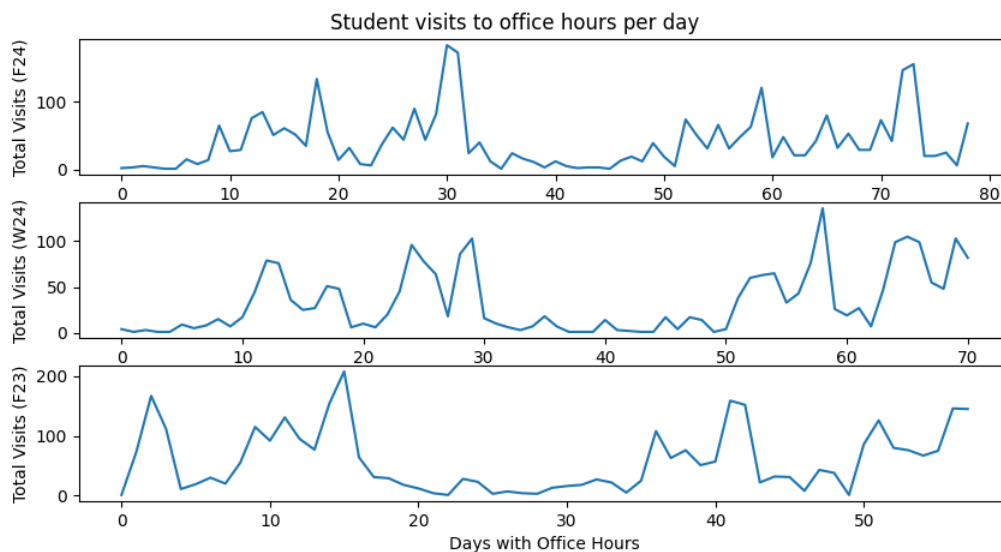


Figure 2: Student Visits per Day. Examining the amplitudes, the earlier statement of averages can be confirmed— on peak days, attendance can sometimes be over thrice as high as on regular days.

Table 1: Average Wait Times on the Queue

	Fall 2024	Winter 2024	Fall 2023
Project 1 Peak	15.4	45.81	28.63
Project 2 Peak	34.85	96.25	65.53
Project 3 Peak	18.16	11.39	18.8
Project 4 Peak	44.34	110.78	86.95
Average Wait (Peak)	28.19	66.06	49.48
Average Wait (off Peak)	50.57	36.06	47.36

The average time on the queue per day is plotted in Figure 3.

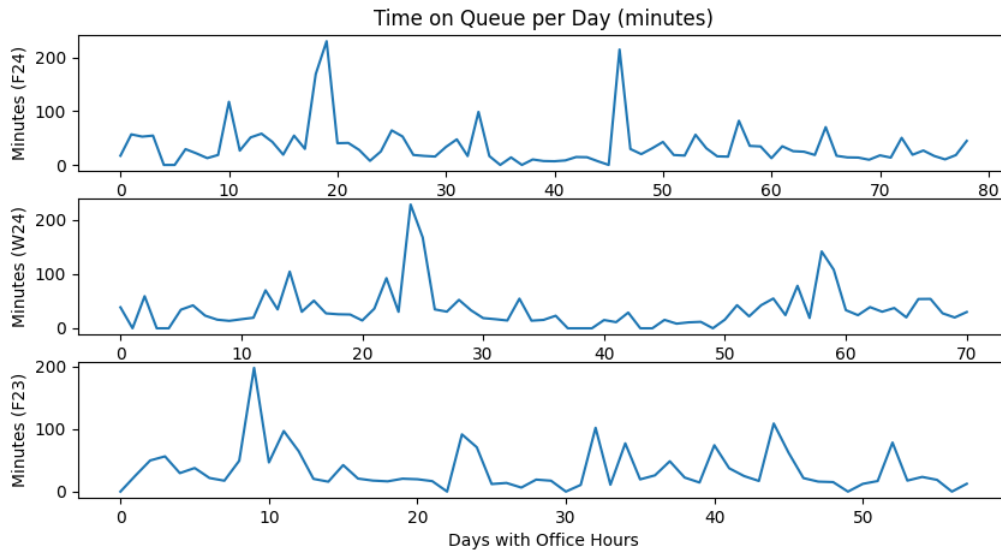


Figure 3: Average time on the queue per day in seconds. Outliers (a time of 800 minutes due to a GSI forgetting to remove someone from the queue) were removed from the dataset.

Average wait time on the queue during normal and peak days. The last entry (off peak) is the average over all time that office hours were open. It can be seen that the Fall semester wait times were comparable, and that in all semesters but Fall 2024 that peak wait time was higher than off peak wait time.

Project Scores

The impact of office hours on student grade outcomes is a contested topic. In this paper, the focus is primarily on increasing availability around project deadlines, and the grades assessed are therefore final project grades. The project grades are herein divided by the previously defined

Table 2: Average grade by Office Hour Attendance in the Fall 2024 semester.

Times attended	Average grade	Standard deviation	Sample Size	Z Value
Total class	93.59	15.14	777	Expected
0 times	92.15	18.99	352	-33.48
1 time	90.88	21.53	106	-18.97
2-5 times	93.28	14.66	136	-278
6-15 times	94.26	14.35	119	5.27
15-30 times	95.2	9.54	55	5.85
30+	95.51	6.34	10	1.27

categories of office hour attendance, with the addition of the zero category for the students who did not attend office hours at all during the course of the semester.

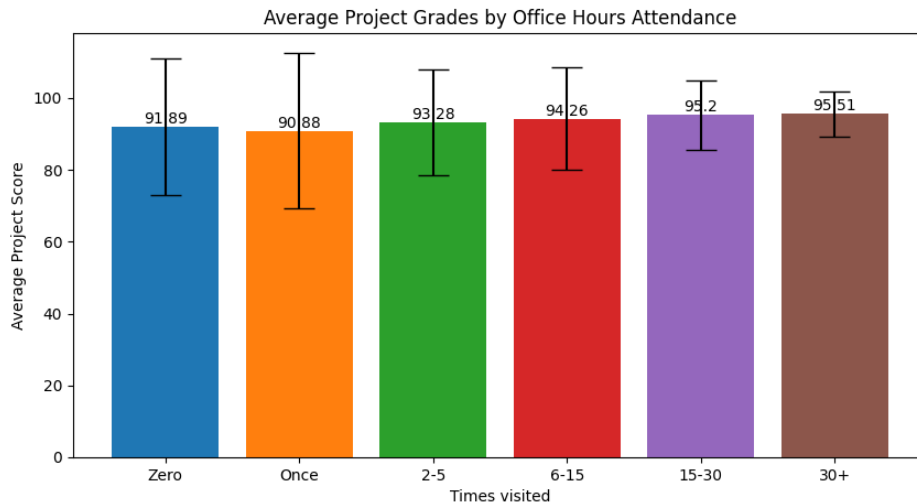


Figure 4: Average Project Grades by Office Hour attendance. The plot shows a 4% increase in final project grades between those who attended 15-30+ times during a semester as opposed to those who did not attend at all.

The grade data was analyzed using the Z test with a significance of 0.01 and a two-tailed grade distribution. Comparing the calculated Z values to the critical values of ± 2.576 , it can be seen that the changes to grade average in each group are statistically significant to the full population in every case but the 30+ group. Since this is the smallest of the groups (representing only 1% of the class), it makes sense that this value is not significant.

Breaking down scores from project to project shows the effect of attendance over time. Figure 5 shows that while initially the scores land in approximately the same place between the bins of times visited, as the semester goes on, the grades of students attending office hours become more

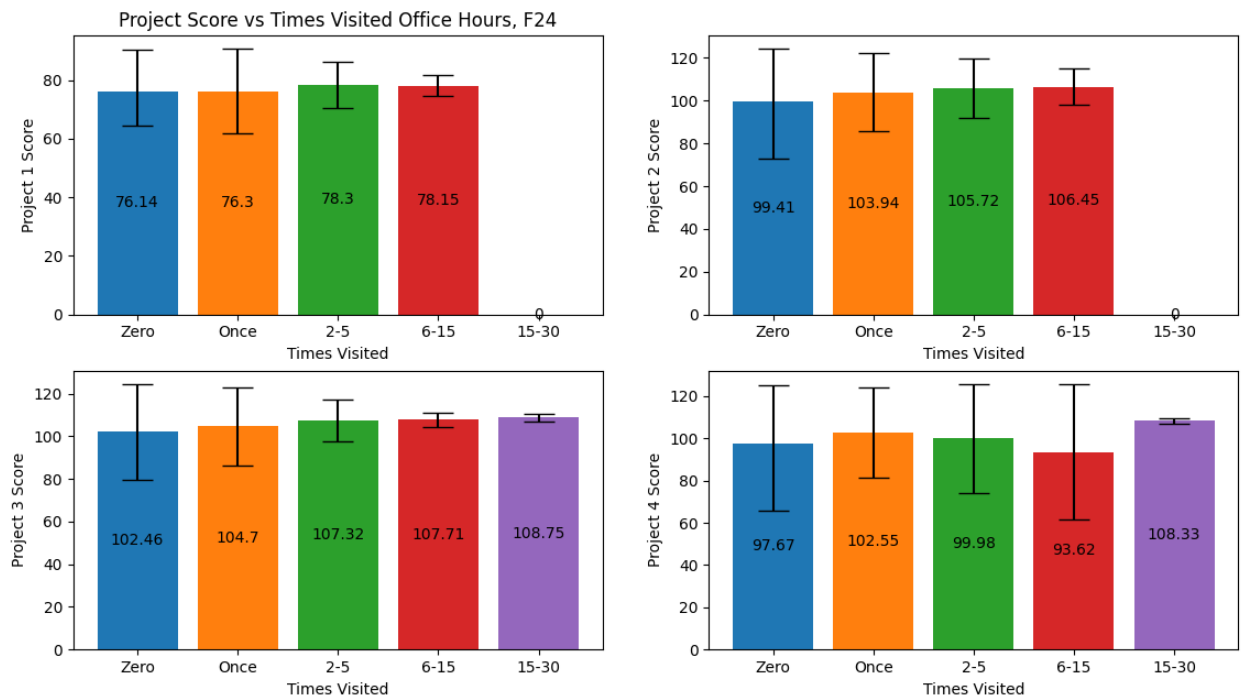


Figure 5: Project Grades by Office Hour attendance, Fall 2024. The attendance data on this and the previous figure is measured in four intervals from project release to project completion.

consistently higher than their peers who choose not to attend. While this trend occurs to some degree in Figure 6 as well, the grades are closer together and the standard deviation is wider despite the smaller sample size in the Winter semester. There are of course outliers– the scores of students who visited 6-15 times for Fall 2024’s Project 4 experienced a spread that did not follow this trend. Additionally, in both terms it appears that while rare, attendance over 15 times for one project did yield higher scores, but that scores at or higher were attainable by students not attending this many times. On all but the first project, the students in the Fall 2024 semester who attended one or more times had higher average grades than their counterparts both in their semester and Winter 2024. The project scores in the Winter 2024 semester were less consistent across categories than in the Fall 2024 semester.

Discussion

The increase in available office hours led to a distinct increase in office hour attendance for students visiting office hours 2-15 times. However, proportional to the size of the class, office hours attendance actually decreased overall in the Fall 2024 semester. In Fall 2024, there were 777 students. Of these, 34% of the class (262 students) visited office hours five or less times, and 60% attended at least one time (469 students). While this represents an increase from Fall 2023, where 426 students attended office hours at least once, the total number of students enrolled in the course in Fall 2023 was lower. With an enrollment of 672 students, 63% attended office hours at least one time. Additionally, the office hours attendance was proportionally lower than that of the

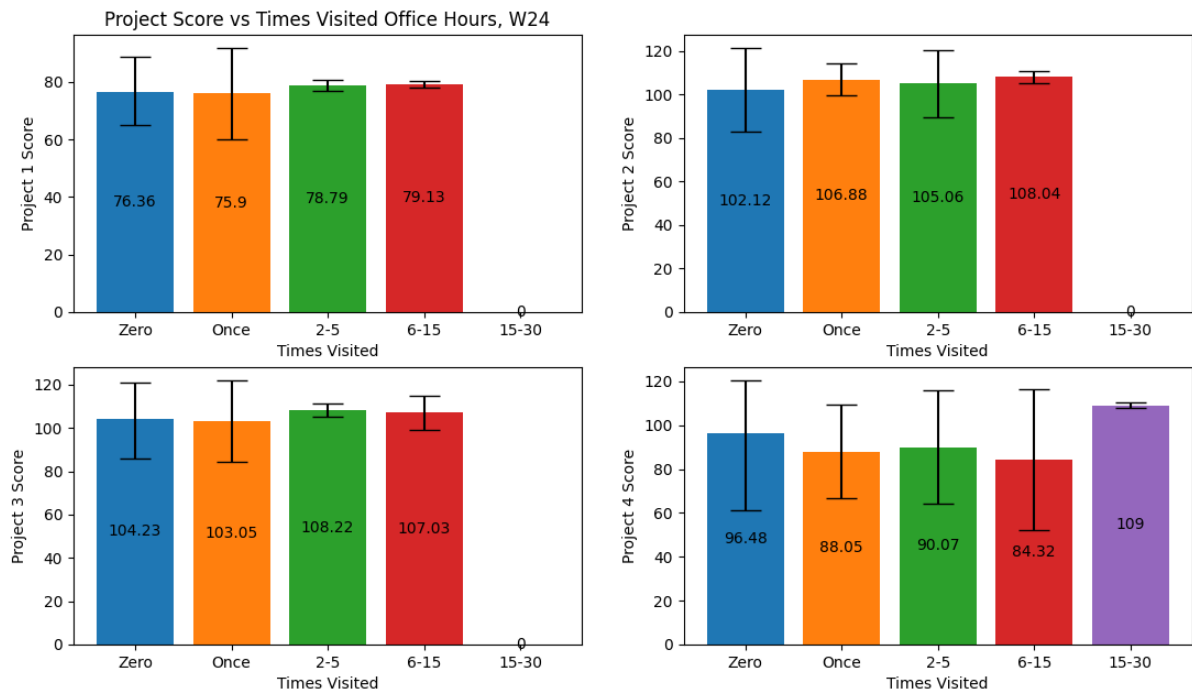


Figure 6: Project Grades by Office Hour attendance, Winter 2024

Winter 2024 semester, which saw 34% (171 students) visit 5 or less times and 65% (323) attend at least once.

Additionally, it is important to note the type of attendee that these available office hours benefited. The increase in availability did not as we had hoped attract significantly more students to attend office hours. However, it did drastically increase the number of repeat attendees (people who attended 2-15 times). From this it can be seen that while increasing availability does not automatically increase attendance, those students who found it a useful resource were able to make more of it than they may have in previous semesters.

In a normal day in the Fall 2024 semester, the average wait time for students on the queue was 50.57 minutes. This time changed in the lead up to each project, as shown in Table 1. This is approximately what was expected from the previous fall's average wait time of 47 minutes. However, when looking at the wait time on peak days, the data shows that the new office hours system reduced wait times by nearly half for the majority of the projects from both Fall 2023 and Winter 2024. This data is supported by anecdotal evidence from our student staff, who reported in a post-semester survey that office hours were much calmer during project weeks than they had been in previous years, leading to a less frenetic environment for students and staff alike. Some reported that they "felt like less students were coming in", which was demonstrably incorrect (as previously mentioned, we saw an increase of 40 unique students attending at least once if not more). However, the perception that there were less students when there were in fact more reinforces the effectiveness of the project office hour system; even though there were more unique

visitors, the queue did not ever back up or become intolerable for the staff. Staff further observed that there were less student complaints regarding queue wait times around projects, as this would often generate extra stress and result in tense interactions.

The impact of office hours is seen additionally in the students' grade outcomes. As seen in Table 2, students in the 2-30 repeat attendee group saw average grades three points above their classmates who attended once or no times. This is the group that saw the largest increase in members during the Fall 2024 semester; the project office hours system appears to have assisted this group in the intended fashion.

Limitations

Since we have only used the office hours queue for three semesters, we have a limited amount of data to analyze. We will be continuing this method of scheduling into the next few semesters and assessing as we go. Further, as previously noted the queue was not used all the time during the Fall 2023 semester, so it is possible that there were more attendees that were not logged in the queue system.

The limitations of the data set extend further to the differences between semesters. Not only do our class sizes decrease in the Winter as compared to the Fall, but our staffing decreases as well. Typically in a Winter semester there are close to 15 student staff members as opposed to upwards of 20 in a Fall semester. Since we typically have student staff operating 4.5-6 office hours a week, this is a significant decrease to the number of office hours we are able to hold over the semester. This means that wait times can tend to be higher in winter semesters even with lower attendance as there is less total time available.

It is notable that there does not exist a tremendous amount of variation in our grades to begin with. The grading scheme for the class is based on mastery and specification grading schemes, where points are awarded based on the accuracy and completion of weekly assignments as well as larger course projects. The projects are graded partially with use of an autograder which assesses the code's ability to handle certain test cases as well as hand graded for certain style components. The generous late submission policy as well as the feedback provided by the autograder and in office hours upon request means that students have many opportunities to gain mastery of the material and tend to score higher as a result, even if the number of attempts varies based on familiarity with the material. It is expected that with a scheme as we have in place students would tend toward obtaining high grades—this allows us to focus on how to best assist students who are not achieving mastery of the material.

Other factors that influence the high grades in the course would be our student population and the variety of experience level coming into the class. As aforementioned, this is an introductory and required computing course for every student entering the college of engineering. Some students enter the class having had significant prior programming experience; some enter the class having never programmed before; and yet others transfer into the school after their freshman year and have taken multiple high level programming classes but need to complete the class anyway for certain college requirements. The course is designed to be accessible to the students who have never programmed before, and as such is not terribly difficult especially for students who have had experience with the material. Furthermore, high grades are sometimes not indicative of

student background, but of external resources available. The course does experience a decent amount of plagiarism and code sharing that violates our institution's honor code. These incidents are reported to the honor council after our cheat-checking process concludes, which can lead to grade decrements in some cases— however, not all of the cases have been resolved between the semesters that we have data for.

Conclusions and Recommendations

From these results, we conclude that expanding the number of available office hours based on student attendance patterns had a positive impact on both student project performance and student experience with office hours. With statistically significant increases in grade for students who attended office hours multiple times over the course of the semester, it can be seen that attending office hours has the intended impact on student performance. This echoes the results seen in other aforementioned studies (eg [5]). Furthermore, the data shows that repeat office hour attendance is more valuable to student performance than attending a single time. From the surveyed staff, the environment of office hours also plays a role in what value students find in engaging with office hours, which aligns with results as seen in “Reenvisioning Office Hours to Increase Participation and Engagement” [6]. It is likely the changes to the pace and availability of the environment was better for facilitating student learning.

It was observed that while office hours were held for not only more time in project deadline weeks but also with more staff, the number of unique students attending fell in line with what was expected from previous semesters. This was not expected, and the hope was that a larger proportion of the class would be able to attend with extended hours. For the most part the students who did attend consistently tended to perform higher than those who did not. Additionally, students who attended office hours had less of a grade disparity with Project 4, notoriously the hardest of our projects as the students receive no starter code and must write the entire project from scratch.

As was expected, staffing office hours with more GSIs and IAs during project deadlines led to lower times on the queue. This is not a result that should be surprising as it was one of the assumptions that we started with when considering the topic for this paper. Rather, the issue was one of logistics; if we could staff office hours with double the instructors all the time, surely then all of our wait times would be lower. Considering that we have a limited number of instructors and a limited space to accommodate at times over 150 students per day, we wanted to use the data that we had to make sure that our students were getting the most out of what we were able to offer.

The data describe a relationship between staffing and wait times that informs our earlier method of determining staffing for office hours. The previously stated procedure was to create a standard schedule such that the ratio of students to the office hours (both asynchronous and in person) was not over 5.5 students per office hours per week. In weeks with project deadlines, this would increase above 6 students per office hours per week. By adding 5 extra project office hours, we were able to decrease this metric from 8.4 to 6.3, which further halved queue wait times and resulted in a more pleasant experience overall for students and staff alike. In this way, the metric of students per office hours per week was shown to be an effective criterion for determining how

to staff office hours for a large course. We found that assigning varied office hours schedules based on student demand yielded positive results for both our student population and the office hours staff.

Future Work

Although the extra office hours did not draw in new students, the data shows that they were more accessible to those who were attending. In the future, we hope to increase the amount of messaging surrounding office hours to make sure that students are aware of both the regular and extra times available. We are also introducing a new assignment at the start of the semester to encourage students to speak with their lab instructors and attend office hours to verify the correct installation of their required software; this is also partially intended to get students used to the cadence of office hours and its existence as a resource.

While this semester the student staff were surveyed for feedback on the office hours system, it would also be useful to get feedback directly from the student perspective. In the future it would be useful to survey the students regarding their experience and what they find helpful or not about the structure we have employed.

One concern raised regarded our investigation of performance metrics and their connection to learning. It could be assumed that in such short interactions with the student staff that the students would just ask what the ‘right thing to do’ was, and after obtaining the ‘right’ answer would leave having learned nothing. This is however offset by a few factors, including both the variety of methods that can be used to arrive at a solution and the style of advice we encourage our student staff to deliver. There is not one ‘right way’ to complete any one of our projects. The students are given what amounts to a set of tools that could be combined to achieve certain technical goals. Often, students will approach problems in ways that differ greatly from each other. Part of the course’s job is to encourage students to develop their engineering problem-solving skills. As such, the projects allow for diversity of thought, which means that each case brought in to office hours is a different challenge for the student staff. There can be common problems; for example, one issue in the second project regarding a specific line width for a box on a graph that takes the student staff about five seconds flat to identify due to the frequency that students bring it into office hours. However, when student staff identify the problem, they can advise the students on what information would help them fix the problem (e.g. using the error message line to find the problem in the code, discussing where in the homeworks or lecture there are helpful examples) but they are not supposed to just give an answer or do the work for the student. Because of this, office hours can be an iterative process, with the student returning multiple times in a day or asking questions across different platforms until they have fully worked through the error. Since we allow for so many opportunities for students to earn credit on the projects, our course connects the student’s learning process to their ability to achieve certain benchmarks with the project test cases. Due to the nature of our projects allowing so many opportunities for submission, it would be helpful to be able to look at the number of submissions per day per project. Unfortunately at this time this is not data that we have access to.

As mentioned earlier, surges in office hour attendance were also observed in our queue log data around other deadlines besides project submission. These included project checkpoints and course assessments among others. The surges were not as dramatic as the ones observed for project deadlines, and for this semester it was decided that the focus would be projects as those are the most important assignments in our course as well as the best metric we have of student understanding of and ability to effectively use class material. Extending the adjustment of office hours to accommodate different deadlines would be insightful into the impact of instructor interaction on course performance and other assignment types.

Acknowledgement

This research was supported by the Foundational Course Initiative at the University of Michigan – Ann Arbor under IRB HUM00150716.

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