SCALING OFFICE HOURS: MANAGING LIVE Q&A IN LARGE COURSES

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ABSTRACT

Computer Science 50 (CS50) is Harvard University's introductory course for majors and non-majors alike. So that students have an adequate support structure with which to tackle the course's weekly programming assignments, we offer weekly "office hours," during which students can receive one-on-one help from teaching assistants.

In Fall 2010 and years prior, office hours were held in a basement-level computer lab. However, this environment did not appeal to staff or students. Moreover, this format for office hours suffered from logistical inefficiencies, repetition of questions among students, and lack of communication among staff, which led to high wait times for students.

We relocated office hours in Fall 2011 to dining halls to create a more social and collaborative workspace, with more staff on duty at once. We also developed CS50 Queue, a web- and iPad-based system for managing office hours' logistics.

Overall, the new format proved a success. Attendance at office hours grew more than linearly, with an average of 120 students attending per night, up from 30 students in 2010 despite only a 23% increase in enrollment. Even though Queue enabled us to scale, new logistical challenges arose, and wait times for students still sometimes exceeded an hour. We intend to address those challenges in Fall 2012 in order to reduce wait times to 15 minutes at most.

1. INTRODUCTION

CS50 is a one-semester course combining concepts typically taught in CS1 and CS2. Students complete nine weekly problem sets covering topics including cryptography, finance, and forensics using languages like C and PHP. Problem sets are assigned on Fridays and due on Thursdays, though students can extend some deadlines by 24 hours by using a "late day." Students have historically found CS50 to be difficult and time-consuming, typically spending more than 10 hours hours per week on problem sets outside of class. However, the course's workload has not proved a deterrent among students, as enrollment has increased from 132 students in 2006 to 607 students in 2011 (+360%), the result of changes to the course's curriculum and a resurgence of interest in the field itself.

Because of the course's difficulty and workload, office hours have traditionally been integral to students' educational experience in CS50. In Fall 2010, we held office hours in a large computer lab where students sat at a workstation to work on the week's problem set, requesting the help of staff when they had a question or bug. Although office hours provided students with opportunities for one-on-one interaction with staff, their location failed to appeal. In addition, we noticed that over 80% of students were using their own laptops rather than the computer lab's workstations. We thus relocated Fall 2011's office hours to dining halls in an effort to create a more social, collaborative workspace for students after dinnertime.

To increase the efficiency of office hours and facilitate the transition to dining halls, we introduced CS50 Queue, a web- and iPad-based system for managing office hours. With Queue, stu-

dents could raise their hands virtually by clicking a button on Queue's website and be dispatched to available teaching assistants by an iPad-equipped greeter.

The relocation of office hours ultimately appealed to students. Whereas attendance in Fall 2010 averaged 30 students per night, with peaks of 60 students, it quadrupled in Fall 2011 to 120 students, with peaks of 160 students (+167%). Even though Queue enabled us to handle this increase in load, unforeseen logistical problems arose, and wait times for students sometimes exceeded an hour.

We present in this paper our method for scaling office hours and managing live Q&A in the midst of rising demand. In Section 2, we describe the problems with office hours that motivated Queue's development, and in Section 3 we present our implementation of Queue. In Section 4, we present the results of our pilot of Queue, and in Section 5 we describe future work that will address the shortcomings of Fall 2011's experiment.

2. BACKGROUND

Prior to Fall 2011, we held CS50's office hours in a basement-level computer lab on weekday nights. Teaching assistants were responsible for holding three hours of office hours per week, and staff signed up for one or more time slots via a shared Google Calendar. During office hours, students sat at a lab workstation, writing their name and location on a whiteboard as soon as they had a question. Meanwhile, teaching assistants systematically helped students in the order they signed up, crossing off names and walking to students' locations to answer their questions. However, these office hours suffered from three problems:

- *Logistical inefficiencies.* That teaching assistants had to walk to and from the whiteboard was not an effective use of time, particularly when students were hard to find because of illegible handwriting. Students would also take advantage (intentionally or unintentionally) of office hours' lack of organization by writing their names above those of their peers or writing their names several times on the whiteboard in an effort to decrease their wait times.
- *Repetition of questions.* The format failed to account for the repetition of common questions among students. Because most students came to office hours seeking help with the week's problem set, it was not uncommon for multiple teaching assistants to answer the same question independently and concurrently, which was not an effective use of time.
- *Lack of communication.* The computer lab was not conducive to communication among the staff, which made it difficult for junior staff members to ask for help if unable to answer fully students' questions. Instead, they would spend an unnecessary amount of time attempting to help students when simply escalating the issue to another staff member could have led to a speedy resolution.

After observing in Fall 2010 that more than 80% of students were setting aside workstations' keyboards in favor of using their own laptops, we decided it was time to revamp the format of office hours. We thus relocated Fall 2011's office hours to residential dining halls in an effort to create a more social and collaborative atmosphere. We also narrowed the availability of office hours to four nights per week, 9pm to midnight (instead of five nights per week, 7pm to midnight) to concentrate more staff across fewer hours (with as many as 20 teaching assistants on duty at once). But, the shift to dining halls necessitated the development of a new organizational model, as dining halls were significantly larger than the lab. Moreover, dining halls lacked features like a central whiteboard and numbered terminals on which we had traditionally relied. We thus developed CS50 Queue to facilitate this transition and manage our live Q&A.

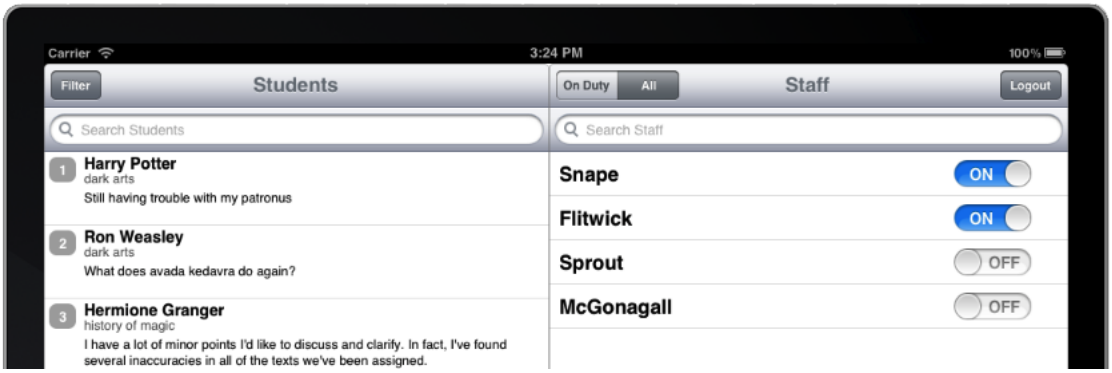

Figure 1: CS50 Queue is a web- and iPad-based system for managing office hours. Pictured here is the iPad's interface with which a greeter pairs students with staff by tapping.

3. CS50 QUEUE

CS50 Queue is a web- and iPad-based system for managing office hours inspired by the Genius Bar found at Apple's retail stores. Upon arriving at office hours, students log onto Queue's web application (hosted at a subdomain of the course's website), where they can raise their hands virtually to ask questions categorized by topic. After posting their questions, students can see their place in line, along with the questions asked by their classmates. If students do not want their question to be viewable by their peers, they can check a box to post their question "incognito," readable only by course staff. To enforce fairness, Queue only allows each student to post a single question in Queue at a time. Students are also able to participate in an online chat with their classmates, whereby chat rooms are organized by problem sets' topic.

Meanwhile, a senior staff member (called the "greeter") manages office hours. When staff arrive at office hours, they check in with the greeter, who marks them as on duty by selecting their names from a list on the iPad. Per Figure 1, the greeter can view a list of students' questions in Queue alongside a list of the staff members on duty. Next to each staff member's name is also the amount of time since they were last dispatched a student, which allows the greeter to identify and assist teaching assistants spending too much time answering a question. By tapping one or more students' names followed by the name of a staff member, the greeter can dispatch students to teaching assistants, who are centralized at a designated staff table in the dining hall. Upon dispatch, Queue triggers a visual and audible alert on students' computers that instructs them to see the specified teaching assistant.

CS50 Queue is open-source, and its source code is available at
`http://github.com/tmac721/cs50-queue`.

4. RESULTS

Overall, the introduction of CS50 Queue, coupled with the relocation to dining halls, was a success, with most of Fall 2010's logistical inefficiencies and lack of communication redressed. However, the new format failed to reduce significantly the repetition of questions and introduced some new problems altogether.

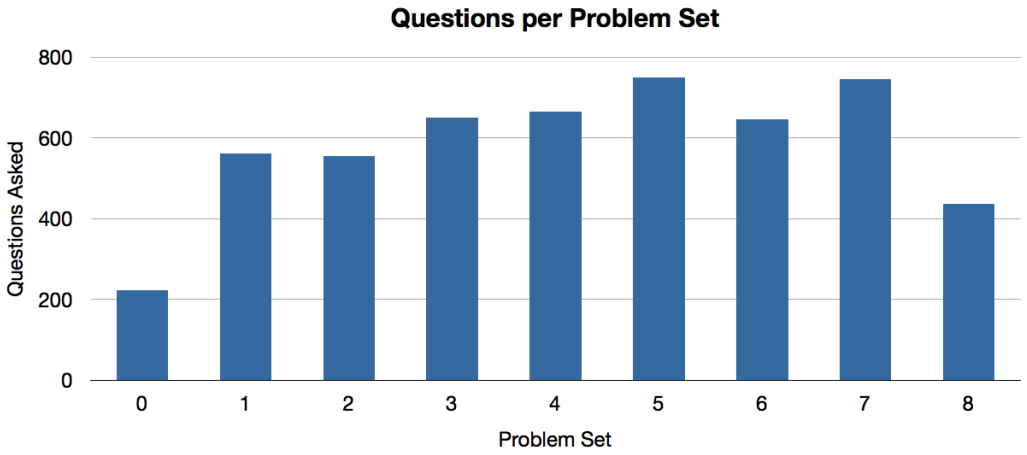

Figure 2: Because CS50 Queue stored students' questions in a database, we were able to quantify students' confusion on each of the problem sets.

4.1 Successes

The relocation of office hours proved popular among students. Whereas 30 students attended office hours on average in 2010, with peaks of 60 students, over 120 students attended on average in 2011 (+300%), with peaks of 160 students (+167%). Demand for office hours grew disproportionately with the course's size, as enrollment increased by only 23% during this time period (and staff size grew proportionally). Given that the course's problem sets and proportion of students with no computer science background did not change in 2011 vis-à-vis 2010, we were pleased to find that office hours' new locations, which were more convenient and social for students, motivated higher attendance. As one student noted in mid-semester evaluations: "I think office hours are a great resource for the students (which is why I basically live at the d-halls 2–3 nights per week)."

Fortunately, CS50 Queue allowed Fall 2011's office hours to accommodate this increase in load. First and foremost, Queue improved the organization of office hours, which was logistically necessary to support larger numbers of students. Second, by allowing the greeter to send multiple students with questions on the same topic to the same teaching assistant at once, we reduced time spent answering repeated questions. Finally, the centralization (rather than mobility) of staff allowed teaching assistants to consult each other if unable to solve a problem.

Queue's storage of students' questions in a database has also provided insights that will help us reshape the curriculum in Fall 2012. For instance, per Figure 2, students asked the most questions about problem sets 5 and 7, which suggests those weeks' specifications were less clear or more challenging than some. Meanwhile, problem sets 0 and 8 elicited the fewest number of questions and seemed to be the clearest or easiest for students.

Finally, Queue has given us a glimpse into the work habits of students. As reflected by the spikes in Figure 3, though problem sets were released on Fridays (and due on Thursdays), most students did not begin to dive into problem sets (and ask questions) until Tuesdays or Wednesdays. Students' tendency to seek help later in the week became more pronounced for the final two problem sets: while 70 students attended office hours on Mondays for problem set 6, only 27 attended for problem set 7. In addition, the number of students attending office hours on Thursdays (offered expressly for those students taking a late day) peaked for problem sets 6 and 7, with attendance reaching 130. It could be the case that many students underestimated the difficulty of these

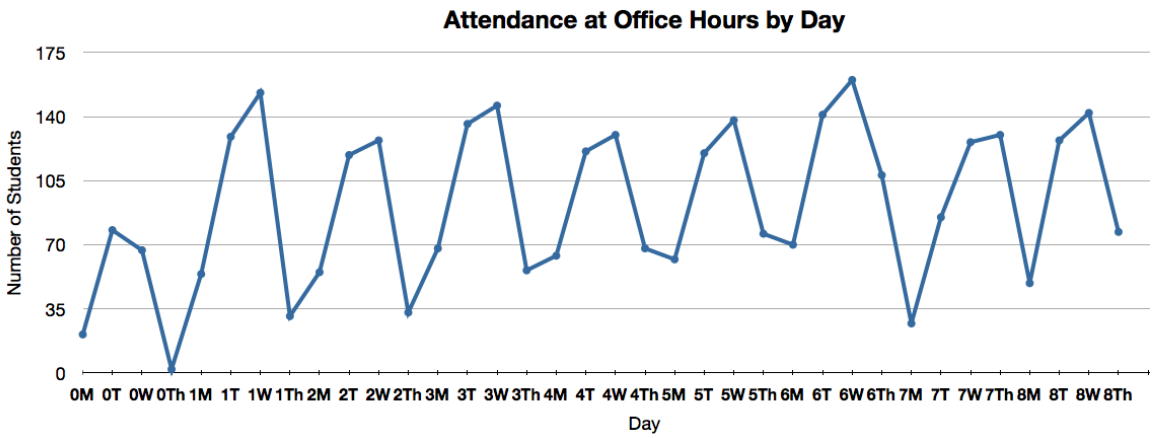

Figure 3: Students' attendance at office hours varied significantly by day. Labels on the x-axis designate week and day; 0M, for example, is Monday of week 0.

problem sets, which perhaps suggests we should make their workload more immediately clear to students. Or, perhaps students reserved their allotted late days for the end of the semester. We plan to look more closely at late days' usage in Fall 2012.

4.2 Problems

Nevertheless, because we did not anticipate the degree to which attendance would increase because of office hours' relocation, students sometimes suffered long waits. Per Figure 4, on nights before problem sets' deadlines, wait times in excess of an hour were not uncommon. In particular, the peaks that occurred on Thursdays in the latter half of the semester were a result of understaffing, as we failed to predict the number of students who would take advantage of late days. Among the primary causes of high wait times was students' understandable tendency to linger around staff after their questions had been answered, anticipating but not yet having additional questions. Because the first iteration of Queue relied on the greeter to observe when teaching assistants were finished working with students (which itself introduced latency), staff members would often spend a disproportionate amount of time with students who continued to work at the staff table even after their questions were answered. Office hours' ultimate goal was not to maximize throughput, but to be fair to all students in need of help. Understandably, many teaching assistants were uncomfortable asking students to leave the staff table after their questions had been answered and were thus seen as unavailable by the greeter. As one teaching assistant commented, "At office hours it was often pretty difficult for me to get a student to move away after I had already given them some advice—they usually wanted to test out whatever I had just advised them to do." Students also did not utilize Queue's chat functionality, instead relying exclusively on staff for help rather than also asking peers. Underlying these high wait times was a misalignment of expectations between students and staff: while staff members sought to "unstick" students and enable them to continue to work on their own, many students expected staff members to walk them through the entirety of the problem set. Queue's own structure thus failed to address adequately the changes that resulted from the relocation of office hours.

Another notable trend we observed among students was a significant decrease in the length of questions inputted into Queue. While in the first week of office hours students' questions were 14 words in length on average, one-word questions were commonplace by term's end. Most students were not inputting questions at all, as common submissions included "bug," "help," and "lost."

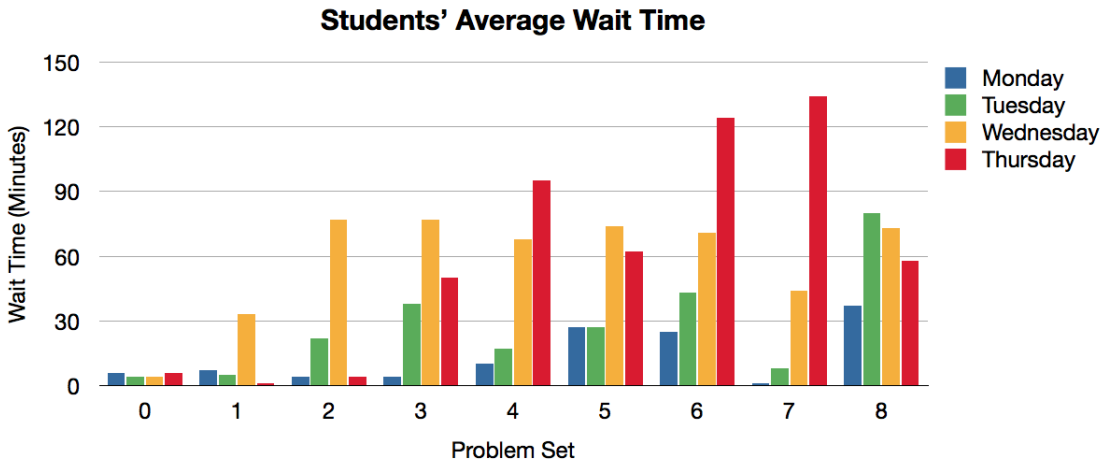

Figure 4: Students' wait times were high for office hours held later in the week. In Fall 2012, we will vary the number of staff present at office hours over time.

Students' brevity was detrimental to office hours' efficiency, as the greeter could not detect, and thus dispatch, students with equivalent questions to the same teaching assistant. We hypothesize that students had less incentive to input detailed questions because most teaching assistants did not have Queue's web application open during office hours and were unaware of the students' questions until they arrived in person.

5. RELATED AND FUTURE WORK

Literature on the management of large-scale office hours is scarce, but others have investigated the effects of holding office hours online: Malan [1], Johnson *et al.* [2], and Lee [3] present mechanisms through which students can synchronously interact with teaching assistants by sharing screen sessions. CS50 Queue, on the other hand, is a management system for in-person office hours.

To reduce wait times in Fall 2012, we intend to facilitate two-way communication between the greeter and teaching assistants via a web application that staff will keep open on their own laptops. Not only will this application empower staff to read questions before students arrive in person (thus decreasing the amount of time required for students to explain their issues), but it will also allow the greeter to ask teaching assistants if they are available to help a new student. We hypothesize that this two-way communication will improve office hours' efficiency, as the greeter will be able to notify staff gently when another student is in need of assistance. In order to prevent long wait times for short, common questions, we will also route questions first to an online forum moderated by a dedicated group of staff members, giving teaching assistants the opportunity to answer questions electronically before they appear on the greeter's iPad as questions to be answered in person. With these improvements in workflow, we aim to reduce student wait times to 15 minutes or fewer, while remaining in dining halls.

6. CONCLUSION

In Fall 2011, we relocated CS50's office hours from a basement computer lab to residential dining halls in order to create a more social, collaborative environment. We also introduced CS50 Queue, a web- and iPad-based system for managing office hours, in order to address prior years' lo-

gistical inefficiencies, repetition of questions, and lack of communication among staff. Fall 2011's revised format was ultimately successful in appealing to students, as average attendance at office hours increased from 30 students to 120 students, with peaks of 160 students, and Queue enabled us to manage that load. However, we did not eliminate the repetition of identical questions, and we failed to anticipate new logistical challenges. As a result, wait times still sometimes exceeded an hour. In Fall 2012, we intend to redress these inefficiencies by adjusting our workflow and Queue's implementation so as to reduce wait times to 15 minutes at most.

7. REFERENCES

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