Measuring impact: Student and instructor experience using an online queue

David Mussulman, University of Illinois at Urbana - Champaign

Dave is an Instructional Technology Facilitator with the University of Illinois at Urbana-Champaign's Engineering IT Shared Services. He helps instructors select and integrate technologies into their courses to enhance student learning and improve course administration.

Prof. Karin Jensen, University of Illinois at Urbana - Champaign

Karin Jensen, Ph.D. is a Teaching Assistant Professor in bioengineering at the University of Illinois at Urbana-Champaign. Her research interests include student mental health and wellness, engineering student career pathways, and engagement of engineering faculty in engineering education research. She was awarded a CAREER award from the National Science Foundation for her research on undergraduate mental health in engineering programs. Before joining UIUC she completed a post-doctoral fellowship at Sanofi Oncology in Cambridge, MA. She earned a bachelor's degree in biological engineering from Cornell University and a Ph.D. in biomedical engineering from the University of Virginia.

Dr. Jennifer R Amos, University of Illinois at Urbana - Champaign

Dr Amos joined the Bioengineering Department at the University of Illinois in 2009 and is currently a Teaching Associate Professor in Bioengineering and an Adjunct Associate Professor in Educational Psychology. She received her B.S. in Chemical Engineering at Texas Tech and Ph.D. in Chemical Engineering from University of South Carolina. She completed a Fulbright Program at Ecole Centrale de Lille in France to benchmark and help create a new hybrid masters program combining medicine and engineering and also has led multiple curricular initiative in Bioengineering and the College of Engineering on several NSF funded projects.

Prof. Lawrence Angrave, University of Illinois at Urbana Champaign

Lawrence Angrave is an award winning Fellow and Teaching Professor at the department of computer science at the University of Illinois at Urbana-Champaign (UIUC). His interests include (but are not limited to) joyful teaching, empirically-sound educational research, campus and online courses, computer science, engaging underrepresented students, improving accessibility and creating novel methods that encourage new learning opportunities and foster vibrant learning communities.

Karle Flanagan, University of Illinois at Urbana - Champaign

Karle Flanagan is a Senior Instructor of Statistics at the University of Illinois at Urbana-Champaign. She has taught introductory statistics to thousands of students at UIUC since Spring of 2014. She also serves as the MS advisor for the statistics department. In 2018, she was awarded the Illinois Student Government's Teaching Excellence Award and in February of 2019, she also won the highest level teaching award at UIUC, the Campus Award for Excellence in Undergraduate Teaching. She completed her undergraduate degree in mathematics, with a minor in secondary education. She previously has taught mathematics and worked as a statistician in the insurance industry. Along with teaching, she is currently working on course development for other advanced statistics courses and data science courses using Python. Her research interests include online education, optimizing efficiency in office hours for large classes, and active learning methods for undergraduate statistics instruction.

Prof. Wade Fagen-Ulmschneider, University of Illinois at Urbana - Champaign

Wade Fagen-Ulmschneider is a Teaching Associate Professor of Computer Science at the University of Illinois at Urbana-Champaign (UIUC). With a passion for data, he teaches thousands of students each year in his courses on Data Structures, Data Visualization, and Data Science. He was selected as one of the National Academy of Engineering's Frontiers of Engineering Education scholars, awarded the Collins Award for Innovation Teaching, and has been consistently ranked as an excellent instructor by his students for the past ten years. His work on data visualizations has been used by governors of multiple states, featured by websites including Popular Mechanics and The Verge, and has been viewed by millions of readers.

Natalia Ozymko, University of Illinois at Urbana - Champaign

Natalia Ozymko is a rising senior majoring in Computer Science with a minor in Spanish at the University of Illinois at Urbana-Champaign (UIUC). She is interested in helping students master advanced topics in Computer Science and building new technologies to improve people's lives. She was awarded the Scott Fisher Outstanding Course Assistant award, and has worked under the direction of multiple faculty members assisting in teaching both Data Structures and Systems Programming.

Rittika Adhikari, University of Illinois at Urbana-Champaign

I am a junior studying CS at the University of Illinois at Urbana-Champaign, and I have worked on implementing features to continue improving the Queue.

Jacqueline Osborn, University of Illinois at Urbana - Champaign

Jacqueline is an undergraduate at the University of Illinois at Urbana-Champaign studying Computer Science. She is a Lead Course Assistant for CS 225 (Data Structures), and was selected as one of the Fall 2019 Outstanding Course Assistants within her department.

Measuring impact: Student and instructor experience using an online queue

Abstract
This paper presents an evaluation of an online queueing system ("the Queue") that has been used extensively at the University of Illinois at Urbana Champaign (UIUC) for several years. This work describes the benefits of the Queue to the users (students, instructors, and advisors) and the results of surveys given to students, educators, and advisors who used the Queue in diverse educational settings. Prior work identified that using technology, such as a mobile-friendly, web-based queue, has benefits to improving student/educator interactions. A survey was developed to collect student, instructor, and advisor feedback to understand best practices, challenges, and perceptions from using the Queue for office hours, active learning, and advising. The survey feedback suggested equity of staff attention and not overlooking student engagements, especially in large courses, as the biggest benefit of adopting the Queue.

1. Introduction

There is an increasing need to facilitate quality instruction in large enrollment courses. In order to address this need, we have previously described the development and early use of an online queuing system for education [1]. The Queue is an open-source application that allows students to add their name and question to an online queue (or virtual line) that is monitored by course staff or advisors. Students can easily access the Queue web page with a cell phone, tablet, laptop, or another device. Both students and course staff can view which students are in the queue and the questions that they list. While the Queue software was originally developed to help maximize efficiency at office hours for large enrollment courses, the software has since been adopted for other educational purposes, including drop-in advising, peer learning, and active learning. Since its implementation in Fall 2017, the Queue has been adopted by 25 courses, 4 advising offices, and has facilitated over 70,000 questions.

In the early use cases of the Queue, we identified several benefits for students and instructors, including but not limited to saved time, improved accessibility, and improved use of space since office hours do not need to be in a fixed location when the queue is used. To understand these impacts and benefits better, two different surveys were created and implemented in late 2019. This paper focuses specifically on the survey that was administered to Queue adopters (faculty, advisors, and staff who use the system). Another survey that was administered to students who use the queue either for their courses or for advising is described in the future work section.
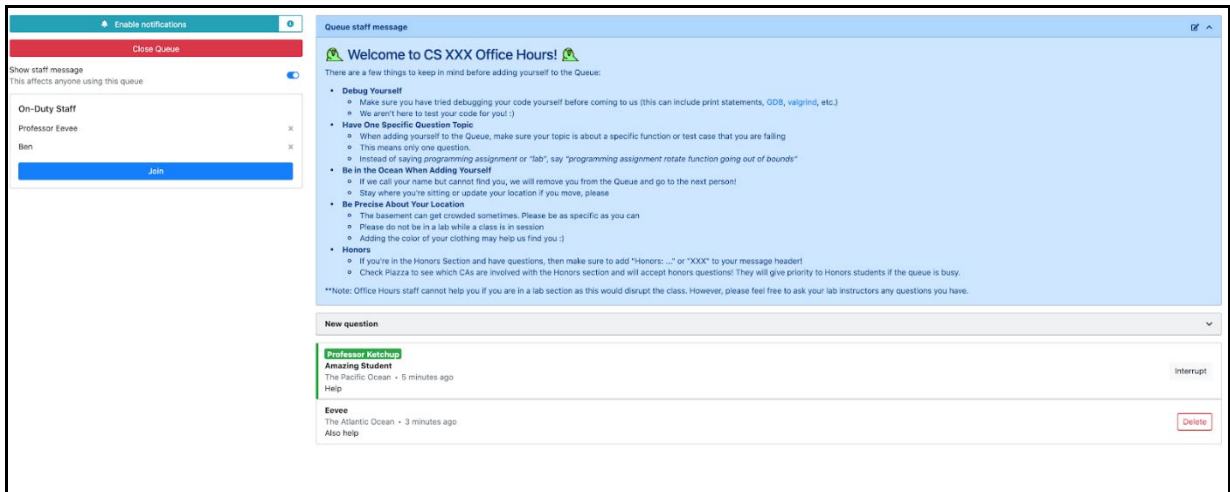
Figure 1: A screenshot of the web-based Queue interface on a laptop computer. The Queue interface shows students the current on-duty course staff helping to answer questions (left area), a course-specific message that is provided to everyone asking questions (large shaded box), and a list of students currently on the Queue (list shown below the shaded box).

2. Background: Use and Benefits of the Queue

The Queue is a web-based application that organizes users into a virtual line -- or "queue" -- that they wish to join. The use of this Queue was initially designed to streamline the process of students writing their names on a whiteboard to get help at office hours. Course staff (professors, teaching assistants, etc.) help students on the Queue according to the first-come-first-served system. Once a student is helped, they are taken off the Queue and the next student can be helped. This system makes helping students during office hours organized and efficient. This section outlines benefits we have observed from the implementation of the Queue.

2.1. Evaluation of Benefits for Students

In our evaluation of the Queue, we have observed that using it in office hours has provided students with several advantages over traditional office hours, especially in large-enrollment courses. In traditional office hours, organization tends to degrade when the number of students seeking help exceeds the capacity of the available instructors or course staff -- there is often no clear line, students do not know when their question will be answered, and they can often be accidentally skipped over.

On the Queue interface, students can see exactly where they are in line, who is being helped by course staff, and how many more students are ahead of them. With this information, students are assured that they will not be accidentally skipped or cut in front of in line. Students also can estimate how long it will take until a member of course staff can assist them because the Queue shows how long each student has been waiting. In addition, this helps students decide if it is worth their time to go to office hours, potentially before they even travel to the office hours location.

Along with assisting students in getting their questions answered, the Queue helps with engagement in large courses. Specifically, students and course staff can both see the names of each other on the Queue. This allows the student to put a name to a face and the course staff to

get to know each student by name, which can help to humanize the course staff. This could, in turn, translate to more class engagement and enjoyment. Traditional office hours may not provide this luxury, as there may be many members of course staff helping students at once, and a student may never be able to put faces to names if they do not ask. Moreover, while using the Queue, students are able to see the questions other students have. If students end up having the same question, they may be able to find each other (since they can also see the location of one another) and collaborate. Even if students do not do this, having the knowledge that other students are struggling with the same concepts can provide peace of mind and comfort in knowing that they are not alone.

2.2. Evaluation of Benefits for Course Instructors

In our evaluation of the Queue, we found that it enabled instructors and course staff to easily facilitate open office hours, thus allowing them to be more productive and utilize their time more effectively. With traditional office hours, especially in large-enrollment courses, course staff are often spread thin trying to figure out who to help next. There is no clear order to which student asked a question first, and both students and course staff are left frustrated. This problem is fixed by using the Queue because it creates a clear order for both the course staff and the students. Additionally, the course staff receive notifications when a student posts a new question, which allows them to immediately see when someone needs assistance without needing to constantly monitor the Queue. Another benefit for the instructors and course staff using the Queue is that they can see a student's questions before they help them. This allows the staff to start thinking about how to help the student and to be prepared for their question when they meet up. This makes the meeting more productive since the staff helping the student has an idea of the context of the student's problem.

Beyond aiding course staff and instructors in the facilitation of open office hours, the Queue provides different classroom organization options. The Queue can enable ad-hoc organization in active learning classrooms, and can provide a platform for effective supervised office hour sign-ups, with a way to restrict the number of people attending. Additionally, the Queue's ability to assign multiple queues for one course allows courses to have queues for different types of office hours. For example, one course that utilizes the Queue at the University of Illinois has three different queues; one queue is for conceptual office hours, another is for lab office hours, and the final one is for the honors section. The different queues allow the instructors to assign staff that are experts at those topics to those queues, again making office hours more productive and efficient.

Besides the course organizational benefits, the Queue also allows instructors to collect data on the office hours held by the course. The Queue allows instructors and course staff to download their course data to analyze interactions. Course data includes the name of the student asking the question, the name of the instructor answering the question, and timestamps of when the question was asked, when the instructor started answering the question, and when the instructor finished answering the question. This information could be used to study the correlation of office hours participation with other student performance measures. It also may be used to evaluate a course staff's effectiveness at answering questions, based on feedback and timing data collected by the Queue. Lastly, this data can also help instructors make staffing decisions. It allows them to see when the busiest days and times each week occur and then staff the office hours accordingly.

2.3. Evaluation of Benefits for Space Utilization

In our use of the Queue, an immediate benefit was the ability to decentralize office hours from a single location and use the available space more efficiently. Traditional office hours are typically held in a single room. Students who need help must come to a specific location and wait for an instructor to be available before their turn. Although this can work for conceptual questions, where the instructor is able to address all of the students at once, this type of office hours doesn't scale easily to larger classes, where students may not fit in one room. The Queue allows a user to specify a location within a certain building or area, and instead of coming to the instructor, the instructor will find the student when the user reaches the top of the queue.

In many courses using the Queue at the University of Illinois, students can sit anywhere in the building and specify their location when asking a question. This allows students to sit in their preferred place and work on their assignments without the intention of going to office hours. If they happen to get stuck on a certain problem, they can simply put themselves on the queue, and then continue working towards a solution while they wait for their turn. Since a large room is no longer needed for office hours, this frees up significant space for other uses. Also, students can continue working in their desired location instead of having to go to an assigned room and wait to get a member of the course staff's attention.

One unexpected use of the Queue has been by student organizations. Without access to large spaces, student organizations can hold office hours, tutoring sessions, and other events in distributed spaces across the building. Several different student organizations have used the Queue during the Fall 2019 semester, and this novel use is something we plan to study more in future work.

2.4. Queue as a Resource in Response to COVID-19

In the transition to online courses, the Queue continued to be used to help students engage for 1:1 and small group office hours. In the first month of use, three different usage patterns have emerged from different Illinois courses using the Queue:

1. STAT/CS/IS 107: Data Science Discovery runs 1-on-1 office hours in a single virtual Zoom conference room. When a student has a question, the student will join the "waiting room" for the Zoom meeting and enqueue their question on the queue. When an instructor is available and the student is the next up on the queue, the instructor will pull the student from the waiting room into a breakout room for 1-on-1 help.
2. CS 225: Data Structures sets up 1-on-1 office hours with every student hosting their own Zoom or Google Meet conference room. When a student has a question, the student will launch their personal conference room and add themselves to the Queue with a link to their meeting room in the question text. When an instructor is available and the student is the next up on the queue, the instructor will join the student's conference room.
3. CS 241: System Programming runs 1-on-1 office hours with every instructor and staff member hosting their own Zoom or Google Meet conference room. When a student has a question, the student will join the queue. When the instructor or course staff starts answering the student's question, the student will join that staff member's meeting room for 1-on-1 help.

3. Survey and Methods

To evaluate the design of the Queue and understand new insights on how the Queue enhances users' interactions and success in courses, we performed a user survey that was given online. The survey was approved for the study under University of Illinois IRB.

The survey was administered to faculty, advisors, and staff who use the system (collectively "Queue adopters"). An initial email message invited Queue adopters to complete the survey, and after five days, a final reminder email was sent to all Queue adopters. A total of 19 adopters were identified for the survey and we received 13 responses (68% participation rate). No incentive was offered for participation.

The survey asked a range of questions (Appendix) to understand the context in which the Queue adopters use the queue (office hours, advising, etc.), the number of students the adopter teaches or supports, the assessed ease of implementation (e.g., "The Queue was easy to implement in my course/office"), and solicited general feedback on features and data collection. We found that many adopters use the Queue for multiple courses (for example, several adopters teach two different courses in a single semester and use different queues for each course) and in multiple contexts (for example, one adopter uses the Queue for both active learning and office hours).

4. Results

Primary Use	Representative Responses for Benefits of the Queue "What are the benefits of using the Queue in your case?"
Office Hours (9 survey responses)	"Usually there are a lot of students in my office hour. I used it for keeping track of sequence of students." "Managing busy office hours, especially making sure no one is being ignored." "The queue helps organize the large number of students that want help near the assignment help. The queue allows students to get help, but not have to stand in a physical queue or waste time. The queue helps course staff understand and prepare for the student's question or confusion. We use Queue data to better understand our students' learning behaviors and to ensure that all students from all backgrounds are taking advantage of office hours." "It was easy to use...no training was needed for the staff or for the students. Students could let us know in a short moment if they were available for a session." "The Queue is intuitive and keeps track of questions in the order they came in. I also consider it a good tool when it comes to fairly distributing instructor attention."

Advising (3 survey responses)	"It is great to have easily-accessible data on the number of visits and peak times, as well as a detailed record of who comes to visit us." "Ease of access to student records (we use their [student identifier] to access their student record before they enter the office)." "No need to decipher handwriting." "Students can gauge how long they might have to wait before being seen by knowing their position in the Queue."
Other (1 survey response)	"For in class, I like seeing the questions for each table and then using the queue to signal that I need to stop and bring everyone together for just-in-time learning or keep rotating table to table."

Table 1: Queue Adopter Survey Open-ended Responses.

Through the Queue Adopter Survey, we saw that the makeup users of the Queue were instructors of primarily large courses or advisors with large advising offices. Among the nine adopters who use the Queue for office hours, three of the nine courses had a course staff of 20 or more when including instructors, graduate teaching assistants, and undergraduate course aides. The average size of the course staff among survey respondents who use the queue for office hours was 13.4 staff members. Two of the three advising offices using the Queue responded with either "Nearly 1,000" and "1,000+" total students who they advised.

Likely due to the large size, the single overwhelming theme when discussing the benefits of the Queue was that the Queue both "ensured no one [student was] being ignored" and that the Queue allowed an instructor to "fairly distribute [their] attention" in helping students in office hours. Table 1 outlines representative responses for different use cases of the Queue.

In addition to understanding the benefits of the Queue, we surveyed the adopters on the ease of the implementation of the queue. Among the 12 adopters who responded to the prompt: "The Queue was easy to implement into my course/office", 8/12 (67%) responded "Strongly Agreed", 4/12 (33%) responded "Agreed", and one did not choose an answer to that prompt.

4. Discussion and Future Work
Queue adopter feedback indicated usage tracking, such as which students engaged in office hours or advising, how much time was spent, on which topics, etc. is a valuable feature of Queue. Currently, raw log data can be exported for Queue adopters who wish to analyze their usage. Future work will investigate which analytics can be included natively inside Queue, and the impacts that analysis has its usage.

As previously mentioned, several different student organizations have used the Queue during the Fall 2019 semester. We plan to look at what type of student organizations are using the Queue, how they are using it, and their feedback in future work. In general, as the usage of the Queue expands, we plan to survey new queue users and adopters who come from new departments and different contexts to see how their queue usage is similar to and different from the current users.

In addition to studying the Queue adopters, a survey was designed to investigate student Queue usage and impacts. The student survey and its analysis will be a part of our future work.

Finally, the queue is an open source tool available on GitHub at https://github.com/illinois/queue and has been deployed at the University of Illinois (UIUC) and the University of British Columbia (UBC). If you are interested in using the queue at your institution, our GitHub page has instructions and contact information to help you and your team get started.

References
[1]: Jensen, K., & Amos, J. R., & Angrave, L., & Flanagan, K., & Mussulman, D., & Schmitz, C. D., & Fagen-Ulmschneider, W. (2019, June), *Adoption of an Online Queue App for Higher Education: A Case Study* Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. https://peer.asee.org/32042

Appendix
Queue adopter survey questions
1. What is your affiliation (department or office)?
2. How do you use the Queue?
   1. Office hours
   2. Advising
   3. In-class activities
   4. Other, please specify:

Queue in Office Hours

3. How many students are in your course?
   1. Fill in
   2. N/A
4. If you use the Queue in a course, how many instructors are involved?
   1. Faculty
   2. Graduate TAs
   3. Undergraduate TAs/course assistants/course aides
   4. Other (please specify)
   5. N/A

 Queue in Advising

5. If you use the Queue for advising, how many advisees do you work with?
   1. Fill in:
   2. N/A

 Range Questions (1-7 Likert: Strongly Disagree ⇔ Strongly Agree)

6. The Queue was easy to implement into my course/office.

Short Answer Questions

7. What are the benefits of using the Queue for your use case? (short answer)
8. Are there features that you would like to see added to the platform? (short answer)
9. Is there anything else you would like to share that was not included on the survey? (short answer)

Other Questions

10. Would you be interested in exporting data from the Queue?
    1. If yes, please specify what data would be useful:
    2. List: Number of questions, why students leave the Queue/cancel, ratings of course staff, etc.
    3. Other, please specify: