IMPACT OF INSTANT AND ANONYMOUS QUESTIONS ON PARTICIPATION IN LARGE LECTURES

BY

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Computer Science
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2017

Urbana, Illinois

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Abstract

Lecture sizes of courses at large universities are increasing, which could affect participation and engagement of students. The goal of this thesis is to explore a method of increasing participation in a large lecture, which could lead to more active learning in a classroom setting with a large number of students.

Traditional approaches of using software to encourage class participation use existing social media, and usually focus on creating a discussion outside of class. Rather than focusing on increasing interaction between students, this work explores the effect of a one-way communication channel from the students to the lecturer. Specifically, I investigate how the ability to ask questions anonymously and instantly during a lecture (through a web application) can affect both the students and the lecturer.

The contribution of this thesis is a quantitative and qualitative understanding of the effect (advantages as well as shortcomings) of allowing students to ask questions instantly and anonymously during lecture. Future work can address these shortcomings and improve on these advantages, to create tools that can improve the student and teacher experience in large lectures.

To my parents, who inspire me every day through their hard work, kindness, and constant passion for learning.

Acknowledgements

This thesis would not be possible without the support and guidance of my advisor Cinda Heeren. She gave me the freedom to work on a topic that I was already passionate about, and helped me expand it in a meaningful direction. Through our discussions, she has taught me how to frame my ideas clearly, and I have learned a great deal about education and teaching from her.

I would also like to thank Craig Zilles, who has been a mentor to me more so outside of my work on this thesis. Under his guidance, I have learned so much about teaching and effective communication. His passion for teaching is contagious and he constantly inspires me to be a better educator. Working with him on CS 233 course staff has one of my greatest experiences at the University of Illinois.

Thank you to all the students who participated in the study. Their participation and feedback made this study possible, and I have learned a lot from them.

I would also like to thank my friends, who have supported and encouraged me throughout my time at the University of Illinois. In particular, I would like to thank Shilpa Subrahmanyam and Hanna Koh, not only for being great teammates in building LectureHelper, but more importantly for being my best friends for the last five years. I am also indebted to the Society of Women Engineers community, where I have made some of my best friends, who have brightened my spirits with their positivity and humor.

A huge thank you to my parents, who first introduced me to the field of Computer Science. Thank you for supporting me and encouraging me throughout my life.

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Chapter 1

Introduction

1.1 Motivation

Large class size can affect student grades at a public university. In public university, there is a negative correlation between class size and grade point average of students, across different departments, student levels, gender, and other factors [1]. There are many disadvantages associated with large class sizes. From the student perspective, asking questions may not be easy. The main reason that students state for not vocalizing questions is a fear of asking due to a potential negative reaction from the teacher and/or fellow students [2]. From the teacher perspective, it can be difficult for the lecturer to receive feedback that students are following along with the content and it can be harder to establish rapport with students [3].

This paper seeks to learn if creating a channel of instant and anonymous feedback can improve interaction in large lectures.

LectureHelper, the tool described in this paper was developed in hope of facilitating communication in large classrooms. Students who are shy or afraid of asking questions can participate in lectures anonymously. Furthermore, lecturers can receive real-time feedback about their lectures and receive questions from a potentially more representative group.

1.2 Related Work

Interaction and active learning are both established topics in educational research, but the use of software in classes to encourage interaction and active learning are more recent developments in the educational space. This section will describe related work in the educational space, moving from interactive learning to the incorporation of software into classes.

1.2.1 The Rise of Interactive Learning

In higher education, teachers have been shifting away from the Instructor paradigm to the Learner paradigm. In the Learning paradigm, the goal is for the students to gain learning, rather than the older Instructor paradigm, where teachers must simply deliver instruction. Under the Learner paradigm, the learning experience is whatever it needs to be for students to learn best. To facilitate a Learner paradigm, colleges have increasingly sought to create powerful, welcoming learning environments [4].

Active learning and increased interaction are primary topics in the pursuit of shifting to a learner-centric environment. There has been significant research on participation and interaction in lectures [5–7]. In interactive lecturing, students are actively involved in the lecture and engage with the material, content, or lecturer in a significant way. Interactive lecturing creates many learning benefits, including active involvement and a higher level of thinking, to increased attention, motivation, and enjoyment from students [5]. Not only do students learn more from active involvement and creative thinking - the lecturer can directly address their students' needs and can inspire students to become more engaged with the course material. Furthermore, the interactive lecturing experience can increase enjoyment for both the students and the lecturer. There is

an ever-expanding list of methods to create an interactive lecturing experience, and past educational research has investigated group discussions, questioning students, surveys, and debates [5].

1.2.2 Software and Learning

With the development of Web 2.0, there have been changing approaches to interactive teaching and active learning. Web 2.0 emerged in the early 2000s from the read-only Web 1.0 to read-and-write Web 2.0. In addition to some of the more traditional methods of interactive lecturing, as described above, recently, there have been attempts to utilize software and media as a learning supplement [8]. Furthermore, the capability of Web 2.0 allows the average person to contribute to, as well as access, online resources. In particular, individuals both consume and contribute in social media. Through social media, students can express their knowledge in creative ways, can use existing online resources to build knowledge, and can engage socially for collaborative learning [9]. The educational experience continues to grow as culture and technology expand and grow [8].

Online resources have expanded to the extent that knowledge can be gained entirely through the web. Blogs, wikis, podcasts, and web sharing applications are all free online resources that can be accessed easily for learning [10]. In addition, E-learning is now prevalent, particularly in the form of MOOCs (Massive Open Online Courses), where content is primarily video and discussion [11]. Social media can also aid the E-learning experience through increased communication, collaboration, community, creativity and convergence, which can help online students better learn and engage with the course material [12].

Outside of the classroom, Twitter can be utilized to discuss and reinforce concepts learned in the classroom. There have been countless studies investigating the impact of Twitter in a course [13–17]. By using Twitter to foster discussion outside of class meetings, student engagement and grades increased, and students communicated more openly in discussion [13]. Furthermore, using Twitter in this way can enhance a student's social presence, and can expand discussion on topics both related and unrelated to the course [14]. Despite these benefits, there are also significant shortcomings to utilizing Twitter, including workload issues, lower quality of interactions, ownership in public spaces, lack of support and/or reliability on Twitter, and spamming. Using Twitter in a classroom can create unnecessary distractions for students, and consequentially, an increased workload from the course staff in order to support the service and filter spammy content [18].

1.2.3 Software in the Classroom

Compared to using software outside the classroom, there has not been as much research on using software to improve real-time interaction *within* the classroom. Some research has investigated the use of social media (Twitter, Facebook, etc.) and microblogging in the class, conferences, and talks, but research on the impact of software during the class is still in early stages [13].

Microblogging has become popular at live events such as conferences and presentations. Attendees may use a hashtag to post questions, comments, ideas, and thoughts about the event, and a live stream of posts containing the hashtag is projected. This can enhance a live event by creating increased dialogue about the content and facilitating social connections between attendees [19, 20].

Within the classroom, Twitter has been used as an instant feedback tool. With this technique, students are able to Tweet or blog about the classroom content during lecture. Several professors have put this to practice in their classes, with overall positive results [21–23].

For example, a web application, "Hotseat", was developed at Purdue University to allow students and their lecturer to interact in real-time during lecture. This has been put to practice by Professor Sugato Chakravarty, a professor of consumer science and retailing at Purdue University. Chakravarty poses questions to the class and the students can respond via Facebook or Twitter. These responses are aggregated and displayed by the Hotseat app so that the lecturer can monitor student responses, answer questions, and dynamically adjust course content based on student inquiry. About 75% of students make use of Hotseat in Chakravarty's class to engage with the professor and with their fellow students. However, there are many downsides to using Hotseat. Chakravarty pointed out that he could not control the discussion while lecturing, and that it was not easy to adjust to viewing the Hotseat discussion while lecturing. Furthermore, students can easily get distracted on a popular social network such as Facebook and Twitter. Despite this noise, Chakravarty, as well as his Teaching Assistants, believe that the system's benefits outweigh the shortcomings, saying, "You have some meaningless stuff, but it's followed by some very good questions that would never be asked." [23, 24]

1.3 Research Questions

There have evidently been many different approaches to interactive learning, particularly with the use of technology and software.

Does instant feedback help increase participation in class? Can participation improve a student's engagement and learning? Does instant feedback help the lecturer, or is it more of a distraction? The study was designed to shed some light on these questions.

This study focuses on utilizing software to improve interaction in the classroom, specifically investigating the effect of instant feedback from the students to a professor in a large classroom. Rather than creating a dialogue between everyone involved in the classroom (i.e. where the professor and all of the students can view and participate in the discussion), this study focuses on understanding how a one-way channel of communication from the students to the lecturer can affect interaction in the classroom.

This approach was chosen to mitigate some of the issues that were experienced with Hotseat. The professor won't lose control of the direction of the discussion because questions cannot be viewed by other students; questions are only visible to the professor. Furthermore, by having a platform independent of existing social media, students can avoid getting distracted by social media during class. However, there may be some additional disadvantages with this approach, as it reduces the ability to interact in creative ways. Since students can only post questions to the professor, it is possible that this approach will be more limiting in creating discussion than prior research.

Chapter 2

Methodology

2.1 Design of Study

The study explores the impact of giving students the ability to ask instant and anonymous questions in a large classroom. A software tool which delivers questions asked by students to the lecturer in real-time was developed and used in this study. The tool was incorporated into one lecture (the treatment group) and the other lecture was left as is (the control group). With a control group and treatment group, this study allows us to compare participation in a classroom with and without the use of this tool. This chapter will describe the design of this study in detail.

2.1.1 Subject Demographics

The study was conducted in two CS 225 (Data Structures) lectures, which are taught by Professor Cinda Heeren, a Teaching Professor at the University of Illinois at Urbana-Champaign. CS 225 is an introductory Computer Science course that is required to earn a major in Computer Science, Electrical Engineering, and Computer Engineering, and to earn a minor in Computer Science. The demographics of the two lectures are provided below:

Gender	Male	80.33%
	Female	19.67%
College	Engineering	69.25%
	Liberal Arts & Sciences	21.33%
	Division of General Studies	7.20%
	Other	2.22%
Major	Computer Engineering	18.84%
	Electrical Engineering	17.45%
	Computer Science	15.51%
	Computer Science + X	7.76%
	Other Engineering	14.96%
	Other	25.48%
Semesters on Campus	1	1.39%
	2	33.80%
	3	2.77%
	4	42.38%
	5	1.11%
	6	15.51%
	>6	3.05%

Table 2.1: 11am Lecture (Control) Demographics

Gender	Male	84.80%
	Female	15.20%
College	Engineering	65.35%
	Liberal Arts & Sciences	20.92%
	Division of General Studies	11.25%
	Other	2.43%
Major	Computer Engineering	16.41%
	Electrical Engineering	16.72%
	Computer Science	12.16%
	Computer Science + X	6.38%
	Other Engineering	17.33%
	Other	31.00%
Semesters on Campus	1	3.65%
	2	33.13%
	3	1.82%
	4	41.03%
	5	0.61%
	6	15.50%
	>6	4.26%

Table 2.2: 2pm Lecture (Treatment) Demographics

The key takeaways from the demographics of these lecture sections are (1) women are a minority (2) the majority of students are in the College of Engineering (3) the majority of the students are Computer Science, Computer Engineering or Electrical Engineering majors (4) most students enrolled in this course are 1st-year or 2nd-year students.

2.1.2 Research Procedures

There are two different lecture sections for CS 225: the 2pm lecture was the treatment group, while the 11am section was the control group. The treatment lecture utilized LectureHelper (a web application that delivered questions asked by students to the lecturer in real-time) while the control lecture did not. LectureHelper will be described in more detail in the next chapter.

In the treatment lecture section, Professor Heeren taught a standard CS 225 lecture. While Professor Heeren taught, students were able to utilize LectureHelper (via portable electronic device) to ask questions in real-time. When possible, Professor Heeren utilized the data from LectureHelper to adjust the lecture such that she can address some of the questions asked. The treatment lecture tracked participation directly within the application (by counting the number of questions asked per day, etc.). The students could self-identify their gender when they create a LectureHelper account, but there was no other identification for the student (they can pick any username).

In the control lecture section, Professor Heeren taught the same (or very similar) CS 225 lecture that she taught to the treatment lecture. Students raised their hands to ask questions directly. The control lecture was tracked by manually counting the number of students that asked questions.

Students could only participate in anonymous, real-time questions if they used an electronic device in class. In Computer Science, most students own portable electronic devices that can access the Internet, whether it is a phone, tablet, or laptop. CS 225 was a good fit for this study in particular, because students are welcome to have electronic devices (laptops, tablets, phones, etc.) out in class and because we expected students taking CS 225 to be more comfortable with using technology and mobile devices.

At the end of the study, we asked all students to opt into participating in a survey through the LectureHelper app. The purpose of the survey is to inform future direction for further research and to understand the student perspective. The students participated in the survey through LectureHelper. This was important in particular for students from the treatement lecture because the student responses could be associated with the student's provided personal information and because survey questions could be tailored based on the student's use of LectureHelper. Furthermore, this ensured continued anonymity for the subjects. The survey questions for the treatment and control lectures are provided in the Appendix.

2.1.3 Subject Remuneration

The students did not receive tangible awards from this study (i.e. money, course credit, gift certificate, etc.). Since this study is measuring course participation, it may be possible that the study could affect the final grade of some students. It will not be possible to quantify this effect.

2.1.4 Confidentiality & Privacy

The control lecture was very similar to a typical lecture. When a question was asked, we simply marked down that a question was asked, not personal information about the person who asked the question. The participation in the LectureHelper lecture was confidential because the students were free to use any username, and we encrypted the username to an integer to prevent accidental self-identification. When the data was aggregated and analyzed for the Results section, the username field is not visible whatsoever.

The survey questions were developed as the study was ongoing, and the survey opened at the end of the semester after students had the opportunity to utilize LectureHelper for approximately two months. Responses were collected via the LectureHelper app. The responses are associated with the participant's LectureHelper account - we did not need the students' personal information. Therefore, we were able to record the interview responses without any identifying personal information.

2.1.5 Data Security

The data (student questions and interview responses) has been kept in a Postgres database in a Virtual Machine. The Virtual Machine is a secure server provided by the University of Illinois. Furthermore, the LectureHelper application uses standard security protocols for web applications. It is built from the Flask framework, which incorporates standard web and networking protocols. Furthermore, user passwords have been encrypted when saved in the database to reduce the risk of an account breach.

Any data analysis and results have been stored in Box, which will ensure a secure storage of this data on the cloud.

2.1.6 Institutional Review Board

Since this research involved human subjects, an IRB was required.

Consent was obtained through the subjects, who are CS 225 students. In lecture, all participants received a hard copy of the informed consent document tailored to their specific condition (experimental v. control) to keep. The informed consent forms for the experimental and control lectures are provided in the Appendix. Due to the nature of the study, in order to maintain anonymity, signed copies of the informed consent documents were not collected. A waiver of documentation of informed consent form was requested and approved.

Participants in the experimental lecture are prompted to consent to an electronic version of informed consent document when they create a LectureHelper account. They are blocked from accessing the application until they give consent.

2.2 LectureHelper

LectureHelper is a web application that was co-developed by Shilpa Subrahmanyam, Hanna Koh, and myself for a class project. This application was created in hope of facilitating interaction between students and their lecturer in a large lecture hall. Students and professors can create accounts, professors can create classes, students can subscribe to classes, and students can submit questions to classes. During a lecture, a professor can view all questions for a class. LectureHelper also provides visualizations of questions asked.

2.2.1 Student View

Students may subscribe to a class, and then submit questions to an ongoing lecture. In addition to the question, the student must also submit a confusion level (Low, Medium, or High), and may choose to provide tags (similar to hashtags on Twitter). The confusion level and tags may help the lecturer understand how confused students really are, as well as an overview of the questions. In future iterations of LectureHelper, students will be able to see recently used tags so that they may use the same tags as other students in the same lecture, potentially allowing questions to be grouped more effectively. At the bottom of the student view, students may view questions they have asked, listed in order of submission.

An example of the student's view during lecture when asking questions is shown below in Fig. 2.1.

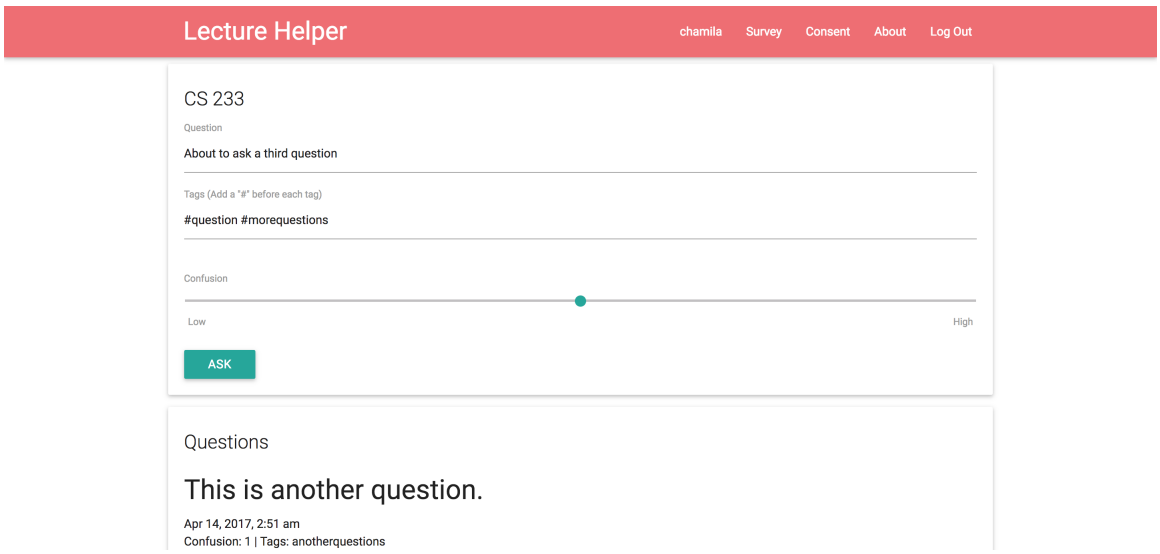


Figure 2.1: Student View Example

2.2.2 Professor View

Professors may create classes, and must share the class name and class key to students, in order for them to subscribe to the class. When students submit questions, the professor will receive the questions in his/her view. However, this runs the risk that the professor may be distracted by the inflow of questions, particularly if many questions are asked rapidly. To minimize distractions, above the list of all questions, there is a section for the best questions to address at the moment. The application uses Part-of-Speech tagging to extract keywords (Noun, singular or mass; Noun, plural; Proper noun, singular; Proper noun, plural) from questions, and uses these keywords to rank questions by relevancy. The top three most relevant questions are provided to the professor in the Best Questions section. Beneath the Best Questions section is the All Questions section, which the professor may refer to if the Best Questions section is unnecessary.

In the study, Professor Heeren used the All Questions section because questions weren't coming in quickly enough that the Best Questions filtering was necessary, and because she wanted to address all questions (she did not want to ignore filtered out questions).

An example of the professor's view during lecture when viewing questions is shown below in Fig. 2.2.

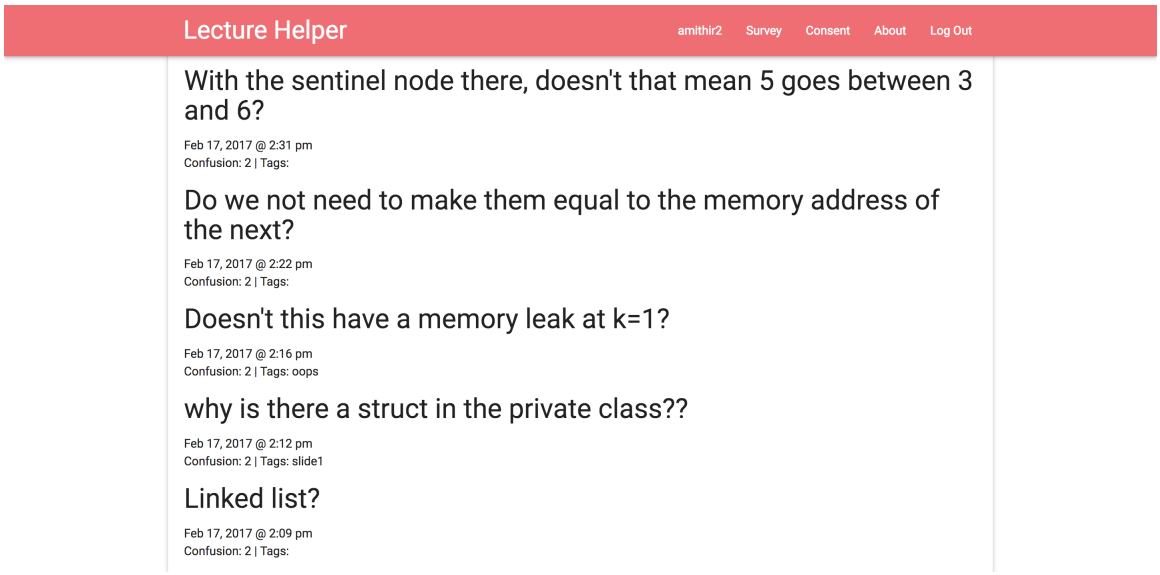


Figure 2.2: Professor View Example

2.2.3 Timeline View

Professors utilizing LectureHelper may also take advantage of the timeline functionality. This visualizes all questions asked in a lecture in a timeline by time asked and confusion. Each question is represented on the timeline as a circle. The circle's color (yellow, orange, or red) represents the confusion level of the question, and the x-location of the circle represents the time the question was asked. The professor may hover over a circle to see the question text. This view also separately visualizes question tags; the font size of a tag represents the number of questions that were asked containing that tag.

This functionality was provided so that professors could review a lecture afterwards, particularly to identify common questions/topics. Professor Heeren did not utilize timelines during the study.

An example of the timeline view for the lecture on 2/15/2017 is shown below in Fig. 2.3.

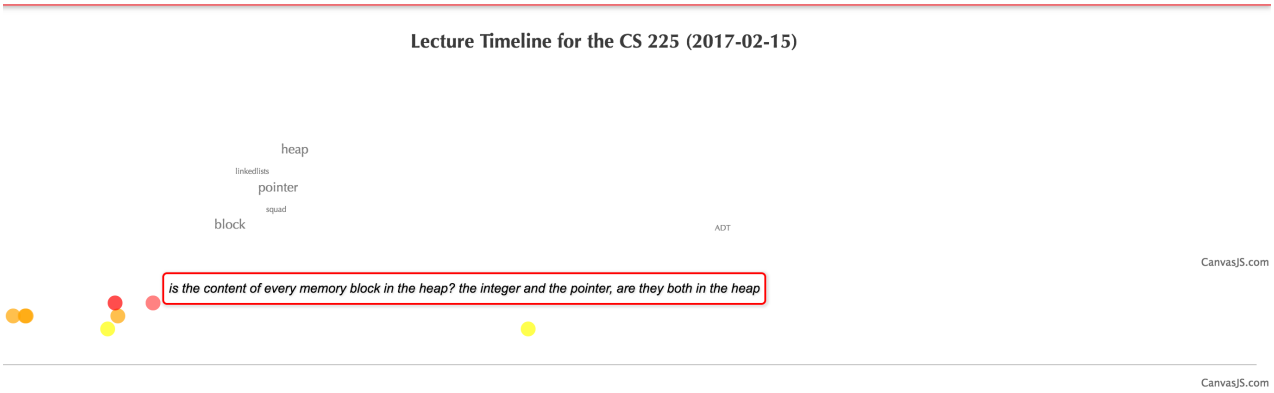


Figure 2.3: Timeline View Example

2.3 Adjustment of Study

During the study, there were several adjustments made to LectureHelper to make the transition to using LectureHelper smoother for the lecturer and students.

Week 1:

- The first time that Professor Heeren used LectureHelper in class, she found it distracting. While lecturing, it was distracting for her to pause the lecture materials to read, process, and answer incoming questions.
- Initially, the Best Questions section took the 10 most recently asked questions, without limiting the time since the question was asked. This was causing questions from previous lectures to appear in the Best Questions section. A filter was added to only query questions that were asked within the last hour.
- When using the Best Questions section, Professor Heeren didn't see some questions, and missed out on an opportunity to answer the question. After this, she decided to always utilize the All Questions section.

Week 2:

- The Best Questions section took the 10 most recently asked questions, and filtered by questions asked within the last hour. However, since the subject matter changed quickly within a lecture, questions about earlier topics would stay in the Best Questions section, while new questions about new topics would take a while to appear in the Best Questions section. The filter was modified to only query questions that were asked within the last 15 minutes.
- Professor Heeren still had some trouble noticing new questions, so she requested something to draw attention to new questions. LectureHelper was updated so that new questions would be displayed in red text for approximately 15 seconds, before turning into black text.

Chapter 3

Implementation

LectureHelper is a web application written in Python, JavaScript and HTML. It uses the Flask web framework, which utilizes WSGI toolkit and Jinja2 template engine, to manage the relationship between the client and the server. On the front-end, the application uses Google's Materialize for a simple, intuitive, and mobile-friendly interface for users, and Canvas.js for the timeline visualization. The application uses PostgreSQL to manage its database. The application is publicly deployed on Heroku, and a demo can be accessed at `lecture-helper.herokuapp.com`. For the purposes of this project, it was deployed on the University of Illinois server, where it can be accessed at `http://lecturehelper.cs.illinois.edu`. It was deployed on the secure University network for use on an actual University course and can only be accessed from within the University network.

The main goal of LectureHelper is to deliver questions asked by students to the lecturer in real-time. However, this tool also has additional capabilities that aren't available in a conventional classroom, which may allow students and their lecturer to interact in richer ways.

3.1 Question Ranking

The term frequency-inverse document frequency (TF-IDF) algorithm is used to quickly rank the questions. The ten most recently asked questions within the last 15 minutes are retrieved. Each question is tokenized and stemmed using a Porter stemmer from the Natural Language Toolkit (NLTK) package in Python. The TF-IDF algorithm is then applied. Each question is given a score by summing TF-IDF for each term in the question. Finally, the retrieved questions are sorted by score, and the three questions with the highest scores are displayed to the professor in the Best Questions section.

Term Frequency

$$tf(t,d) = \frac{f_{t,d}}{\sum_{t' \in d} f_{t',d}}$$

where t is a word,

d is a question, and

$f_{t,d}$ is the raw count of word t in question d

Inverse Document Frequency

$$idf(t) = \log \frac{N}{n_t}$$

where N is the total number of questions,

n_t is the number of questions in which the word t occurs

Term Frequency-Inverse Document Frequency

$$tfidf(t,d) = tf(t,d) \times idf(t)$$

Question Score

$$score(d) = \sum_{t' \in d} tfidf(t',d)$$

Chapter 4

Results

4.1 Quantitative Results

Participation of students in the two lectures were tracked. The questions asked in LectureHelper were counted by the web application itself, while verbal questions were counted by myself through lecture attendance and video replays (all CS 225 lectures are recorded independently of the study). Furthermore, the responses from the student survey were extracted and analyzed.

4.1.1 Overall Participation

	Experimental			Control	
Date	LectureHelper	Verbal Questions	Total	Verbal Questions	Total
Lecture 1 (2/13/2017)	17	4	21	14	14
Lecture 2 (2/15/2017)	8	6	14	12	12
Lecture 3 (2/17/2017)	12	4	16	8	8
Lecture 4 (2/20/2017)	2	2	4	2	2
Lecture 5 (2/22/2017)	5	6	11	5	5
Lecture 6 (2/24/2017)	6	2	8	9	9
Lecture 7 (2/27/2017)	5	4	11	10	10
Lecture 8 (3/1/2017)	1	4	5	1	1
Lecture 9 (3/3/2017)	0	4	4	6	6
Lecture 10 (3/6/2017)	2	3	5	5	5
Average (first half)	5.80	3.90	9.70	7.20	7.20
Hiatus (Instructor Travel & Spring Break)					
Lecture 11 (3/27/2017)	1	1	2	7	7
Lecture 12 (3/29/2017)	0	0	0	2	2
Lecture 13 (3/31/2017)	0	4	4	7	7
Lecture 14 (4/3/2017)	0	3	3	7	7
Lecture 15 (4/5/2017)	0	8	8	6	6
Lecture 16 (4/7/2017)	1	4	5	2	2
Lecture 17 (4/10/2017)	1	4	5	6	6
Lecture 18 (4/12/2017)	0	2	2	7	7
Lecture 19 (4/14/2017)	1	9	10	6	6
Average (second half)	0.44	3.89	4.33	5.56	5.56
Net Average	3.26	3.89	7.16	6.42	6.42

Table 4.1: Question Counts for Experimental and Control Lectures

Overall, the experimental lecture asked slightly more total questions than the control lecture, despite the control lecture having more verbal questions.

The drop-off in participation is evident in verbal questions as well as experimental questions. As the semester progressed, students asked fewer questions in the traditional method (by raising their hands). This effect is magnified in the LectureHelper questions. This could be because students forgot that LectureHelper was available, especially after the hiatus of instructor travel and spring break.

4.1.2 LectureHelper Participation

In LectureHelper, 64 students were subscribed to CS 225. Of these students, 41 self-identified as male, 11 self-identified as female, and 12 self-identified as non-binary. The demographics of the participants are reflective of the lecture demographics, as described in Section 2.1.1.

Out of the subscribed students, 14 students participated in CS 225 by asking questions via LectureHelper. Of these students, 11 self-identified as male, 0 self-identified as female, and 3 self-identified as non-binary. These 14 participants asked a total of 62 questions in CS 225 via LectureHelper.

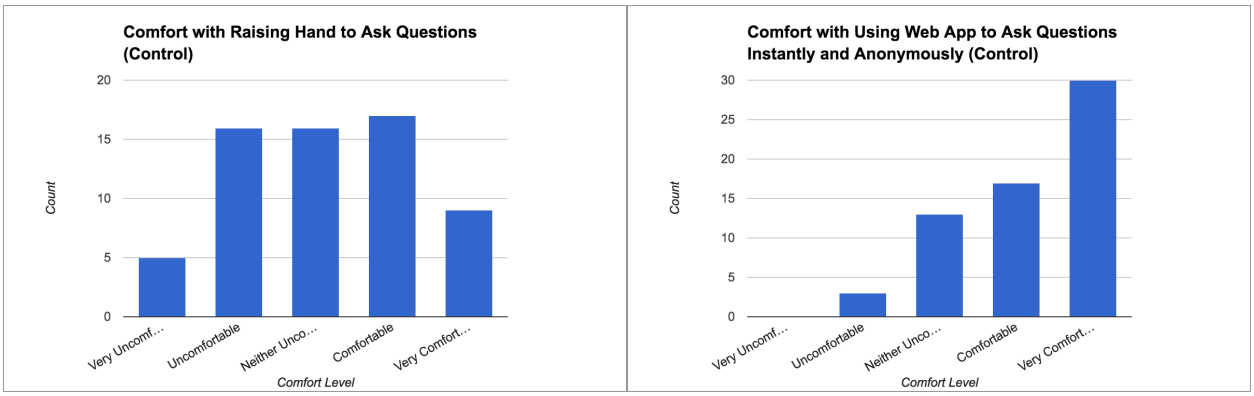
User 3 (self-identified as gender non-binary) asked 16 questions, User 10 (self-identified as gender non-binary) asked 15 questions, User 4 (self-identified as male) asked 7 questions, and User 13 (self-identified as gender non-binary) asked 6 questions. The other 10 participants asked the rest of the questions (each asking 1-4 questions), and all identified as male.

Given the option to ask questions anonymously and virtually, only 14 students actually utilized this tool. Furthermore, it is clear that they asked significantly more questions than they would have without LectureHelper, and that the top participants asked a disproportionately large number of questions.

4.1.3 Student Survey

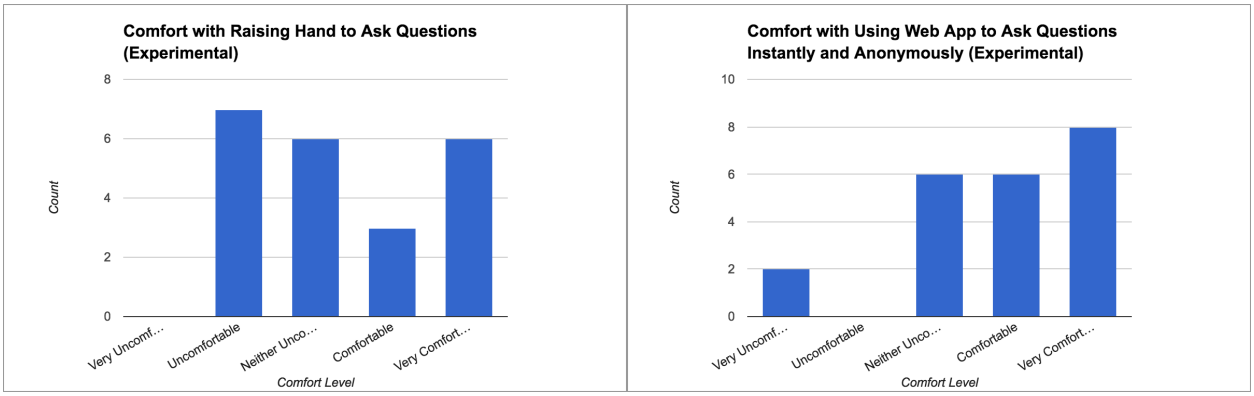
Of the experimental lecture, 22 students completed the experimental survey, out of which 1 had actually used LectureHelper to ask questions in class. Of the control lecture, 63 students completed the control survey. The surveys were completed at the end of the semester, after the students had experienced a full semester of CS 225 lecture.

Overall, students stated that they were more comfortable using a tool to ask questions instantly and anonymously compared to raising their hand to ask questions. Both subsets of students (control and experimental) each stated that they were more comfortable using a tool to ask questions instantly and anonymously compared to raising their hand to ask questions, with the control group having a more significant gap between the two options than the experimental group (Fig. 4.1, Fig. 4.2).



(a) $\mu = 3.14$ **(b)** $\mu = 4.17$

Figure 4.1: Control Lecture

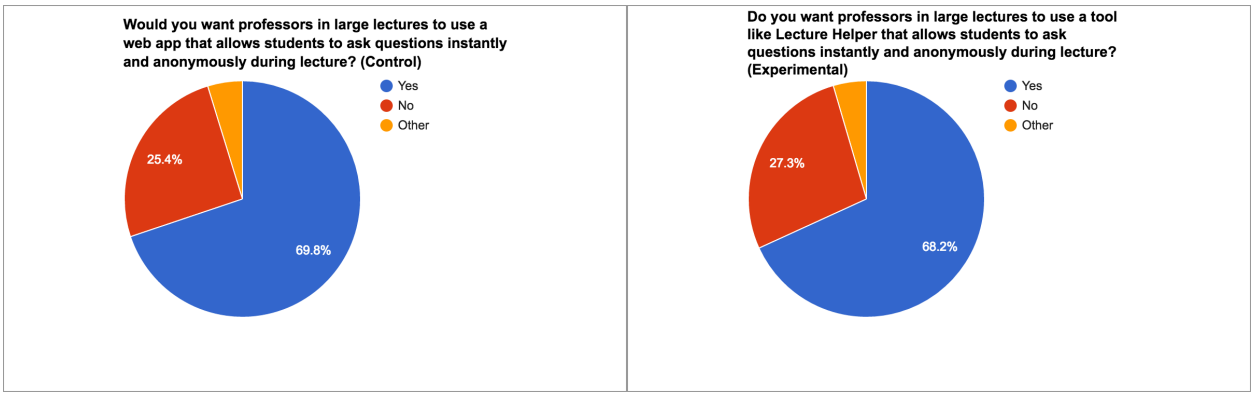


(a) $\mu = 3.36$ **(b)** $\mu = 3.82$

Figure 4.2: Experimental Lecture

Of the 63 control group survey participants, 44 participants (69.8%) indicated that they would use a web application to ask questions instantly and anonymously during CS 225 lecture, 16 participants (25.4%) indicated the opposite (that they wouldn't use a web application to ask questions during CS 225 lecture), and 3 participants (4.8%) answered other (Fig. 4.3a).

Of the 22 experimental group survey participants, 15 participants (68.2%) indicated that they wanted professors in large lectures to use a tool like LectureHelper that allows students to ask instant and anonymous questions during lecture, 6 participants (27.3%) indicated the opposite (that they wouldn't want a professor to use a tool like LectureHelper during lecture to facilitate questions), and 1 participant (4.5%) answered other (Fig. 4.3b).



(a) **(b)**

Figure 4.3: Should professors use a web application to facilitate instant and anonymous questions during lecture?

Of the 63 control group survey participants, 33 participants (52.4%) indicated that they would ask more questions if a web application was available to them to ask questions instantly and anonymously during CS 225 lecture, 26 participants (41.3%) indicated the opposite (that they wouldn't ask more questions if a web application to ask questions during CS 225 lecture was available to them), and 4 participants (6.3%) answered other.

Of the 22 experimental group survey participants, 10 participants (45.5%) indicated that the accessibility issues with LectureHelper impeded their ability to to participate in LectureHelper, and 12 participants (54.5%) indicated that the accessibility issues with LectureHelper did not affect their participation in LectureHelper. Of the 10 participants with accessibility issues, in a separate question, 9 participants (90%) indicated that if LectureHelper was available outside of the University network, they would have participated more.

4.2 Qualititative Results

The professor interview explores in-depth some of the benefits and disadvantages of using LectureHelper as a tool to ask questions.

4.2.1 Professor Experience

Overall, Professor Heeren found that using LectureHelper in class was a positive and productive experience. She felt that LectureHelper created an opportunity for students to ask questions, particularly the students that might not have participated otherwise.

In terms of her experience of using the tool in class, Prof. Heeren needed some adjustment time to get used to glancing at the LectureHelper interface during lecture. After this adjustment period, she used the tool to glance at the questions in batch and then address them in lecture. Rather than using the Best Questions section, she chose to utilize the All Questions section, so that she could address all questions. She addressed questions in two different ways: (1) by using the questions as a cue to direct the classroom discussion or (2) by stopping to answer the question explicitly. Neither of these methods were easier or better; she made decisions about how to answer a question in the moment and she used the method that was best suited for the question. Prof. Heeren noted that a key issue in using LectureHelper was the lack of adoption and participation. She said that she wasn't sure what caused this but she recommended some methods to encourage adoption:

- Having the tool URL on every lecture slide
- Potentially making questions visible to the entire class
- Modifying the interface to encourage continued interaction/following up with an asked question.
- Following up with all questions on Piazza (the class forum) and posting answers to questions on Piazza.

There were several novel and interesting occurrences of how students utilized LectureHelper during class. Some students utilized LectureHelper to answer questions posed by the professor to the entire class. Furthermore, Prof. Heeren didn't realize that she would have two different techniques to address questions (explicitly or implicitly), and so in the moment, she picked whichever technique that worked for her and for the question.

Prof. Heeren recommended that this tool would be ideal for a course in which students regularly have a laptop open during class. This would make it more convenient for the student, and the student would not have to go out of their way to open a device (and get distracted) simply to ask a question.

4.2.2 Problems Encountered

There were several factors that hampered this study.

Since this study was conducting University research and collecting confidential data, the LectureHelper web application needed to be hosted on a University server. Due to security restrictions associated with hosting websites on the University servers, the website was only accessible from the University network, that is, IllinoisNet WiFi or Illinois VPN. At the beginning of the study, we anticipated that most students would use the IllinoisNet WiFi, as it is provided for free in many university buildings and devices automatically connect to this WiFi network. However, many students actually used faster alternatives such as public Wi-Fi networks or data to access the Internet. Furthermore, most students were unwilling to open a VPN connection. In the student survey, a large number of students acknowledged that this network issue hampered their ability to participate via LectureHelper.

We also noticed that as the semester progressed, participation in LectureHelper dropped significantly. If students were not reminded that LectureHelper was an option to utilize during lecture, students were less likely to make use of it. In the student survey, students described the following as reasons for not participating in LectureHelper:

- Unwillingness to connect University network
- Unwillingness to switch from viewing lecture slides to the LectureHelper site
- Not knowing that LectureHelper is an option to ask questions
- Not having a question to ask
- Preference for more convenient approaches to ask questions, such as Piazza (which has a 13 min response rate to questions) and office hours.

Furthermore, in lecture, some students explicitly stated that as the end of the semester was approaching, they became less willing to actively participate in lecture.

CS 225 utilizes Piazza, a Question & Answer web service, where students can anonymously post questions, and instructors or other students can answer. The average response time for CS 225 is 13 minutes, so the

student questions are usually not addressed immediately, but they are addressed very quickly. Since there already exists a resource to ask questions anonymously and quickly, students in the survey expressed that the functionality of LectureHelper may be redundant. Even though LectureHelper is a different use case (LectureHelper should be used during lecture, Piazza should be used outside of class meeting times), students can (and do) post lecture questions on Piazza.

It is also important to note that Professor Heeren is also the advisor for this thesis, raising the possibility of bias in this study. As the advisor for this thesis, Professor Heeren was invested in making LectureHelper work. Regardless, in order to use an application like LectureHelper, the lecturer must be willing to commit to utilizing it and would need be invested in making it work. Furthermore, this study focuses on the effect on students, not the lecturer. In terms of perceived bias from the students, this was an important component of the IRB consent form. When presenting the study to the subjects, we were required to talk about this in detail to reduce any perceived coercion. It was made clear that participation in this study is optional and anonymous and would not affect their performance in CS 225. To emphasize the separation between the study and grades/performance in CS 225, it was also emphasized that Professor Heeren would only be involved in the study in an advising capacity.

Chapter 5

Conclusions and Future Work

5.1 Future Work

This study is a preliminary look at the impact of using software to facilitate questions during lecture. This study could be expanded in many different ways.

First of all, there were several issues with this study, primarily the accessibility issues with LectureHelper and the lack of participation on LectureHelper. If students are not impeded by accessibility issues, it is possible that this would have led to more participation, especially as indicated by most of the survey respondents from the experimental group.

This study could be replicated with different courses, particularly with different teachers and in different subjects.

Furthermore, this study could be extended to discover if students who ask questions in real-time have improved performance in the course. Another study could be conducted, where the questions remain anonymous in the Professor View, but the students can still be associated with their grades in the class. At the end of the course, participation and performance could be analyzed, specifically looking for a statistically significant increase or decrease in course performance for students utilizing LectureHelper to ask questions.

This study could also be extended to discover if there is a correlation between gender identification and engagement. Computer Science is a subject that is male-dominated, and women are less likely to participate in science, technology, engineering, and mathematics (STEM) classes compared to men [25]. If anonymous questions can improve the participation and engagement of a minority group in the classroom, LectureHelper could be helpful in leveling the educational playing field for minority groups.

The technology utilized in this study could be expanded in many different ways. After asking a question, students could provide additional feedback to the professor about whether their question was answered or not. If the student does not feel that their question was addressed, this feedback would indicate to the professor that they need to be more explicit with their answer. When the question is satisfactorily answered, the professor would be able to know that the student is no longer confused, and this could help student remain engaged with the class.

Finally, this approach of using technology to post questions during large lectures could be downsized to smaller sections like discussion or lab. For example, in a discussion section where students must work on a worksheet, students could post a question or answer a question posed by the teacher once they reach a certain checkpoint. This would allow the teacher to track the progress of all of the students, and to even visualize the progress of different groups. Furthermore, if students have common misunderstandings or incorrectly answer the question posed by the teacher, the teacher will be able to identify key concepts that they should review to the entire class.

5.2 Conclusion

This work is a preliminary investigation on a new method of engagement in a classroom. This study shows that one-way, instant feedback can be used as a channel for communication in a large classroom. However, there was no significant difference in participation between the treatment lecture and the control lecture.

The overall reaction to a web application to ask questions in lecture was mixed. Despite a majority of the control lecture indicating that they would utilize a web application to ask questions instantly and anonymously in lecture, a majority of students in the treatment lecture chose not to utilize LectureHelper. This could be because (1) the University network impeded students' accessibility to LectureHelper (2) LectureHelper's user interface was not effective for the students' question asking needs (3) in practice, students are unwilling to utilize a web application to ask questions instantly and anonymously for a variety of reasons.

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Appendix A

IRB Consent Form (Control)

Impact of Real Time Question Facilitation on Course Engagement

You are being asked to participate in a research study. Researchers are required to provide a consent form such as this one to tell you about the research, to explain that taking part is voluntary, to describe the risks and benefits of participation, and to help you to make an informed decision. You should feel free to ask the researchers any questions you may have.

Principal Investigator Name and Title: Cinda Heeren, Teaching Professor
Department and Institution: Department of Computer Science
Address and Contact Information: Contact Chamila Amithirigala at amithir2@illinois.edu
Sponsor: N/A

Why am I being asked?

You are being asked to be a subject in a research study about course engagement in large courses.

You have been asked to participate in the research because you are enrolled in CS 225.

Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future dealings with the University of Illinois at Urbana-Champaign. **If you decide to participate, you are free to withdraw at any time without affecting that relationship.**

Approximately 800 subjects may be involved in this research at the University of Illinois at Urbana- Champaign.

What is the purpose of this research?

We want to find out if giving students the ability to ask questions instantly and anonymously will improve the number of questions asked, particularly in large lectures such as CS 225.

What procedures are involved?

This research will be performed in CS 225 lectures.

You will need to come to the study site ECEB 1002 (i.e. attend class) 3 times/week over the next 12 weeks.

Each of those visits will take about 50 minutes.

The study procedures are as follows: During class, you will be able to ask questions in the standard method (by raising one's hand and asking in person). The amount of questions asked in your lecture will be compared to the amount of questions asked in the experimental lecture.

What are the potential risks and discomforts?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life. Your grades will not be impacted by your choice to participate or not participate in this study. Furthermore, graduate student Chamila Amithirigala will be coordinating this study and she is not a CS 225 TA, so she cannot influence your grades.

Are there benefits to taking part in the research?

This study is not designed to benefit you directly. This study is designed to learn more about course engagement in large lectures. The study results may be used to help other people in the future.

What other options are there?

You have the option to not participate in this study.

Will my study-related information be kept confidential?

Faculty, students, and staff who may see your information will maintain confidentiality to the extent of laws and university policies. Personal identifiers will not be published or presented.

What are the costs for participating in this research?

There are no costs to you for participating in this research.

Will I be reimbursed for any of my expenses or paid for my participation in this research?

You will not be offered payment for being in this study.

Can I withdraw or be removed from the study?

If you decide to participate, you are free to withdraw your consent and discontinue participation at any time.

The Researchers also have the right to stop your participation in this study without your consent if:

- They believe it is in your best interests;
- You were to object to any future changes that may be made in the study plan;

Who should I contact if I have questions?

Contact the researchers Chamila Amithirigala at amithir2@illinois.edu:

- if you have any questions about this study or your part in it,
- if you have questions, concerns or complaints about the research.

What are my rights as a research subject?

If you feel you have not been treated according to the descriptions in this form, or if you have any questions about your rights as a research subject, including questions, concerns, complaints, or to offer input, you may call the Office for the Protection of Research Subjects (OPRS) at 217-333-2670 or e-mail OPRS at irb@illinois.edu

What if I am an Illinois student?

You may choose not to participate or to stop your participation in this research at any time. This will not affect your class standing or grades at UIUC. The investigator may also end your participation in the research. If this happens, your class standing or grades will not be affected. You will not be offered or receive any special consideration if you participate in this research.

What if I am an Illinois employee?

Your participation in this research is in no way a part of your university duties, and your refusal to participate will not in any way affect your employment with the university, or the benefits, privileges, or opportunities associated with your employment at the University of Illinois at Urbana-Champaign. You will not be offered or receive any special consideration if you participate in this research.

Remember:

Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting that relationship.

I have read (or someone has read to me) the above information. I have been given an opportunity to ask questions and my questions have been answered to my satisfaction. I agree to participate in this research. I will be given a copy of this signed and dated form.

Signature: _____
Printed Name: _____
Date: _____

Signature of Person Obtaining Consent: _____
Printed Name of Person Obtaining Consent: _____
Date(must be same as subject's): _____

Appendix B

IRB Consent Form (Experimental)

Impact of Real Time Question Facilitation on Course Engagement

You are being asked to participate in a research study. Researchers are required to provide a consent form such as this one to tell you about the research, to explain that taking part is voluntary, to describe the risks and benefits of participation, and to help you to make an informed decision. You should feel free to ask the researchers any questions you may have.

Principal Investigator Name and Title: Cinda Heeren, Teaching Professor
Department and Institution: Department of Computer Science
Address and Contact Information: Contact Chamila Amithirigala at amithir2@illinois.edu
Sponsor: N/A

Why am I being asked?

You are being asked to be a subject in a research study about course engagement in large courses.

You have been asked to participate in the research because you are enrolled in CS 225.

Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future dealings with the University of Illinois at Urbana-Champaign. **If you decide to participate, you are free to withdraw at any time without affecting that relationship.**

Approximately 800 subjects may be involved in this research at the University of Illinois at Urbana- Champaign.

What is the purpose of this research?

We want to find out if giving students the ability to ask questions instantly and anonymously will improve the number of questions asked, particularly in large lectures such as CS 225.

What procedures are involved?

This research will be performed in CS 225 lectures.

You will need to come to the study site ECEB 1002 (i.e. attend class) 3 times/week over the next 12 weeks.

Each of those visits will take about 50 minutes.

The study procedures are as follows: During class, you will be able to ask questions anonymously and almost instantly to your professor, Cinda Heeren, through your Lecture Helper account. The amount of questions asked in your lecture will be compared to the amount of questions asked in typical lectures (i.e. lectures in which questions are asked by raising one's hand and asking in person).

What are the potential risks and discomforts?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life. Your grades will not be impacted by your choice to participate or not participate in this study. Furthermore, graduate student Chamila Amithirigala will be coordinating this study and she is not a CS 225 TA, so she cannot influence your grades.

Are there benefits to taking part in the research?

You may directly benefit from increasing your engagement through Lecture Helper, but no benefits are guaranteed.

What other options are there?

You have the option to not participate in this study. At any point in this study, you may choose to withdraw, and you can do so by simply stopping to use the Lecture Helper web app.

Will my study-related information be kept confidential?

Faculty, students, and staff who may see your information will maintain confidentiality to the extent of laws and university policies. Personal identifiers will not be published or presented.

What are the costs for participating in this research?

There are no costs to you for participating in this research.

Will I be reimbursed for any of my expenses or paid for my participation in this research?

You will not be offered payment for being in this study.

Can I withdraw or be removed from the study?

If you decide to participate, you are free to withdraw your consent and discontinue participation at any time. You can do so by simply stopping to use the Lecture Helper web app.

The Researchers also have the right to stop your participation in this study without your consent if:

- They believe it is in your best interests;
- You were to object to any future changes that may be made in the study plan;

Who should I contact if I have questions?

Contact the researchers Chamila Amithirigala at amithir2@illinois.edu:

- if you have any questions about this study or your part in it,
- if you have questions, concerns or complaints about the research.

What are my rights as a research subject?

If you feel you have not been treated according to the descriptions in this form, or if you have any questions about your rights as a research subject, including questions, concerns, complaints, or to offer input, you may call the Office for the Protection of Research Subjects (OPRS) at 217-333-2670 or e-mail OPRS at irb@illinois.edu

What if I am an Illinois student?

You may choose not to participate or to stop your participation in this research at any time. This will not affect your class standing or grades at UIUC. The investigator may also end your participation in the research. If this happens, your class standing or grades will not be affected. You will not be offered or receive any special consideration if you participate in this research.

What if I am an Illinois employee?

Your participation in this research is in no way a part of your university duties, and your refusal to participate will not in any way affect your employment with the university, or the benefits, privileges, or opportunities associated with your employment at the University of Illinois at Urbana-Champaign. You will not be offered or receive any special consideration if you participate in this research.

Remember:

Your participation in this research is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting that relationship.

I have read (or someone has read to me) the above information. I have been given an opportunity to ask questions and my questions have been answered to my satisfaction. I agree to participate in this research. I will be given a copy of this signed and dated form.

Signature: _____
Printed Name: _____
Date: _____

Signature of Person Obtaining Consent: _____
Printed Name of Person Obtaining Consent: _____
Date(must be same as subject's): _____

Appendix C

Survey for Treatment Lecture

* Required

1. How comfortable do you feel raising your hand to ask questions in CS 225 lecture? *
   Response: Slider with range [1, 5], where 1 is Very Uncomfortable and 5 is Very Comfortable

2. How comfortable do you feel using a tool like LectureHelper to ask questions instantly and anonymously in CS 225 lecture? *
   Response: Slider with range [1, 5], where 1 is Very Uncomfortable and 5 is Very Comfortable

3. Do you want professors in large lectures to use a tool like LectureHelper that allows students to ask questions instantly and anonymously during lecture? *

   - Yes
   - No
   - Other: _____

4. Did LectureHelper's lack of accessibility outside the University network (i.e. outside of University Wi-Fi or VPN) affect your participation in LectureHelper? *

   - Yes, I participated in LectureHelper less because of the University network requirement.
   - Yes, I participated in LectureHelper more because of the University network requirement.
   - No, the University network requirement did not affect my participation in LectureHelper.
   - Other: _____

5. If LectureHelper were accessible outside the University network (i.e. outside of University Wi-Fi or VPN), would you have participated more through LectureHelper? *
   Select N/A if you selected No for the previous question.

   - Yes
   - No
   - N/A
   - Other: _____

The following questions were asked if the participant had asked at least one question via LectureHelper in lecture:

1. Do you think that you asked more questions in CS 225 lecture because LectureHelper was available to you? *

   - Yes
   - No

- Other: _____

2. Participation through LectureHelper significantly dropped at the end of the semester. Why did you stop asking questions through LectureHelper in CS 225 lecture? *
   Response: Long text response

3. Did you feel that the professor saw your question(s) asked through LectureHelper in a timely manner? *
   - Yes
   - No
   - Other: _____

4. Did you feel that the professor answered your question(s) asked through LectureHelper? *
   - Yes
   - No
   - Other: _____

5. How do you want the professor to address your LectureHelper questions in lecture? *
   - I prefer the professor explicitly repeating my question and then answering it.
   - I prefer the professor smoothly incorporating the answer to my question into the lecture content.
   - Other: _____

6. Briefly describe any benefits that you experienced from utilizing LectureHelper in CS 225 lecture.
   Response: Long text response

7. Briefly describe any disadvantages that you experienced from utilizing LectureHelper in CS 225 lecture.
   Response: Long text response

The following question was asked if the participant had not asked any questions via LectureHelper in lecture:

1. Briefly describe why you chose not to ask questions through LectureHelper in CS 225 lecture. *
   Response: Long text response

Appendix D

Survey for Control Lecture

* Required

1. How comfortable do you feel raising your hand to ask questions in CS 225 lecture? *
   Response: Slider with range [1, 5], where 1 is Very Uncomfortable and 5 is Very Comfortable

2. How comfortable would you feel using a web app to ask questions instantly and anonymously in CS 225 lecture? *
   Response: Slider with range [1, 5], where 1 is Very Uncomfortable and 5 is Very Comfortable

3. Would you want professors in large lectures to use a web app that allows students to ask questions instantly and anonymously during lecture? *

   - Yes
   - No
   - Other: _____

4. Do you think that you would have asked more questions in CS 225 lecture if you could ask questions instantly and anonymously through a web app? *

   - Yes
   - No
   - Other: _____

5. Briefly describe any benefits that you would experience if you could ask questions instantly and anonymously during lecture through a web app.
   Response: Long text response

6. Briefly describe any disadvantages that you would experience if you could ask questions instantly and anonymously during lecture through a web app.
   Response: Long text response