LARGE LECTURES ARE HARD:
AN EXPLORATION IN MEANINGFUL SOCIAL VISUALIZATIONS FOR LARGE GROUP COMMUNICATION

BY

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THESIS

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ABSTRACT

Large lectures are a difficult and complicated area of exploration, both technologically and socially. Here is presented a discussion of existing areas of investigation related to large lectures, including fostering crowd engagement, backchannel communication, and various classroom communication technologies. Next, work is reviewed regarding a system for real-time classroom interaction, the Fragmented Social Mirror (FSM), as well as the results that were seen with the FSM in a pilot study. The design of a continuance of the first FSM study is then presented, an interview study designed to elicit feedback from instructors regarding classroom communication technology. Preliminary results from this interview study are presented with commentary and suggestions for future directions.

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"Climb.
Climb to the top of the world.
And as you stand tall, you will see that,
When you fall,
You will fall from a height most men will never reach."

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CHAPTER 1: INTRODUCTION

"And my main thought about all this is, lectures are over.
That's a style of teaching that is over, and we have got to find something else."

The lecture is a centuries-old paradigm in academia, and is the modern-day format for many large teaching arrangements. It is also a format that has historically been arranged around a single presenter, and has provided limited opportunities for engagement by audience members. Part of this is a time concern, in that large lectures often do not have enough time to field one-on-one interaction with a large number of audience members. Another concern is that of the social dynamic of lectures, as it is sometimes expected that the collective interruption brought on by audience interaction will be too great, so as to make crowd feedback in large audiences infeasible. A number of systems and strategies to date have attempted to address this problem area of large crowd feedback, with the result being more of a continued dialogue in teaching than one unified platform. Additionally, in the face of paradigms such as the ubiquitous projected slides, it has been difficult for a new technology or strategy to break into lectures, as the cost of a full paradigmatic shift must be justified by concrete gains in teaching outcomes.

In this exposition, I assert that large lectures are a difficult and complicated area of exploration, both technologically and socially. On the one hand, classroom technology available to faculty and lecturers tends to fit a limited number of teaching strategies, namely that of the presentation. It behooves the designers of new technological extensions in the classroom to adapt to existing facilities. On the other hand, students and lecturers alike are largely comfortable with the existing presentation style, despite both sides finding plenty of faults within it. New extensions must be mindful of the cognitive burdens imposed by any system, of the potentials for abuse of more verbose systems, of learning outcomes and how those are affected by presentation style, and of the perceptions of any system by both lecturers and participants alike.

I present here first a discussion of existing areas of investigation related to large lectures, including perspectives on communication and technology alike. I then present work that we reported on a novel system, the Fragmented Social Mirror (FSM), and the results that we saw with the FSM in a pilot study. I will discuss briefly our design goals for a new iteration of the FSM, and I will then present the methodology of a study underway right now to gauge lecturers' perspectives on large lectures and our system, as well as presenting some preliminary results from this second study. Finally, I will discuss future directions for any such work in this field, based on the feedback across both studies that we have received, as there is always yet more to be done.

CHAPTER 2: BACKGROUND

Effective group communication has been a topic of investigation for centuries, and there are immeasurable volumes of academic and anecdotal literature on the subject at large. To be sure, it is not our goal here to cover comprehensively the entirety of group communication, as such an attempt in a single document would not do justice to the field. We will instead narrow our focus to a handful topics relevant to large group communication in a lecture setting: fostering crowd engagement, backchannel communication, and various classroom communication technologies.

2.1 Crowd Engagement

Capturing the crowd, especially in an academic setting, is both a necessary task and a skill to be cultivated by the presenter. Without adequate incentive for attention and participation, learning outcomes become only a passing ideal. Cothran and Ennis, in line with work previous to theirs, found that students' belief in the relevance of their education and in the legitimacy of rules governing their interaction were major factors affecting students' learning outcomes [9]. Referencing work by Grant, they find that faculty and students alike are aware of the "crowding problem" in large groups, which is essentially a negative correlation between class size and students' sense of belonging and social connection [9]. Going further, understanding how to successfully engage and command a crowd has safety implications as well, as Johansson et al suggest in their analysis and modeling of high-density group dynamics [23]. It is interesting as well that research into commanding crowds spans as diverse a set of literature as this, from physical education to physics! Surely, there is room for improvement, from almost any angle.

Many attempts have been made to successfully capture the crowd to some productive end. Work out of crowd-sourcing literature suggests methods for fast collaborative problem-solving and task management. Bernstein et al, for instance, demonstrate a handful of interfaces for collaborative photo processing and animation [6]. Dow et al suggest a platform for crowd-driven managership and feedback, whereby a small cabal of automatically selected managers oversee the work of a larger group of similarly selected workers, leading to increased work quality for a series of micro-tasks [11]. Domain-specific crowd interfaces are also relatively common, such as that by Barkhuus and Jørgensen to present realtime applause measurements to a DJ during a musical performance [3], or that by Heath et al to bridge remote and live audiences at auctions via an "intelligent" gavel [20]. Closer to our work, we find systems such as that by Kaviani et al, which enables public feedback on an arbitrary topic through discreet interactions over SMS [25].

In the classroom, Audience Response Systems form a primary method of interaction. Fitch [15] and Stowell & Nelson [39] both present systems whose interactions are limited to multiple choice and true/false responses, respectively. Interfaces such as these are limited in their usefulness, perhaps unsurprisingly, to multiple choice questions presented by the lecturer to the student, thereby placing the burden of structuring interaction (and also lecture materials) squarely on the lecturer. Many systems are built around specialized hardware and presentation software, mostly to support small remote control or similar feedback devices [26]. These do not permit a wide range of feedback from students, and so many students and lecturers alike grow to resent the tools, seeing them as little more than advanced attendance-taking measures [26].

2.2 Backchannels

Backchannels are an idea from linguistics, first used to describe meta-conversational listener responses in conversations [46]. These include both verbal responses, such as "mmhm" and "uh-huh" utterances, and nonverbal forms, such as head nods or eye movements. People use backchannels in regular conversation to signal degrees of interest, understanding, and other social-psychological cues [44]. The actual content of any particular backchannel communication is usually quite limited, and its form varies between cultures. Additionally, meta-conversation between individuals of the same general culture may also differ between subgroups within that culture. Between men and women, for instance, differences in perceived meta-communicative cues can lead to misunderstandings at best, and outright conflict at worst [31]. Overall, though, such communication is a valuable component of most human interpersonal communication, as it serves a sort of synchronization of understanding between participants in conversation.

Technologically supported public backchannel communication has been of great interest to researchers, instructors, and professionals. Joi Ito muses about the creation of a so-called *HeckleBot*, which would accept messages via an IRC server and relay them over a scrolling LED text panel to the speaker at a lecture. It is unclear as to whether Ito ever implemented such a system, however the date (2003) is notable, as it predates *Twitter* and other modern systems as a backchannel source by several years [22]. McCarthy, boyd, et al actually implemented IRC chat rooms as a backchannel medium across a major academic conference, with multiple chat rooms used to support multiple concurrent presentations [30]. *ClassCommons*, a tool from Du et al, allows students to contribute to a publicly visible text-based backchannel. This visualization was integrated directly into the presentation space during a large lecture, and students could contribute directly to the conversation using their own computers or computer terminals in the lecture area [13]. Harry, Green, and Donath developed *backchan.nl*, which allows for very verbose feedback during a lecture presentation. Voting and moderation were incorporated into the system, and the top comments as voted on by users were presented to the audience at large [19]. Purdue University's *Hotseat* connects with students' social network services to aggregate student feedback during lectures [40]. *Slandr* allows live aggregation of backchannels such as instant messaging, micro-blogging, and plain SMS messaging, to enrich lectures and conference presentations [27].

Backchannels are of course not exclusively presented as mediums of direct communication. Some classrooms have begun using so-called "Google jockeys" to provide real-time human-directed fact checking in lecture settings. Pence, Greene, and Pence explored this usage in an undergraduate lecture for environmental sustainability, whereby the assigned jockey was to retrieve relevant images and web links for students during the lecture. These images and links were placed on a publicly visible screen, and were set apart from the main lecture content [34]. By this, a conversation from teaching assistant to audience is developed, leading the audience to engage the lecturer on new content that otherwise may not have been presented. The act of "Twitter subtitling" has also emerged as a use of backchannel information. Hirst demonstrates a proof of concept of this at a conference talk, whereby the Twitter hashtag *#carter* was used (chosen for the speaker, Lord Carter) along with timestamps to create a set of subtitles for the video recording of the talk [21]. Again, by this, the backchannel conversation taking place on Twitter is highlighted in the greater context of the talk itself; later video releases of the particular talk had the relevant Twitter messages directly overlaid with the talk.

Virtual collaborative environments also often exploit backchannel technology. Real-time collaborative editors, for instance, typically leverage some sort of chat functionality in addition to a shared editing space. *SubEthaEdit* is a software tool that leverages the Apple Bonjour protocol to provide real-time editing and document version control. As Apple's default platform is also able to leverage Bonjour for chat, an implied backchannel is present in every SubEthaEdit session [35]. Systems such as *Google Docs* take this a step further, allowing collaboration outside of one's Bonjour-accessible network with anyone using Google's platform, via any supported web browser. For any shared document, a persistent chat window is included in a sidebar, accessible by editors and viewers alike [18]. The relatively new *Novacut* project is seeking to push collaborative editing even further with real-time video editing, however it is unclear as to how backchannel communication will be supported in their system. At current, though, tagging and real-time video clip playback are supported, which would arguably qualify as backchannel signals [33].

2.3 Classroom Technology

Classroom technology has progressed substantially since the mere slate chalkboard, though arguably the use of slate chalkboards itself was a significant turning point in the progress of educational technology. Multiple volumes trace the use of classroom technology in the last century, whereas myriad others provide guides to instructors as to the effective use of technology in teaching. Cuban is one such writer in the former category, tracing nearly seventy years of technology usage and reporting the following. Film projection in classrooms surged between the 1930s and mid-1950s, with only 11% of teachers at the elementary level and 19% of teachers at the secondary level reporting in 1954 that they never used films in their classrooms [10].

Television was the next medium to see a surge of use, beginning in the 1960s as a way to bring instruction to remote or rural classrooms, and continuing through to the 1980s to become another tool in the repertoire of teachers. By 1977, for instance, approximately 15 million students were regularly receiving some degree of instruction by television [10].

The computer was the next medium of promise, and is our platform of greatest interest for this work. Perhaps unsurprisingly, the Internet as a source of information, collaboration, and exploration became the breakaway success of computing, a notion which the US Department of Education has given particular attention. A 2005 study put forth by the National Center for Education Statistics reported that, in only ten years, the percentage of US public K-12 instructional rooms with Internet access had skyrocketed from 3% in 1994 to 94% [43]. Additionally, nearly 100% of US public schools had Internet access in some form as of 2005, with 97% reporting broadband access or better [43]. Wireless internet access also continues to grow in adoption, with 45% of public schools with Internet access using wireless connections as of 2005 [43]. This is not simply throwing technology at a problem, either: as of 2001, 68% of public school teachers rated a computer station with access to electronic mail to be critical to their teaching capacity [28]. This was the top ranked of technologies surveyed, which included also presentation software, encyclopedic reference software, and even Internet access itself [28]. This seems to suggest room for growth for at least teaching software, if not technology use itself.

Moving to more specific technologies, traditional computers themselves have not been alone as mechanisms for learning. Audience response systems, “clickers”, have taken root in higher education as a means to encourage audience participation, solicit feedback, take attendance, and so forth [24]. Tangible interfaces also see increasing adoption in classrooms.

Tablet computers with touchscreen interfaces, for instance, allow students to engage creatively almost as fluidly as they might with paper, with the benefit of the instructor being able to directly observe their progress in many arrangements [41]. Interactive displays, for example SMART Boards, can enable new interactions by students, however instructors must take careful charge of integrating such technologies into their teaching plans in such a way that they engage students without becoming a distraction [2]. Even the lowly laser pointer is worth mentioning as a successful interaction device, with the mouse and cursor as its modern equivalent, as many lecture spaces at current are simply not equipped with more than a computer and projector [32].

Special focus in the next sections will be given to audience response systems, backchannel-enabling software such as Twitter and backchan.nl, and strategies for encouraging crowd feedback. These platforms and methods directly inform our discussion of the Fragmented Social Mirror; strains of these are evident throughout the FSM projects.

CHAPTER 3: FSM PILOT STUDY [1]

With these existing systems and practices in mind, we set out to design a platform that would support both an engaging public conversation as well as a useful backchannel conversation. We wanted a system that would encourage conversation and questions, that would decrease the anxiety felt by students in lectures, and that would provide instructors with a quick and straightforward way to gauge the current state of their audience. We wanted to leverage existing technologies and paradigms, such as small text messages, while at the same time pushing forward the state of audience response technology. Finally, we wanted to create something that students would actually *want* to use, that would engage them on a level beyond the current lecture-presentation paradigm. From these goals, we set forth in designing what would become the Fragmented Social Mirror, leading to our first pilot study in this area.

3.1 Design

Our design for the FSM client and visual interface began as a series of conversations on what should constitute a "good" classroom feedback system. We had in mind two working models for feedback systems that we were hoping to bridge: a verbose feedback model, such as *Twitter*, and a narrow feedback model, such as *iClickers*. Both approaches were previously seen in use for large lectures and seminars, with degrees of success for both. We felt that borrowing affordances from each would yield a best-of-both-worlds approach. From these, a series of prototypes were built, eventually culminating in a pilot study in a large lecture setting with both observation and systems components. Our design follows from previous work by Bergstrom and

[1] Contains previously published material from [1], used with permission

Karahalios on social mirrors, which are tools used to depict interaction in real-time as an augmentation to natural face-to-face communication [4]. Specifically, the FSM departs from previously implemented social mirror platforms in that, instead of one shared visualization, we gave students individual ("fragmented") controls by which to manipulate a public display. Additionally, instead of showing a long history of interaction as would a social mirror, our system brings focus only to recent interactions.

The observation component of FSM began by observing an active and engaged classroom of 100+ students to see what students say when engaged in an active class. The lecturers of these classes were generally rated as among the best in the department. They were engaging during lecture and good at encouraging student participation. To facilitate a greater degree of participation, the lecturers posed a question and waited for responses, thus guaranteeing an answer or a question for clarification. We noted all the types of student responses to better understand what a student wants to say during class. The responses were narrowed down to the following list of categorical responses:

- Questions: Students ask questions based on what has just been taught.
- Information: Students add their own information to the current discussion.
- Agreement/Disagreement: Answering a Lecturer's question.
- Slow Down/Redo: Students did not understand the lecturer.
- Cannot Hear/Repeat: Students did not hear the lecturer.

The message categories serve as a means to identify and group similar responses and highlight important categories like questions. We drew upon feedback types that were available in other work, used to mark up a presentation slide [42]. From this set of six feedback types, we set forth in developing a system that would cleanly support such feedback. In parallel with our interface design, we investigated imagery for each of these six categories of messages (described in the next section). Due to this process, “Slow Down/Redo” and “Cannot Hear/Repeat” were eliminated, as they were not felt to be strongly needed in a general lecture support tool. Moreover, the icons we presented in the survey were not universally clear in their meaning, and their purpose could easily be replaced by an “Information” message with appropriate text. In other words, we decided that they were too specific and would be used too infrequently, to support their addition in our system.

Many of our initial interface prototypes borrowed design components from the *Conversation Clock* [5] and *Conversation Votes* [4], incorporating user feedback into a timeline that structured the activity throughout the session. In some cases, we included indications of the active speaker, to further differentiate between periods of lecturer speech and audience feedback. Much like a standard instant messenger, the full history of messages could be read through at any time, which we felt would better support offline/asynchronous and distanced learning. These interfaces showed potential for the review of archival classroom data, but did not serve our specific purpose of encouraging classroom interaction. These prototypes, tested amongst our own group, required too much attention to adequately understand; we sought to simplify.

After refining the initial prototypes, we settled on a simple interface that students could use without inordinately diverting attention away from the lecturer. Thus, the mechanism for user input in FSM was used only for capturing one comment at a time. Feedback was only seen on the public display, and was limited to only the most recent comments. Messages were configured to fade away after a period of time, though additional commentary could keep a message "alive" for longer. We felt this was especially useful for questions for which multiple side comments were needed. Additionally, the needs of the lecturer necessitated this type of design, as the lecturer's attention faculties were even more constrained. Specifically, the lecturer needed to be able to read feedback from the hundreds in the audience while still being able to teach effectively. Thus, we felt that a system that robbed the lecturer of their attention would have an overall deleterious effect in lectures, an outcome that was completely antithetical to our project. To this end, we considered that, in past studies, a social mirror was primarily viewed by the listeners (and not the speaker) in conversation because they had more free attention [5]. In our design for FSM, the captured feedback of conversation is significantly pared down, so that the lecturer can receive the benefits from the social mirror with minimal attention. Therefore, current comments and questions are displayed so as not to overwhelm the viewers (audience and lecturer) with a long history.

The FSM interface presents information primarily through icons, which were of our own design at first and were refined by a side investigation that we ran as part of this project. These icon graphics serve to simplify the message, so that a lecturer may quickly perceive the general ambiance of the classroom without reading too much content. Based upon informal observation of classroom sessions and prior work [42], we designed icons based on the messages earlier: "I have a question," "I have information/an answer," "Yes/agree," "No/disagree," "Speak Up," "Slow Down." Three researchers independently drew by hand any graphic that they felt reasonably captured these messages. We digitized these drawings, and combined them into sets for each category, with a total of 5–15 images for each message. Samples of these drawings may be found in Appendix B.

We conducted an electronic survey of Computer Science undergraduates to test our icon designs. A total of 54 Computer Science undergraduates completed our survey. Respondents were shown all of the proposed graphics per section, and were instructed to rate the clarity of the icon in representing the idea to which it was associated. Responses were captured on a range from “Disagree” to “Agree” using a five-point Likert scale [29]. None of the icons for “Slow Down” conveyed an adequate message to the student, so we eliminated this message; similarly, we removed the “Speak Up” messages. This left us with a simpler 4-icon interface, which (at risk of committing a “sour grapes” error) we came to see as a better design choice anyway. We felt that students could use the Information and Question messages with additional text to signal “Slow Down” and “Speak Up” if and when such ideas needed to be communicated; separate icons for each only served to clutter the design.

We designed two FSM interfaces: the student’s client interface for a computer or handheld device (Figure 1), and a larger public screen for the lecturer and audience (Figure 2). The public display is situated in the front of the room, though the lecturer sees the public display on a personal screen. The four different icons categorize student responses in the student interface. The icons represent: Information, Questions, yes/agree, and no/disagree. Information and Question signals can be augmented by a 40-character message, while Yes and No messages are simple text-less messages. The short messages allow students to clarify their questions or possible answers when there is no opportunity to speak while the Yes/No buttons allow students to answer simple questions quickly. From the lecturer’s perspective, the Yes/No responses allow the lecturer to quickly poll the audience on binary choice questions, while the Question and Information responses allow a lecturer to address some concerns inline with their presentation, instead of stopping abruptly to directly address questions.

Figure 1: The client interface for FSM as seen by students. Students were instructed to click on one of the four icons to indicate their intended feedback. On clicking one of the two leftmost icons, the user's cursor focus would shift to the text entry area beneath the icons, to include a short message if desired.

Students use the client interface in Figure 1 to send their message to the public display shown in Figure 2. The Yes and No icons, when clicked, would be transmitted immediately to the server, while clicking the Question or Information icons would put focus to a text entry area for clarification. We felt that this was a good compromise in the interface, as the Yes/No responses did not appear to need clarification associated with them. All messages were then rebroadcast to the public display, and were are grouped by their associated icon to increase legibility for the speaker. The speaker could look up and see many questions that need to be addressed, or they can glance to answers that students provided via the display, addressing some, all, or none at their discretion. We grouped icons by their type, and we weighted the presentation such that the icon group with the most messages moved to the top of the screen with a larger icon, with progressively smaller main icons used for decreasing message counts. Within icon groups, the most recent message of this type appears at the top of that icon in white text set against the black background. For icons with multiple messages, a count is displayed to the left of the icon.

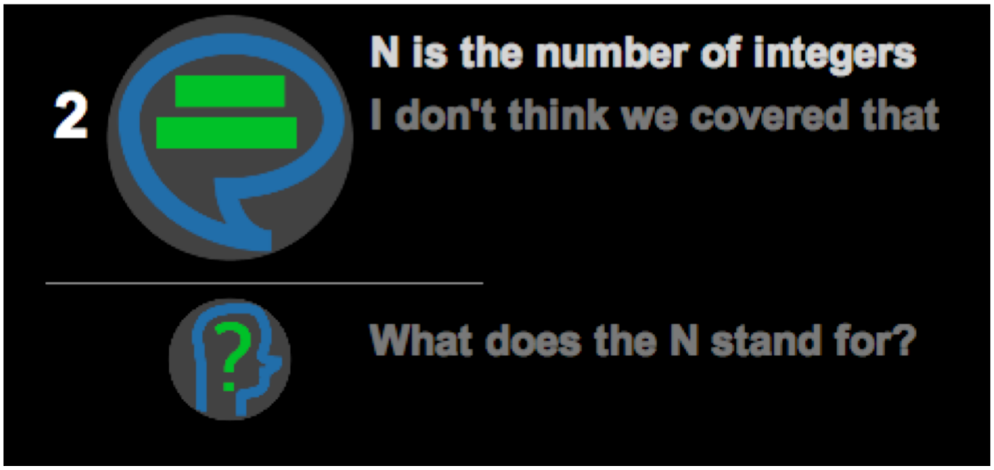

Figure 2: The public display is populated by messages as students interact with their client devices. Messages are grouped thematically, with a count of the total messages received in a given time period showing to the left of an icon (if multiple were received). This display was visible both to students and to the lecturer.

As a message ages, it fades to grey before finally disappearing after a pre-configured time (in our configuration, 30 seconds). The rationale for this design was two fold. Primarily, we did not want the lecturers to be confused or overwhelmed by reading old questions from a prior part of the lecture. The act of reading through new messages and differentiating new from old to get even a rough feeling of the current state of the audience was seen to be far too great of a cognitive burden; we wanted a system that could, at a glance, give an accurate snapshot of the audience, at that point in time. Secondly, if a question goes unanswered and disappears, this removal may encourage a student to verbalize the question in class or to repost it. One of our main goals is to encourage more class interaction. If a student has it communicated to them that they are not alone in their confusion, in our case via a public visualization, they may be less apprehensive to speak out and ask a question.

Abuse mitigation was one of our goals in designing FSM, as we saw this potential existing in other verbose feedback systems. In the backchan.nl system, for instance, some users voted up questions for humor, leading to a need for a moderator in publicly available responses

[19]. The public availability of the channel in FSM, by contrast, is ultimately at the discretion of the lecturer, though it was our hope that our design would permit for public viewing while mitigating avenues for abuse. We also built in a mechanical constraint to our system: once a student sends a signal, text-based or not, they are temporarily blocked from sending additional signals. In our pilot, this lock-out period was 10 seconds, which we felt struck a balance between regular feedback versus excessive social chatter and monopolization of the channel. Furthermore, we went as far as to lock the entire client from use during this period, so that a savvy student could not simply prepare a new message to be sent after the ten-second delay. Of course, the student could prepare the message in another text editor, however we only had but so much control over our interface.

3.2 The Pilot Study

We conducted a pilot study to investigate the FSM in the classroom, using a required lecture-based introductory computer science course as our testbed. The course had approximately 180 students registered at the beginning of the semester, which we felt was an appropriate venue for our system, and the instructor was not affiliated with our research team. We began by observing the participation levels before the introduction of the FSM and again with the FSM in place, by note-taking in the first half and automated logging in the second. We observed a total of six course sessions: three initially without any augmentation, and three with the addition of the FSM. During observation, an average of 100.0 students were in attendance, though there were fewer students in the final sessions (attributed to an intervening midterm and final day to drop the course). Given the size of the class, not many students had the opportunity to speak, and most did not. A summary of the attendance is found in [1], FSM's original publication. Prior to our first tests of the FSM in class, we sent a “pre-survey” to the students, which inquired as to the students’ comfort level while participating in this large lecture versus in their smaller discussion sections. Feedback from the survey confirmed that students were indeed not comfortable asking questions or asking for clarification during class, though they were comparably more comfortable asking in their smaller recitation sections. Similarly, students were cognizant of their own levels of participation, and they largely recognized that they do not participate or ask questions during class. Detailed presentation of results may also be found in [1].

Our initial observations also showed little interaction between audience and lecturer over the course of three 50-minute sessions. Instead of student-directed commentary, the only activity from the audience was in response to questions posed by the lecturer. For example, in reference to discussions of various formulae used in proof writing, the instructor asked students questions such as “[a variable] *n* is divisible by what?” and “What is the cardinality of set Q?” The class averaged about four responses per class, with a response defined as any kind of vocal public feedback for which the lecturer had paused for a response. The students initiated zero interactions themselves, five of the twelve responses were general indefinite murmurs from the class, and two responses involved raising hands. Various sets of one to three unidentified students spoke up to answer the remaining six questions.

We then tested the FSM in three class sessions, and found the students to be proactive in using the system. In the classroom, the lecturer used a central projection screen to work through problems by hand and to present lecture notes, while a smaller screen showed the public FSM display to the side of the larger screen. At the lecture podium, the lecturer also had a copy of the public FSM display available during the class activity. With the system in place, students initiated dialog with the lecturer by asking questions 11 times, compared to zero without the system. When on topic, students used the system to ask questions of the lecturer, to keep the lecturer from moving on too quickly, and to answer any questions posed by the lecturer. Again, detailed information regarding the participation in each of the 6 classes may be found in [1]. Most of the on-topic dialogs either began with or contained a question for the instructor. These lead to discussions with the instructor and information to enrich the class. However, there were also many off-topic messages. These messages were irrelevant to the class topic and were used to draw the attention of other classmates away from the lecture material for their own entertainment.

Survey results from students indicated that students indeed felt that the system encouraged participation and question-asking within the lecture. Students also felt that having feedback from others made the lecture more enjoyable, and that the system (perhaps marginally) made students feel more connected to the lecture. Less convincing, however, were students' opinions on whether our system helped students to understand lecture material, with an overall response for that idea tending toward neutral to slightly negative. This seems to indicate that learning outcomes may be unchanged in using a system like this, that it may only affect how students perceive the atmosphere of their lecture.

3.3 Lessons Learned

We had underestimated students' drive to disrupt public systems like this. Despite adding in what we thought to be protections against such usage (the 40-character limit, the 10-second timeout, the 30-second fading of messages), we still saw students intent on posting song lyrics or other nonsense messages. Future designs should incorporate ways for lecturers to manually toggle aspects of the system, such as a screen-mute for periods that the lecturer deems important for focus. We have also considered the prospect of varying degrees of anonymity; FSM as we implemented it was completely anonymous, however we had built in a framework for handling students' names. An asynchronous logging subsystem for later playback and review was also one of our broader goals for FSM, which would have incorporated this naming system. Such an addition would allow instructors to review their lectures later to see who made disruptive comments, and to pursue disciplinary action as needed.

Another pattern of behavior in need of support was the "+1" convention and similar others adopted by some students. Students seemed to want to express agreement with the content of some questions or responses, which we had hoped would be accomplished using the Yes/No buttons. To a degree, this usage was indeed seen, however some students ignored it in favor of adding textual agreement. Part of the rationale on the students' behalf was likely that adding a textual agreement had the effect of keeping a message "alive" and visible on screen longer, thereby increasing its chances of being seen by both the audience and the professor. For valuable questions, this was a positive strategy, however in light of patterns of abuse we also see where such a capability could be used to prolong disruption. A new system may allow students to support a specific comment or question in lieu of posing one of their own, however care should be taken so that this does not become a channel for collective abuse of the public display.

Overall, we felt this pilot study to be a success, in that we had seen students engaging positively with a crowd feedback tool. They asked more questions, felt better about their lecture, and even found creative ways to use the system (much to our chagrin). To us, this signaled that we were on the right track.

CHAPTER 4: FSM INTERVIEW STUDY [2]

Following the success of the FSM pilot study, we set forth in extending the FSM project in new and meaningful directions. A point left largely unaddressed from the pilot was the lecturer's perspective in the process. This was chosen to be the next extension in the FSM project: investigating lecturer sentiments regarding large lectures, classroom communication technologies, and what would become the design of the next FSM classroom tool.

4.1 Motivations for Questions

We needed to pare down what would constitute our main themes of investigation for this phase of FSM, and we needed to fit this to an investigation and data processing model. We decided to pursue an interview-based investigation, whereby we would interview faculty from varying disciplines to gauge their opinions on classroom communication. After reviewing both the previous study and various published descriptions of similar systems, we chose four main themes that would guide our questions: Interaction and Engagement; Technology; Identity, and; Design.

Interaction and Engagement has been a central focus of FSM since its inception. One of our goals has always been to foster communication between lecturer and audience, between professor and student, and so for this stage we felt it was critical to delve into the lecturer's perspective on this topic. As explained in earlier sections, engagement is known to directly foster learning at multiple levels, so there are tangible benefits to encouraging engagement as well. Any level of interaction, however, has a degree of cognitive load associated with it, and so a

[2] Contains unpublished material from a study currently in progress by the author and collaborators

secondary concern in this realm is to balance interaction with distraction. Finally, we wanted to ensure that the interaction modes we sought to present in the next design were welcomed by lecturers, that they would constitute a positive (or at least neutral) addition to FSM.

Technology as a topic of interview should go without explanation. Another goal to FSM, perhaps secondary, has been to develop a technology that would function in an arbitrary large lecture setting, one that would not require significant adaptation by the lecturer. We also wanted to develop a system that could be adapted to multiple presentation styles, as a limitation of the first FSM was its need for a second visible projection screen. To this end, we developed several questions related to classroom technology, and we included two parts of interview: one that occurred before showing the previous FSM design to the lecturer, and one after. We felt that this split would keep from tainting the responses received that were not specific to FSM.

Identity is more of a guiding theme than a bona fide subject of interview. In considering the next designs of FSM, we gave thought to the ways that various presentations of identity would influence students' perceptions, usage, and interaction. With the shift in focus to the lecturer, we were also interested in how lecturers use information about identity in responding to students, and how they might use identity in a communication tool. One of our concerns is that including elements of identity would negatively impact the quantity and tone of students' responses, without offering anything new to the lecturer. This is a question better addressed by students, though, as it would likely reflect more upon their usage than that of a lecturer. As such, it is of lesser emphasis in the actual series of questions that we pose in interviews.

Design, in this phase, speaks to the design of the visual components in FSM, as these are what we present to lecturers. We felt that any machine-facilitated input method for the lecturer would create an even greater cognitive burden, while not providing any clear benefit to communication and interaction. In the first phase of the project, we considered the iconography behind our inputs, explained as part of the survey that we ran. We assumed, perhaps in error, that our design would adequately fit the needs of a classroom communication technology, by basing some of the design choices (icons, input methods) on existing technologies. In this phase, by contrast, we take a more comprehensive view of our platform: how classroom technologies tend to be used, how certain input methods would impact usage, how backchannel communication can be harnessed for learning, and so on. These lead to questions of interface design: how icons and a character limit affect engagement, what visual aspects will be shown to each type of user. From the lecturers specifically, we wanted to learn how distanced learners tended to be incorporated into the course, how the lecturers engaged their classes overall, and how they may redesign our original software.

4.2 The Lecturer's Perspective

Why should we care specifically about the lecturer? Is it feasible in a room with multiple hundreds of people in attendance to stop every few moments to entertain questions? Anecdotally, we can surmise that the length of a lecture is among the greatest limiting factors of the degree to which a lecturer may interact with a large audience, but the question of lecturers' perspectives on technology stands apart. Shannon investigated this in 2001 at a large state university, and found two remarkable patterns of use. First, of departments surveyed, the department with the least access to technology in classrooms was also the department seen to most frequently use technology in overall teaching, with web pages and online tools forming the core of technologies used. Second, regardless of access to technology, faculty felt under-trained as to their usage and generally held negative opinions of the technologies available to them [37]. This paints a fairly bleak picture of technology at the turn of the millennium, but what of more current perspectives?

Chen et al suggest that specific technological affordances, followed by clear instruction and social support, are the most important factors in the uptake rate of new classroom technologies. If one of these is in conflict - if a system does not provide adequate avenues for integration into a teaching model, if the system's use is unclear, or if the instructor does not have sufficient resources by which to learn how to use and maintain the system - then technology usage can regress to previous patterns, despite any known drawbacks of those patterns [8]. Therefore, in introducing a new technology, it is essential to consider the instructor's needs as part of the design itself. Elliot suggests similarly, that schools must actively support instructors in learning to adapt to new technologies, and that technologies must clearly have their capabilities and benefits communicated as they directly pertain to classroom material. Elliot also notes that this support must come as early as possible in an instructor's term of service, as notions of technology come to shape the fundamental pedagogical decisions made by the instructor, a sort of trickle-down effect [14]. A decade later, it appears that perceptions on technology have improved, that instructors are more willing (or perhaps, are resigned) to use technology in their classrooms. The need for effective instructor support toward this end, however, has not changed.

As expressed previously, a drawback of the first FSM study was its lack of input from the instructor in whose class we ran the initial pilot study. Our focus at first was simply to put forth a working prototype, synthesized from recommendations in previous work and from our own anecdotal experiences with technology in classrooms. While we stand by the design of the original FSM, we see avenues for extension, such as by designing certain features to better support lecturers as they use our system. For instance, we did not design a method by which to address abuse of the system in real-time. Using a screen mute or disconnecting the system are obvious workarounds to any designed feature, however we saw these as inferior to what could be enabled by successfully designing a control interface around the lecturer. That is one of our design goals for the next iteration of the FSM project.

4.3 Asking the Right Questions

How did we know that the questions we chose to ask were the correct questions to inform our design? Here we present a breakdown of each question grouping and their justifications. The raw question script is found in Appendix A.

Our introductory questions were intended as one may imagine: to help frame the interview, and to begin priming the participant to answer questions related to classroom communication technology. Asking for the participant's familiarity with crowd feedback tools and their awareness of tools at the University was seen as a necessary inclusion, as it could not be directly assumed that every lecturer had been exposed to such. In the informal conversations that helped to form these questions, it became clear that many students and faculty had never been exposed to systems like iClickers or backchan.nl, so this was also an avenue by which we could explain what was meant by "classroom communication technology" and "crowd feedback tool" in the context of our work. Furthermore, we chose these terms to further differentiate our design goals from those of established audience response systems, systems for which the response space is extremely limited. Asking for familiarity with other technologies, perhaps unsurprisingly, also helped us to assess how deeply we could ask as to their usage of such technologies; we had a slightly modified question script for lecturers with no exposure whatsoever. Finally, another area of interest related to classroom communication was in backchannel communication. We surmised that lecturers were likely well-aware of such communication in their classrooms, but we wanted to make sure to have explained the term at least once in context.

Questions on engagement delved further into lecturers' teaching style, as student engagement is an area of interest across disciplines. We wanted lecturers to describe how they normally interacted with their lecture participants, how they encouraged feedback during lectures, how they polled for various conversational cues, and so on. All of these were directly related to the original design for FSM, so we felt it to be a natural place to begin our more focused questions. Another aspect of modern classrooms left largely unexplored from FSM was the question of distanced participants, those students who elect to participate in lectures remotely. It may go without saying that lecture participants who only use recorded lectures for course purposes would not necessarily be of focus for the FSM project, however the usage of those students who participate in real-time would very distinctly be of interest to us. We wanted to know how lecturers captured the attention and feedback of these distanced learners, so that we could better design a system that supported distanced learning as well as traditional onsite participation. Finally, in keeping with our investigation of backchannel usage, we wanted to explore some of the more constructive ways in which lecturers used backchannels in their courses, both real-time and asynchronous.

Our technology questions were where we intended to lead toward discussion of the design of FSM itself. We wanted to address the potentially disruptive nature (disruptive in an attention sense) of additional technology introduced in a lecture setting. We also wanted to know simply what were lecturers' opinions on classroom technology. After showing a mockup of FSM during interviews, we asked design questions - what would lecturers want to change, how would certain aspects help or hinder learning and engagement, and so on. Here was also where we wanted to broach the question of anonymity in the interface. One of the design features that we had intended to include with the original FSM was the ability to toggle students' names in various interface configurations. In truth, the capability exists in FSM at current to permit such, as we built FSM with future applications in mind; we just never used it. One of our future research goals for FSM has been to incorporate these named vs. anonymous conditions, so we wanted to hear as to how lecturers felt anonymity would affect relationships in the classroom and the usage of such a system.

In closing, we also wanted to address the question of disruptive behavior by students. Another thought, described in the writeup for the original FSM, is that narrowing the field of expression for a feedback system does indeed mitigate abuse of that system, however at the cost of also narrowing legitimate expression. As discussed, we felt that the original FSM struck a good balance between expression and abuse mitigation, however we wanted to present this notion to lecturers as well. In future designs, we hope to be able to widen the types and depths of expression available to students, but we need to first know how to do that; questions on design of classroom feedback systems such as these would help to inform such.

4.4 Study and Results

The second phase of FSM, as discussed, is an interview study. This study is still underway at the time of writing, so here we will describe the design of the study and a selection of preliminary results. Note that, as our data are as yet incomplete, extrapolations and conclusions reached here should not be construed as complete in any substantive sense. Furthermore, we have not yet performed any sort of scientifically supported analysis of our data, nor have we assessed our current data for any degree of validity outside of basic human studies data collection procedures. That said, from even our most preliminary assessments, we feel there are multiple concrete avenues for improvement over the original FSM design.

For this phase of FSM, we have identified and contacted approximately 18 faculty at UIUC who teach in large lecture arrangements. Our selection criteria included sizes of lectures taught and subject areas. Our lower bound on lecture size was chosen to be roughly 80 persons; that is, we contacted lecturers who hosted lecture sections of 80 or more people. We felt that this lower bound would distinguish our lecture settings from small seminars (10-15 people) and medium-sized classrooms (30-40 people), as we are specifically targeting the problems found in large lectures in our investigation. On subject areas, we wanted to capture responses from a wide range of disciplines and (presumably) teaching styles and paradigms: mathematics, social science, biological and chemical sciences, communication, fine arts and art history, and our home discipline of computer science. As this is still a study in progress, we do not know what our final distributions will be, however we would like at least two lecturers from each discipline to respond.

Our interviews are being conducted as semi-structured, and our question script is reproduced in Appendix A. Following transcription of interviews, we intend to undertake a grounded theory (GT) analysis of the ideas put forth by lecturers [16]. We will deviate from some admonishments related to GT; specifically, we will have already performed a background literature review, and we are taping our interviews as part of the interview process. We do not feel that these will substantively affect the GT process, however. On background work, we have a system (the original FSM) that we are looking to directly extend. The background review is as such inevitable in our case, however it only serves to narrow the field of questions that we pose within interviews. Our interview questions are also sufficiently open-ended to allow for a breadth of responses within this specific problem area. On taping, the main admonishment is that the process of transcription is lengthy and can drain researchers' motivation. We feel that the relatively small number of interviews should limit the size of this task. Taping also allows us to extract a wealth of salient quotations, which themselves should prove valuable both in the coding stages of GT and in framing later analysis of this work.

4.5 Discussion

One of the more striking comments received so far has come from an interview with a faculty member from communication:

> *"What I want is for students to be composing a thought. … Somehow the commercial technologies haven't gone that way, they've gone to the sort of least effortful thing for a student to do, which is just what I don't want. So I'm interested in having some sort of crowd response, I'm interested in kinds of*

technologies. I'm a little conflicted about the division of students' attention that would still be an unintended consequence of that. ***And my main thought about all this is, lectures are over.*** *That's a style of teaching that is over, and we have got to find something else."*

We had expected to receive comments critical of the current paradigms of audience response tools, but none so distinctly dismissive of the status quo. Surely, this is echoed by some researchers; Brown, among others, suggests that the most recent generation of students will not respond as well to traditional text-centric lecture styles, that collaboration and active assimilation of multiple forms of media are better able to engage current students [7]. Sticklen et al demonstrate a system that puts this notion to the test, showing that interactive web-based lectures do not differ in their learning outcomes from traditional lectures, but that they do foster distinctly positive attitudes from students toward this interactive presentation style [38]. Wiecha et al go even further, demonstrating a fully virtual learning environment based in *Second Life* for continuing medical education [45]. The movement away from traditional lectures and toward these new forms of presentation is not wholly unexpected, and is in line with the stark commentary presented above.

The same faculty member also said of classroom participation:

I think that if students aren't engaged and communicating then they are not getting the full benefit of being in a classroom at all. ***A lot of our arrangements and expectations and the way we do things here, the way faculty are steered, is almost designed to prevent participation by the***

> ***student.*** *My classroom is clearly designed to prevent participation by the student.*

This was a major concern of ours, going into the design of the first FSM and leading some of our questions for the second FSM. We want to foster participation in lectures, which we feel is an area with vast space for improvement, . To hear this same concern echoed in interview was a validating moment, although it would be premature to suggest that one interview conclusively validates any particular viewpoint.

Attention was a concern expressed as well. From one computer science faculty member:

> *"So, I don't understand the capacity that students have to focus on multiple things at the same time, so if there's multiple things going on at the same time,* ***I worry that they won't pay the right amount of attention to the right things.****"*

Similarly, from a communications faculty member:

> *"Something that worries me a lot is* ***the increasingly obvious demand on the instructor to command attention, and not on the student to allocate attention****. It's very scary, in terms of… if you think of that as a basic intellectual skill, like Rheingold [36] does, and create the expectation that the individual is not responsible for managing attention, that anybody who wants your attention is responsible for commanding it."*

One of the design goals in FSM has been to limit the attention demands of the system, both in its input and in its presentation. We felt that by limiting the interaction so tightly, we could produce a system that were still free-form in its expression, but that did not detract from the overall attentional task taking place in the lecture space. González and Mark explored attention management in workplaces, and suggested similarly that task switching is a pattern to support in information technology [17]. If we consider lecture participation to be a form of student work among other competing forms of student work, then in limiting the attentional demands in our system we feel that only a marginal cognitive burden is added to the course of a lecture. Additionally, in contrast to certain efforts in teaching to restrict electronic distractions, such as the practice of banning laptops or disabling Internet connections during lectures, our system makes the case for *continued* technology use in the classroom, as students use their computers to directly engage with their lecture [47].

Disagreement existed over how to address the question of anonymity in our system. From a faculty member in communication:

> *"If what you want to get is spot feedback on whether this exercise worked in the classroom, you'd want that to be anonymous. If what you want to do is promote a community of learners, where people start to identify a position with a person, then you need them named, and named with real names. So* ***different circumstances would require different settings****."*

However, a computer science faculty member suggested the following:

> *"If there was some archive that, with some effort, if somebody was really misbehaving, I could send them a cease-and-desist letter…* ***If the students knew that there was a record of this being made*** *[with their names associated*

with comments], that if they were screwing up, I would know who would screwing up, ***that would stop people from screwing up.****"*

Additionally, a faculty member from mathematics said even more starkly:

"[Students] need to know that I'm going to have a transcript of everyone's conversation, and associated with that conversation will be the student who posted it… even if it's just their [student ID], ***because clearly I won't look up everybody's [student ID] unless I have a reason to, and if I have a reason to, you should pack your bags and leave the university****. And I will probably say that on the first day of lecture!"*

This contrast in perception about anonymity was unexpected. Certainly, anonymity or pseudonymity in a system would potentially change the behaviors of participants in a lecture. This much has been observed in other platforms, such as by Draper and Brown wherein anonymity induced users to pick an answer despite a large degree of uncertainty as to the accuracy of that answer [12]. These comments seem to suggest that students may seek to limit themselves to a degree not foreseen by our background work, in the face of even a confidential (lecturer-visible) non-anonymous system. To be certain, we had discussed as an extension to FSM the possibility of testing various named/anonymized conditions, to see what the effects may be under each; we are still considering this as an avenue for future work.

CHAPTER 5: CONCLUSION

5.1 Final Discussion

As the second iteration of FSM is currently underway, it is difficult to speculate as to the range of responses that we will receive. Surely, every instructor's perspective will vary, and on some subjects professors are sure to disagree entirely. We cannot reasonably hope to incorporate every suggestion into our forthcoming design. That, however, is one of the strengths of this project: in seeing multiple avenues for extension, we can potentially pursue multiple designs for varied educational contexts. Perhaps, for instance, we will see that the 30-second timeout window is perceived to be too quick for certain types of lectures, and some lecturers will want a wider response window that can be arbitrarily configured; it cannot yet be said.

Perceptions from the instructor side of classroom technology is an area that is woefully understudied, despite a plethora of both classroom tools and studies as to the efficacies of those tools in delivering learning outcomes. Reasons for this discrepancy in investigation are not well understood. An avenue of future study could very well be to conduct a holistic inquiry into classroom technology, encompassing students, instructors, designers, administrators, parents, and any other groups likely to be influenced by classroom technology. What would parents want their children to have in a system? How do department heads choose to allocate funds to educational technology? How could technologies be designed either to better make use of existing lecture equipment to stave off upgrades, or to supersede existing technology at the point of upgrade? All of these factors merit consideration, as the stakeholders in educational technology are not simply limited to students and instructors.

5.2 Conclusion

Hopefully, the complexity of addressing even as visible and apparent a problem of student engagement in the classroom has been communicated here. We began with a review of existing ideas in classroom technology, of backchannels in lecture spaces, and of strategies for encouraging engagement in the classroom. We presented a tool, the Fragmented Social Mirror, already tested and published, which sought to address a gap in existing systems. Our findings with the FSM were promising, but inconclusive in the larger context of encouraging classroom communication. From this, we presented also the design and the most preliminary results of a study intended to inform the next iteration of our tool, which we hope will come to address questions such as how to balance anonymity with anxiety, how to give lecturers more control, and how to broaden the experience for distanced learning students. Large lectures are indeed hard; the overall task of supporting large lectures is far from complete.

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APPENDIX A: FSM INTERVIEW STUDY QUESTION SCRIPT

Read the following paragraphs to Interviewee:

The following questions will be used to inform research into better real-time crowd feedback tools. Remember that you can decline to answer any question, and you can ask to stop at any time.

A real-time crowd feedback tool is a tool that enables a secondary channel of conversation (a backchannel) during some kind of crowd-centered event, often with some public visual component. Examples of this include iClickers in classrooms on campus, *Twitter* and SMS shown on large screens during concerts, sanctioned public chat rooms, etc.

Backchannel communication technologies, on the other hand, allow participants in an event to have a side-conversation of some variety, potentially removed or hidden from the participants of the event. Examples here would be Twitter and SMS between members of the audience, instant messaging, ad-hoc chatrooms, etc. A backchannel can also be as simple as two people whispering to one another; a technology is not a necessity.

Our focus is on large university lectures and seminars, and we will be asking you questions with that in mind. Please be as candid and thorough with your answers as possible.

A.1 Introductory

Describe the classes you teach, and the lectures you lead. How large are they? What sorts of students make up your lectures?

Are you generally familiar with crowd feedback tools? What are your thoughts about them?

Are you aware of technologies like these at UIUC?

Have you ever used one in your lectures? If so, which? [If not, why not?]

Do you use any other technologies for your class? (newsgroups, message boards, wikis, chat rooms, Compass/Moodle) If so, which and why? [If not, why not?]

How do you feel about students engaging in backchannel conversation during your lectures?

A.2 Engagement

How would you describe the current level of participation in your main lecture(s)? Is it where you would want it to be?

How do you personally measure this? What criteria do you use?

What strategies do you use to encourage participation in lecture? Do you feel that more comments and questions during lectures lead to a richer discussion? [Or, for what reasons do you prefer not to encourage direct participation?]

How do you know when students have questions or comments during lectures? How do you know when you are moving too quickly or slowly? Are there cues that you watch for?

Do you have distance-learning students enrolled in your course? How do you bring them in to the main discussion? [If not, hypothetically, how would you?]

Do you feel that students engage more in backchannel conversation than they participate in lecture? How do you feel about this?

Have you ever encouraged students to engage in backchannel conversation during your lecture? Why or why not?

A.3 Technology

How do you feel about using multiple forms of communication technology during a lecture? [Or, do you prefer to use only "standard" technologies such as slides? Why?]

Do you find technology in the classroom to be a distraction? Why or why not? How do you cope with distractions brought on by technology?

How do you feel that technology influences the connections that you are able to build with students?

Given access and funding, are there classroom technologies that you would like to incorporate into your teaching? [If not, why not?]

Would you be willing to change your lecture materials, to accommodate a new classroom technology? Why or why not?

Show and explain a mockup of the original FSM software, including both the client software and the public visualization. Be sure to explain that FSM is designed to encourage discussion and participation; it is not a replacement for students to ask questions. If desired by you or by interviewee, also explain other new technologies, e.g. Backchan.nl.

What are your first thoughts about a technology like this?

Do you feel that a technology like this would change the interaction dynamic of your lecture? If so, how?

Do you feel that you would need to change your lecture materials to accommodate a system like this?

How do you think that this system would engage distanced learners? Would it be more or less beneficial toward that end?

What do you perceive to be some of the advantages and drawbacks of the 40-character text limit in our system?

How could we improve upon this design? What would you add or remove to this to make it better for your lectures? Why?

We have considered varying degrees of anonymity in our designs for this system. What do you feel would be the differences between a fully anonymous system and a less-than-anonymous system? (pseudonyms, full names, names shown only to lecturer, etc.)

A.4 Closing

How do you feel that "junk" or disruptive messages could best be mitigated in a platform that allowed for more expression?

If you were asked to design a new communication platform for your class, what would you put into it? [Or, do you feel that technologies are too burdensome already?]

Are there other classroom communication tools that you know about, that we haven't discussed here?

Is there anything else that comes to mind about participation in lectures, or technologies that enable participation?

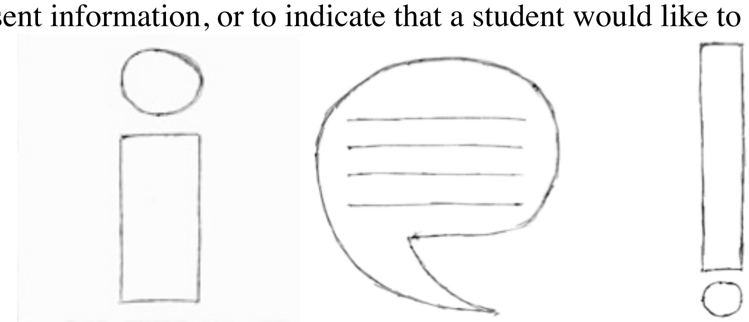
APPENDIX B: ICONS CONSIDERED FOR FSM INTERFACE

The following are a selection of icons that were considered for the FSM interface. These were first drawn freehandedly by the researchers, digitally scanned, and placed directly into the survey. The highest rated of these were then also recreated as vector graphics, and researchers chose among these to use in the FSM interface.

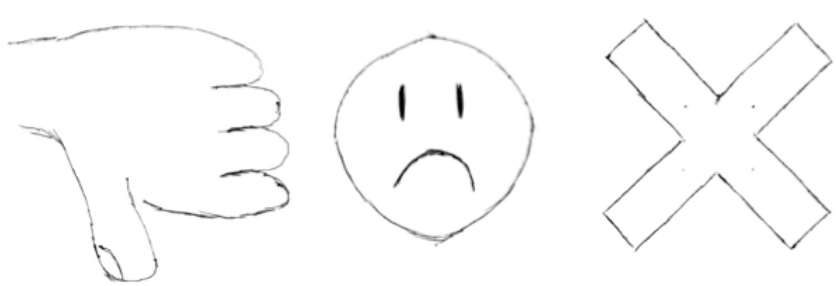
B.1 Freehand Icons

Icons to represent confusion, or to indicate that a student has a question:

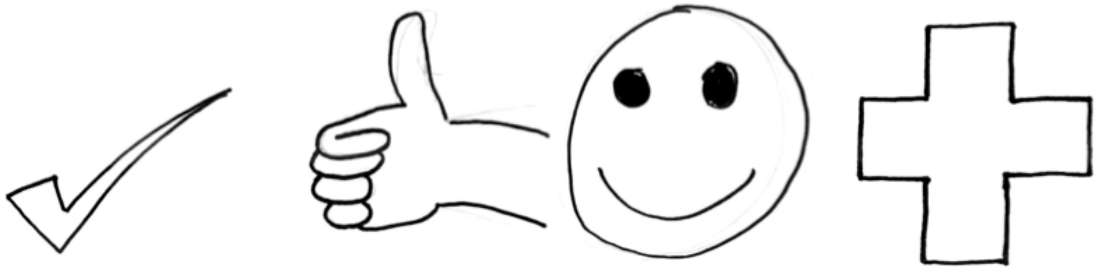
Icons to represent information, or to indicate that a student would like to contribute a comment:



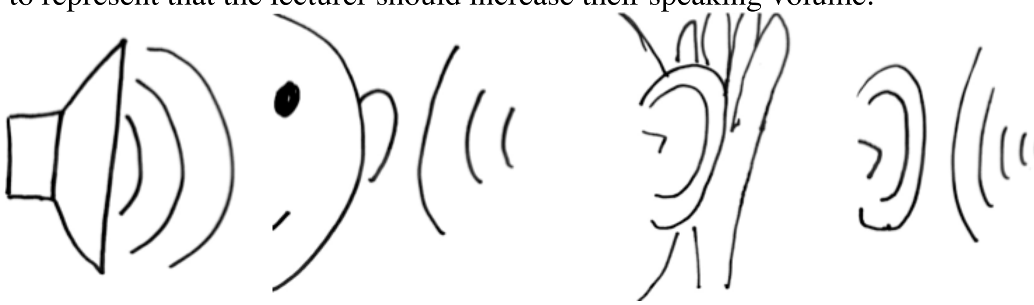
Icons to represent disagreement, or a negative response:



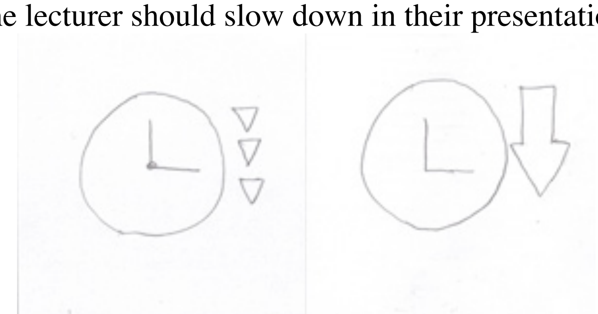
Icons to represent agreement, or a positive response:



Icons to represent that the lecturer should increase their speaking volume:



Icons to represent that the lecturer should slow down in their presentation:



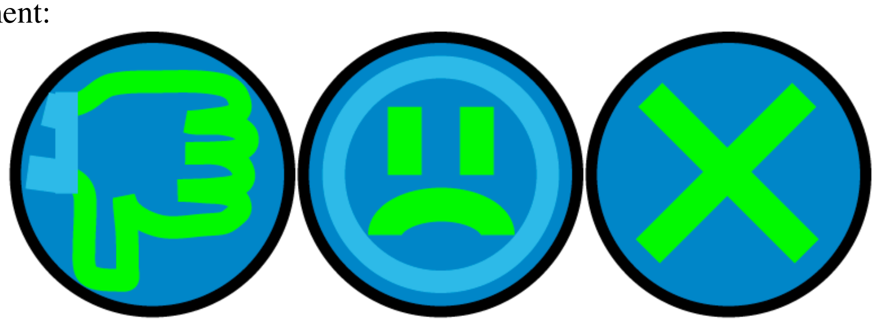
B.2 Digitized Icons

For questions:

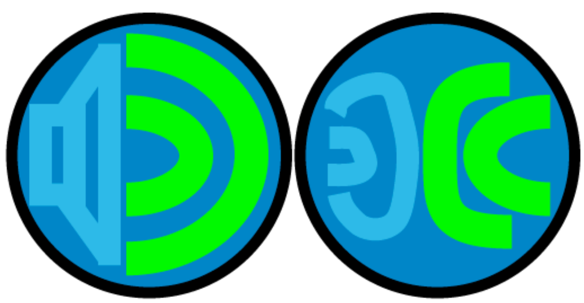
For information:

For agreement:

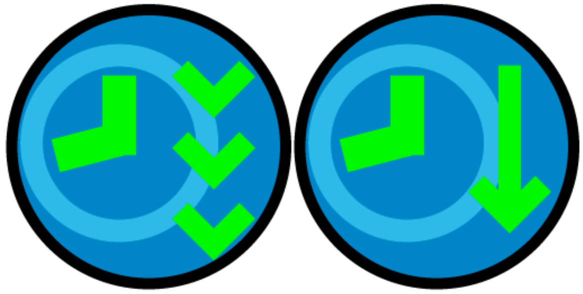
For disagreement:



For increasing volume:



For slowing down:



B.3 Final Icon Set

Question Information Yes/Agree No/Disagree