RICHARD J. ANDERSON, RUTH ANDERSON,
TAMMY VANDEGRIFT, STEVEN WOLFMAN, KEN YASUHARA

# PROMOTING INTERACTION IN LARGE CLASSES WITH COMPUTER-MEDIATED FEEDBACK

**Abstract.** Eliciting student participation in large college classes is difficult yet critical to learning. This paper describes a design experiment with the Classroom Feedback System (CFS), a computer-mediated feedback system for promoting class interaction. We delineate challenges to interaction based on successive background and pilot studies. CFS addresses these challenges by enabling students to post annotations (*e.g.*, MORE EXPLANATION) directly on lecture slides. The instructor sees the annotations in real time. Evidence from a large lecture study shows that CFS enhances interaction by addressing challenges to interaction.

## 1 INTRODUCTION

Student-instructor interaction is vital to student learning, but soliciting student feedback in large, university-level lecture classes is challenging. As universities serve more students and face tighter resource constraints, these large lectures are likely to persist, necessitating innovative approaches to large class challenges.

We designed the Classroom Feedback System (CFS) to address this problem. Following design experiment methodology (Brown, 1992), we studied large classes through observations. Based on these observations and existing literature, we identified key challenges to interaction. Next, we studied three successive pen-and-paper and electronic prototypes of CFS in large classes, refining CFS's design and our list of challenges. Finally, we studied an introductory programming course using the full-featured CFS. This paper focuses on the challenges, CFS's design, and experimental results from the most recent study.

## 2 CHALLENGES TO INTERACTION IN LARGE CLASSES

The education community has long discussed the challenges of facilitating student-instructor interaction in large classes (Geske, 1992; Gleason, 1986). Based on literature, observations, and experiments with prototypes of CFS, we have identified several primary factors inhibiting student-initiated interaction in large classes:

**Feedback Lag:** suppression of questions due to lecture tempo. Students in our pilot study doubted the value of their questions on a topic until the topic was closed, but when lecture moved on, they felt the chance to ask their questions had passed.

**Student Apprehension:** fear of speaking due to the size or climate of the class. In our pilot study, 6 of the 12 participants reported feeling apprehensive of participating.

**Single-speaker Paradigm:** model in which only one person (student or instructor) speaks at a time. This model does not scale to broad participation in large classes. In our pilot study, 3 of 12 participants reported class size as a factor limiting participation.

## 3 DESIGNED SYSTEM

CFS (Figure 1) responds to these challenges. The instructor navigates and writes on a slide-based presentation from a wirelessly connected Tablet PC. Students view the slides on the classroom display and on personal wirelessly networked laptops.

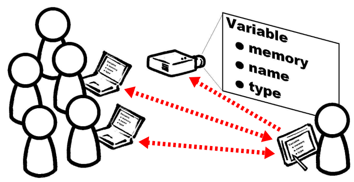


*Figure 1: System setup, consisting of instructor and student devices, and a projector for the classroom display. Arrows represent wireless transfer of the presentation and feedback.*

Students generate feedback by clicking a location on a slide and selecting from a fixed menu of possible annotations such as MORE EXPLANATION (Figure 2(a)). The student view displays both the current and previously presented slide (to address feedback lag) with the student's feedback superimposed. The student can remove feedback that has been addressed by clicking it.

The instructor controls the presentation from her view (Figure 2(c)). This view shows aggregated student feedback with a shaded dot for each annotation and a highlight for all annotations on a single slide region. The dots show categorical information by color (*e.g.*, red for MORE EXPLANATION) and slide context by location, but student identity is not displayed. The instructor's filmstrip view of the slide deck (on the left in the figure) summarizes feedback on several surrounding slides.

An episode from the last day of our study illustrates CFS's use: A student raised her hand but was not seen by the instructor. After a minute, the instructor advanced the slide, and the student abandoned asking her question aloud. Instead, she posted MORE EXPLANATION on the previous slide (Figure 2(a)). The instructor soon noticed the feedback in the filmstrip view (Figure 2(b)) but continued on his current topic for 40 seconds, perhaps waiting for a breaking point. He then returned to the annotated slide (Figure 2(c)) and responded to the feedback. Although the student did not remove her feedback, she indicated in a later survey that the instructor had addressed it.

CFS leverages the increased presence of technology in the classroom to address the challenges from Section 2. Networked computers provide an alternative to speech, sidestepping the single-speaker problem. Anonymity—easy to establish in a computer-mediated system—helps address student apprehension. Prepared slides provide a persistent context for feedback, allowing for lagged feedback out of synch with the fleeting context of the spoken lecture.

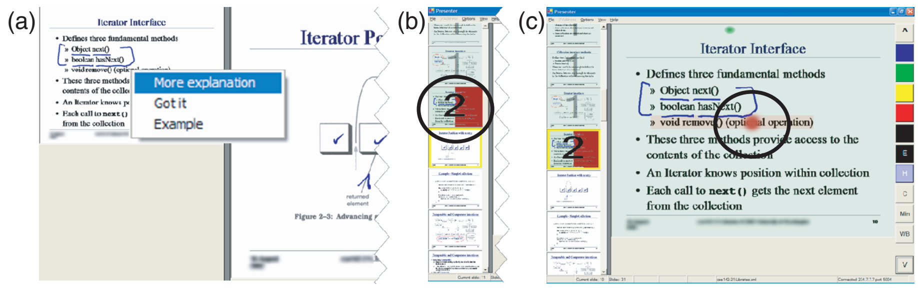


*Figure 2: CFS student (a) and instructor (b,c) views.* **(a):** *left side of the student view. The student posts* MORE EXPLANATION *on the last slide presented.* **(b):** *left side of the instructor view with an added circle around one thumbnail slide. The new feedback from (a) and one older feedback yield a count of two on the circled thumbnail.* **(c):** *instructor view with an added circle around the new feedback. The instructor returned to the slide with new feedback. The new feedback is a dot on "optional" while the old feedback is a dot above the title.*

## 4 IN-CLASS FEEDBACK EXPERIMENT

We studied a large, university-level introductory programming class's use of CFS, focusing on changes in interaction. The course had 120 students and met for three 1-hour lectures weekly for nine weeks. CFS was used during the last three weeks. We configured CFS with three categories: MORE EXPLANATION requests elaboration, EXAMPLE requests an illustrative example, and GOT IT indicates understanding. 12 students participated, each supplied with a laptop. On average, 8 of the 12 checked out their laptops each lecture. (Attendance was spotty as in many large classes.)

We collected a variety of data in order to "triangulate" interesting phenomena: notes during regular meetings with participants; observations by two researchers at each lecture (137 handwritten pages total); all class handouts; replayable logs of CFS use; a long survey from student participants (11 of 12 completed it); a brief, class-wide survey (42 students completed it); publicly available course evalution data; and, at the end of the study, an audio-recorded interview with the instructor.
CFS promoted interaction (Table 1). There was a substantial, statistically significant increase in student input with the system. Even discounting GOT ITs (which rarely initiated interactions), the change is suggestive of increased interaction, considering that only one in ten students in class used the system.

Non-GOT IT feedback was usually addressed. The instructor felt that ignoring such feedback would be as egregious as ignoring a spoken question. 7 of 11 students in the survey believed the instructor responded to almost all of their feedback. At the same time, CFS did not seem to hinder traditional interactions. As shown in Table 1, the number of student voicings before CFS and during its use were consistent with each other. Students with laptops continued to participate aloud in class.

The data suggest that CFS addressed the interaction challenges but sometimes with surprising side-effects. Overall, satisfaction with CFS correlated with students' perception of challenges. All (and only) students who reported challenges to spoken participation (8 of 11) also reported enjoying CFS. Below, we discuss each challenge:

*Table 1: Comparison of total student input per class before CFS (first column only, 15 classes) and during its use (7 classes). "Spoken" indicates spoken student comments or questions. "All" is spoken plus CFS feedback. "All except* GOT IT*" discounts* GOT IT *annotations. Significance tests were heteroscedastic, two-tailed t-tests. (*: significant at $p < .1$.)*

| | Spoken pre-CFS | Spoken | All | All except GOT IT |
|---|---|---|---|---|
| # per class | 2.4 | 2.6 | **15.9*** | 7.9 |
| p-value | —— | .91 | **.04*** | .14 |

**Feedback Lag:** CFS alleviated feedback lag for students. 3 of 11 students in our survey felt that unsolicited, spoken questions would interrupt the flow of lecture. All 3 felt CFS addressed the problem. (2 other students felt displaying only one previous slide was *not enough* for their lagged feedback.)

Two strategies emerged for overcoming feedback lag with CFS. The first was expected: waiting for the instructor to finish discussing a point before annotating it. (See episode in Section 3.) Students also created feedback opportunities by annotating points prior to discussion. Many instructors identified this practice as a problem when trying CFS out. However, CFS's private communication channel and persistent annotations rendered this strategy acceptable and even valuable to our study's instructor.

**Student Apprehension:** Students felt apprehensive about speaking in class. 6 of 11 students surveyed cited challenges to spoken participation such as "nervousness" and "larger class size." Some evidence suggests CFS addressed student apprehension. None of the 6 students reported apprehension with CFS. In one telling case, the instructor was unable to elicit spoken elaboration from a student who gave CFS feedback, apparently because of apprehension at the public spotlight.

Although anonymity addressed apprehension, it also sometimes hindered the instructor's interpretation of feedback. Without student identities, the instructor could neither evaluate a student's feedback based on his knowledge of the student nor follow up with the student outside of class. Furthermore, he had trouble understanding sets of related annotations. For example, one student annotated three of a set of six Java classes to indicate which ones confused him. Without knowing that one student made all these annotations, the instructor could not judge how many students were confused nor easily interpret the feedback as expressing a single concept.

**Single-speaker Paradigm:** CFS allows multiple students to express themselves simultaneously. However, this introduces a new challenge: managing multiple speakers. The instructor felt this challenge sometimes made him appear flustered. He said of one heavy period of feedback (7 annotations by 4 students on one slide) that students probably thought he was having "some sort of brain seizure." Neither of our observers noticed anything unusual about the lecture during that time, but the instructor's concerns still indicate a problem which would be exacerbated by more student participants. Better aggregation techniques and more practice with CFS might improve instructors' comfort with the "multi-speaker paradigm."

## 5 CONCLUSIONS

We have described the Classroom Feedback System (CFS), a system for promoting interaction in large classes. Through classroom observations and design and deployment of CFS, we engineered a more interactive learning environment. In the process, we identified key challenges to interaction and grounded these challenges in literature and data from real classes. Analysis of one experiment demonstrated CFS's success in promoting interaction and revealed interesting interplay with the challenges.

Our system builds on prior efforts in supporting classroom interaction. Some existing technologies support instructor-initiated interactions like quizzes (Dufresne et al., 1996). Brittain's work with mobile phones (Brittain, 2001) was inspirational for our work. ActiveClass (Ratto et al., 2003) supports both instructor- and student-initiated interaction. CFS differs from all these feedback systems by providing rich context: merging comments with slide context to aid students in crafting meaningful feedback and the instructor in interpreting that feedback. (VanDeGrift et al., 2002) reviews related work more extensively.

Our experiments suggest new directions to investigate. Revealing correlations among feedback (but not student identities) might clarify the meanings of related annotations and enable new interactions. Allowing extra categories (as in ActiveClass) or supporting free text might help students express themselves and provide extra confidence to instructors in their interpretation of feedback. Displaying information about a comment on mouseover would be one mechanism to implement these extensions: popping up associated freeform text and highlighting correlated annotations. Allowing the instructor to modify feedback would enable in-system mechanisms for following up questions (as the instructor in our study requested). New patterns of use to study might include setting time aside for feedback on certain slides, designing feedback opportunities into classroom assessment activites, or improving slides from term to term using archived feedback. Finally, we hope to study broader adoption within a course and across a variety of courses.

*Computer Science & Engineering, University of Washington, Seattle, WA, USA*

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