

Final Report
2012 CELT Summer Instructional Development Grant

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Abstract

The ClassResponse (CR) software developed during this project facilitates anonymous, student-instructor communication during class using mobile devices such as laptops, tablets, and smart phones. CR supports several types of communication, including open-ended questions, multiple-choice polls, and student-initiated feedback about the pace of class.

The pilot study of ClassResponse was carried out in the Fall 2012 section of a sophomore-level computer science course, which had 26 students enrolled. Students who used ClassResponse cited anonymity as one of the top reasons to use the system. When asked to rank the usefulness of the different modes of communication, the students found the multiple-choice polls to be the most useful, followed by the open-ended questions, with the pace of class feedback listed as the least useful. However, each mode was ranked as “most useful” by at least one student, indicating that all of the modes contribute to the software.

1 Introduction

Student participation in undergraduate classrooms is positively related to their learning (Section 6.1), but few students actually participate. Even fewer students participate often. This phenomenon has been observed in several studies, dating from 1976 to as recently as 2002 (Section 6.2). The consistent results from these studies underscore the continued prevalence of this issue in undergraduate education.

There are several reasons that students choose not to participate in class (Section 6.3). Some of the most cited reasons are the students’ inability to formulate specific questions and their fear of appearing unintelligent to the instructor and to peers. The technological innovation in this project—called ClassResponse or CR—addresses these issues by letting *students communicate with the instructor anonymously, during class, without needing to articulate a specific question*.

The next section (Section 2) describes CR in more detail. Section 3 examines some related work, and Section 4 describes the pilot study and the results.

2 ClassResponse

CR is a form of individual response technology (IRT). It lets students use any web-enabled mobile device (e.g., smart phones, tablets such as iPads, or laptops) to communicate with the instructor during class in real time. Mobile devices are increasingly popular among students: 49% of surveyed college students had smart phones in 2010, up from 27% in 2009 [Hernandez, 2010]. Future generations of students will have grown up using these mobile devices. This project leverages that fact to help the students connect with the instructor. Using students’ existing devices, instead of requiring separate hardware, follows the “bring your own device” trend (e.g., King [2011], ISACA [2011]). This approach eliminates potential hurdles to using an IRT, such as purchasing, learning about, and toting a separate device to class. For instance, Draper and Brown [2004] found that 25–35% of students forgot to bring their clickers to class!

Both the student interface (Figure 1) and the instructor interface (Figure 2) for CR are designed for small screens like on smart phones. The simple interface for the students will reduce their cognitive load, an important part of effectively using mobile phones for IRT [Lindquist et al., 2007].

The heart of the CR system is the variety of communication mechanisms it supports between the students and the instructor. The interfaces have different sections for the different communication mechanisms: “pace of class” feedback, open-ended student questions, and multiple choice questions (MCQs).

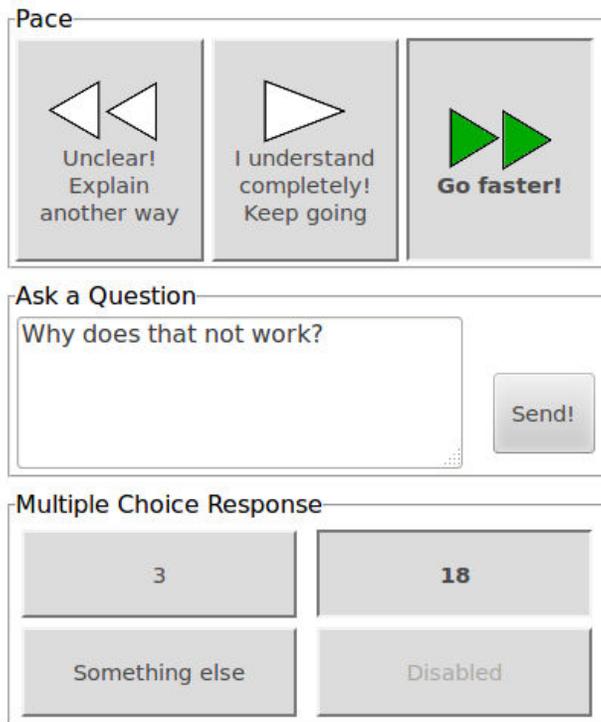


Figure 1: Students' interface

2.1 Pace of Class Feedback

When a student is bored or is confused but cannot formulate a specific question, they can communicate via the “pace of class” mechanism. The student can simply click a button to indicate that the pace of class is too fast, about the right speed, or too slow. This is student-initiated, limited-response (SILR) communication: students can provide or change their feedback any time by selecting from a few possible responses. Section 6.3 describes the research that suggests this type of communication might be important for encouraging participation. This form of communication is the primary factor that distinguishes CR from other IRTs (Section 3).

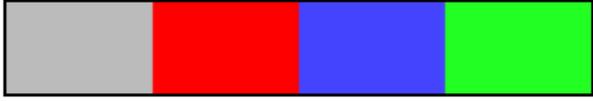
The bar graph in the instructor’s “Pace of Class” display provides a real-time picture of what the students think about the pace of the class. The bar is divided into four sections. The leftmost section is gray, corresponding to students who are logged in but have not yet indicated an opinion about the pace of class. The other three sections indicate how many students think the pace is too fast, just right, or too slow. They are colored red, blue, and green, respectively. The relative sizes of the sections show what fraction of the class is indicating each pace preference.

2.2 Open-Ended Student Questions and Comments

Whenever a student has a specific question or comment, they can send a short message to the instructor. The instructor sees the question or comment appear in the list of student questions. He or she can address each question immediately, later, or not at all (e.g., for an inappropriate or irrelevant comment). The instructor’s interface includes a checkbox for each question so they can keep track of which questions they have addressed and which questions are still unanswered.

The list is displayed in reverse chronological order, so new questions appear at the top. Older questions that have already been addressed are removed from the screen as space is needed. If the

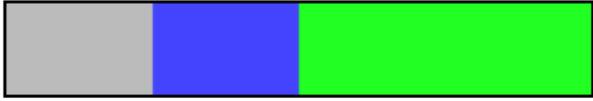
Pace



Student Questions

- X Why not use a char*?
- X Why does that not work?
- X What is a pointer?

Multiple Choice



Correct? Num.

<input type="checkbox"/> 3		Options	3 ▾
<input checked="" type="checkbox"/> 18		Defaults	
<input type="checkbox"/> Something else		Start	
<input type="checkbox"/> D		Stop	

Students who are Logged In

johndoe, joycta01, fowlm01, krumr01

Figure 2: Instructors' interface

list is still too long, the instructor sees a scroll bar appear so they can access all the unanswered questions. This prevents the list of questions from taking too much screen space from the other panels in the interface.

2.3 Multiple Choice Questions

While the “pace of class” and open-ended questions are student-initiated communication, the multiple choice questions (MCQs) are instructor-initiated, similar to “clickers.” To initiate an MCQ poll, the instructor chooses the number of possible responses (from 1 to 4), types in text for the different responses (e.g., “Yes” and “No”) or clicks the “Defaults” button to get A, B, C, and D, then clicks the “Start” button to open the poll for student responses.

When the poll is opened, the students’ buttons are enabled and they see the text of the different options show up on their buttons. (Those buttons are disabled except when the instructor has an open MCQ poll.) As the students provide their responses, the instructor’s bar graph updates in real time. Similar to the “pace of class” view, the bar graph is divided into different sections: one for “no response” and one for each possible response. The responses are color coded for easy identification. When the instructor closes the poll, the students can no longer ring in with their answers. The instructor’s bar graph is frozen with the responses from the students at the time the poll was closed.

2.4 Other Notes about Communication

All of the CR communication mechanisms are anonymous.¹ The anonymity is designed to encourage participation by eliminating students’ fear of appearing unintelligent to peers and the instructor (Section 6.3). Indeed, several researchers who have explored IRTs mention anonymity as a reason for adoption, often supported by qualitative feedback and comments from students [Draper and Brown, 2004, Markett et al., 2006, Poirier and Feldman, 2007, Ratto et al., 2003]. Furthermore, the emphasis on SILR communication in CR is intended to reduce students’ inhibitions about participating when they cannot articulate a specific question or comment.

The different types of communication are designed to complement each other, as each one has its own strengths and weaknesses. For MCQs, the limited form of the student responses makes them easy for the instructor to digest quickly, even for large classes. However, they do not permit students to initiate contact with the instructor, so they do not provide an anonymous channel for students’ questions. This limitation is addressed by IRTs that let the students send short messages to the instructor. But it takes time for students to type in the message [Lindquist et al., 2007], and it also takes time for the instructor to read and understand the questions. Furthermore, such IRTs require students to formulate a question or message, which is a significant barrier for student participation (Section 6.3).

3 Related Work

IRTs such as mobile phones or “clickers”² have been successfully used in several disciplines and a range of class sizes. For example, both Morling et al. [2008] and Poirier and Feldman [2007] found that classes using clickers performed better on exams than those who did not. In a broader study, Draper and Brown [2004] studied the use of clickers in 8 different departments, with class sizes ranging from 20 to 300. They found that the “use of the handsets was judged by both learners and teachers to benefit them.”

Many existing IRT systems support either instructor-initiated multiple-choice questions or

¹The system logs who sends each message, but that information is not available to the instructor.

²“Clickers” are handheld devices that let students press one of several buttons to respond to multiple-choice polls.

Table 1: Research on individual response technologies (IRTs) for handheld devices

Citation	Feedback Type	Class Size	SMS-based?
Morling et al. [2008]	MCQs	320	No
Poirier and Feldman [2007]	MCQs	>400	No
Draper and Brown [2004]	MCQs	20–300	No
Elicker and McConnell [2011]	MCQs	40	No
Lindquist et al. [2007]	MCQs, text, or photo	12 (mock session)	Yes
Ratto et al. [2003]	Open-ended	75–150	No
Markett et al. [2006]	Open-ended	12–18	Yes

student-initiated short messages, but not both. Other interactive learning systems include several forms of communication as well as integrated slide-viewing and note-taking capabilities (e.g., LectureTools [2012], DyKnow Vision [2012]). However, these systems are designed for use on laptops, making them difficult or even impossible to use effectively on smart phones. To my knowledge, only one such system supports SILR communication: LectureTools. It lets students flag slides that they find confusing. This is not a prominent feature of the system, which focuses on displaying the lecture slides to students and letting them take notes with the slides.

Table 1 lists some existing work on IRTs for handheld devices (e.g., cell phones), including the different types of communication they use. Markett et al. [2006] is one of the few IRT studies to examine small classes specifically. Students sent in questions during class via SMS (i.e., “text messages”), with 47% of the students choosing to send a question to the instructor. Both students and instructors felt that some class discussions that occurred with the IRT would not have happened without it. The primary drawback they found—typing the text of the question distracts the students—should be reduced by other forms of communication in CR, as well as the fact that students are more likely to be using smart phones. They are better suited for typing than the 12-key phones typically available during Markett’s study.

Lindquist et al. [2007] examined the use of mobile phones with an IRT supporting various types of communication (MCQs, writing short computer programs, camera-phone photos of diagrams, etc.). However, all of the communication was in response to instructor-initiated exercises, not student-initiated questions. Furthermore, they only tested their system in one mock lecture session with 12 volunteer students. Based upon their observations, they made some recommendations about IRT with mobile phones—minimize the amount of symbol-typing and the cognitive load on the students—that informed the design of CR.

4 The Project

This project incorporated CR into the course CS 23200 “Introduction to C and UNIX” during the Fall 2012 semester. CS 23200 is a core computer science course, required for all computer science majors. I taught it for six semesters before this study, with approximately 20 students enrolled each semester. I am currently the only instructor for this course.

The class meets twice a week for 75 minutes each session. The format of the class session depends upon the material to be covered. Over 25% of the sessions are lab sessions, where most of the time is devoted to working through an example problem. A few sessions are devoted to review sessions or exams. The remaining sessions (about two-thirds of the class) are lectures with active learning exercises throughout.

Almost all of the students in CS 23200 are computer science majors (or a closely related major).

In the typical class, over half of the students have had no exposure to the C language (which is the focus of the class). Most of the remaining students have had less than a year of experience with C (or C++, a closely related topic), although occasionally there is a student who enters the class with extensive (10+ years) experience in C. The students range from freshmen to seniors, with sophomores being the largest population. The students have already been introduced to programming, taking two programming courses as prerequisites for CS 23200.

4.1 Research Questions

While there are many questions to explore with respect to CR, this project was intended to focus on the following questions:

- Participation level:
 - If and to what extent will CR increase the number of student-initiated, open-ended questions that the students ask during lecture?
 - If and to what extent will CR increase the number of students who initiate at least one question during lecture?
- Grades:
 - If and to what extent will CR improve the average course grade?
 - If and to what extent will CR improve the course grade for students below the median?
- Student feedback:
 - What aspects of CR do students find to be most useful?
 - What suggestions do students have for improving CR?

The first two questions examine participation levels. They are the most direct measures of how CR impacts the classroom. Measuring participation levels is important because participation has already been linked to student learning (Section 6.1). The two questions about grades are designed to directly measure the impact on student learning. The feedback questions will provide information for improving the system and continuing research on CR.

4.2 The Baseline: Spring 2012

In preparation for this project, I collected data on participation levels in the Spring 2012 section of CS 23200.³ Other than introducing CR, there were only very minor differences between the course content, assignments, etc. in Spring and Fall 2012.

I measured the number of student-initiated questions during the Spring 2012 semester of CS 23200. The measurements included each class session that covered new material (i.e., not primarily reviewing concepts from prerequisite courses) and was not an exam review, an exam, or a lab session. There were 17 such sessions, each of which was 75 minutes long. On average, 28% of the students attending a class session participated at least once. This is consistent with other research studies (Section 6.2), providing further evidence for the lack of participation in class.

Of the seventeen students in the course, only one (5.8% of the class) met the definition of a “talker” (i.e., an average of two or more questions per class session [Karp and Yoels, 1976]). Figure 3 shows the average number of questions each student asked during each class session when they were present. The talker’s statistic is an outlier (5 questions per session), possibly related to the fact that the student dropped the course about halfway through the semester.

³The data collection for this project was conducted with IRB approval (Protocol #1201011732).

Average Number of Questions

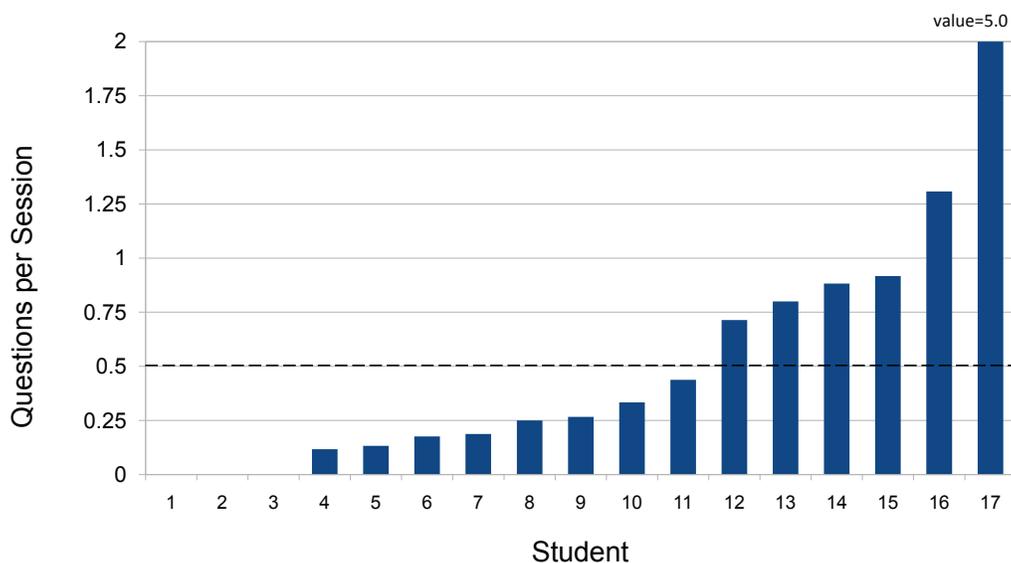


Figure 3: The distribution of how often each student asked a question in the average class session.

Despite the lack of talkers according to the definition of Karp and Yoels [1976], there is still evidence for the consolidation of responsibility in my class. Looking at Figure 3, one can see two tiers of contributors to the class: those who ask more than 0.5 questions per class, and those who ask less. The former category consists of 6 out of the 17 students, 35% of the class. These students account for 74% of the student-initiated questions. Thus, using a lower threshold for defining “talkers,” the behavior in my class is similar to results from other studies (Section 6.2), demonstrating the consolidation of responsibility and general lack of participation.

4.3 The Intervention: Fall 2012

In Fall 2012, there were 26 students enrolled in CS 23200, which was 53% more than in Spring 2012. The larger class led to a different classroom atmosphere. Thus, the difference in class size is one variable that could explain differences between Spring 2012 and Fall 2012, in addition to the introduction of CR. Even though differences between the semesters cannot be attributed to CR, Section 4.3.1 provides some comparison of the two semesters. Section 4.3.2 describes how students used CR, and Section 4.3.3 discusses their feedback about the system.

Table 2: Participation Levels

	Spring 2012	Fall 2012 (with CR)
Num. students	17	26
Total questions	90 (5.3 / student)	88 (3.4 / student)
Questions via CR	N/A	17 (19.3% of questions)
Students asking at least one question	14 (82%)	16 (61%)
Students asking more than 0.5 questions per class	6 (35%)	5 (19%)
Questions asked by those “talkers”	67 (74%)	55 (62.5%)

Table 3: Grade Comparison

Percentile	Spring 2012 Grade	Fall 2012 Grade (with CR)	Change
12.5%	49.1	53.1	4.0
25%	57.3	69.8	12.5
37.5%	70.3	74.0	3.7
50%	75.5	75.2	-0.3
62.5%	80.6	75.9	-4.7
75%	85.1	79.8	-5.3
87.5%	91.9	89.9	-2.0

4.3.1 Comparing Spring 2012 and Fall 2012

Just as in Spring 2012, I measured the number of student-initiated questions during Fall 2012. However, with CR in place, these questions could come either from hand-raising or through the open-ended question part of CR.

Table 2 compares the participation levels between Spring 2012 and Fall 2012. All of the measures that adjust based on class size (e.g., questions per student) show that participation went down from Spring 2012 to Fall 2012. However, the absolute numbers, like number of questions overall or number of students asking more than 0.5 questions per class, are very similar between the two semesters. This may indicate a ceiling to the number of questions to expect on this material, regardless of class size. In fact, one of the student comments on the survey about CR was that “the teacher already answers most of the questions I have when I don’t ask them.”

While the number of questions asked in Spring 2012 (90) is almost identical to the number for Fall 2012 (88), over 19% of the questions in Fall 2012 came via CR instead of by raising hands. Section 4.3.2 looks at this usage in more detail.

Table 3 compares students’ grades in Spring and Fall 2012. The primary difference is a tightening of the grade distribution: percentiles above the median decreased while percentiles below the median increased. This indicates more consistency across the class in the Fall 2012 semester. As mentioned earlier, there are several factors other than CR that could cause this effect, such as the difference in class sizes.

4.3.2 Usage Patterns for ClassResponse

One part of this project was to study how students used (or did not use) CR. There was no incentive for them to use the system, although I did mention it at the beginning of each class session.

Figure 4 shows how often each student logged in to CR. Almost every student logged in at least once, and some students logged in for 90% of the class sessions.

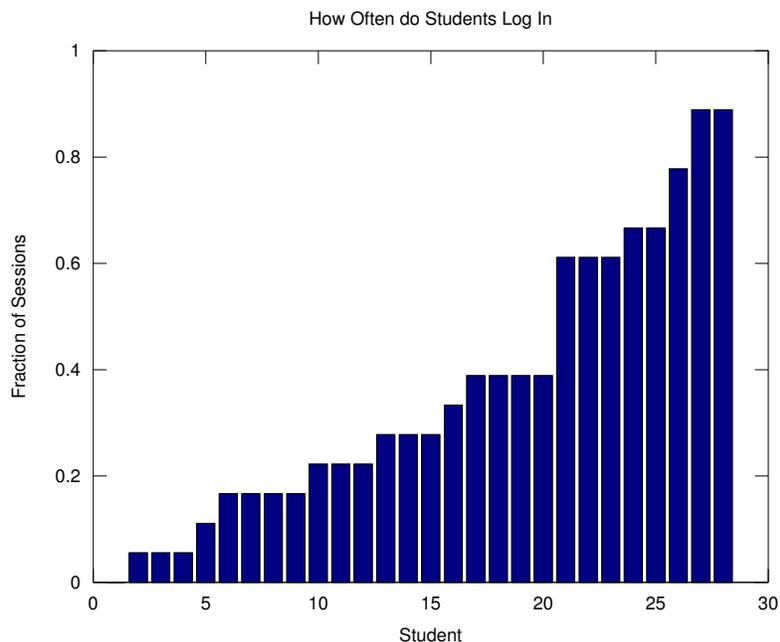


Figure 4: Login Frequency

I did not use multiple-choice polls very often during the semester, in part because simply asking the class to raise their hands and vote was easier. One area where CR could be improved is by making it easier for instructors to conduct multiple-choice polls.

The pace of class feedback was not used as often as I had anticipated. Figure 5 shows that the vast majority of pace responses were “keep going.” Furthermore, much of the time, students did not indicate any feedback about the pace after logging in. However, there were three times during the semester when I adjusted the pace based on students’ feedback. Two times I sped up and one time I slowed down and went back to review some material.

Figure 6 illustrates how often students indicated different pace preferences in different classes. The dark cells indicate a student who entered at least two different pace responses during a single class session. Looking at the figure row by row will give an indication of what is happening each class session, while examining it column by column will bring to light trends for each student. For example, student 14 almost always indicates at least one pace preference and often indicates two or more. Looking at row 12 highlights the fact that class session 12 prompted several students to indicate more than one pace response.

As mentioned above, 17 of the 88 student-initiated questions (19.3%) came through CR, as opposed to students raising their hands. Figure 7 shows how many questions each student asked over the semester, broken down into CR questions and raising-your-hand questions. The students are sorted by the number of questions for which they raised their hands. This highlights the fact that the students submitting questions via CR do not often raise their hands in class. In fact, one student asked questions only via CR.

4.3.3 Student Feedback about ClassResponse

I surveyed the students in my class about CR during the middle of the semester and again at the end of the semester. 22 and 16 students responded to the surveys, respectively, for response rates of 85% and 62%. The end-of-semester survey included the same questions as the mid-semester

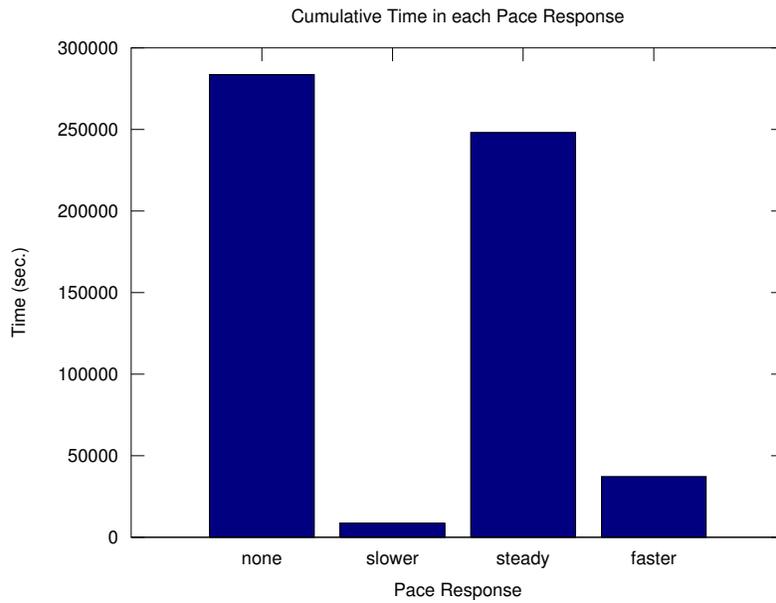


Figure 5: Pace responses over the course of Fall 2012

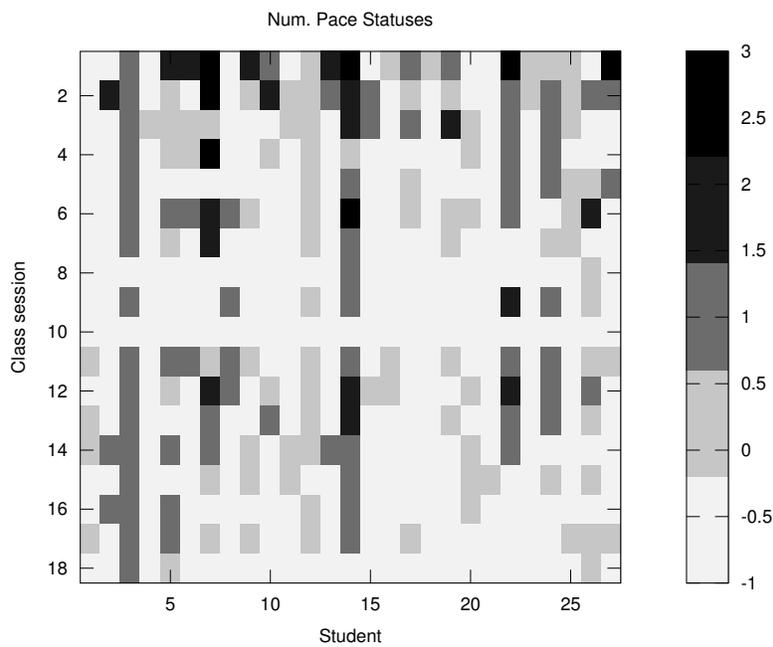


Figure 6: Pace responses broken down by student and by class session. The darker cells indicate times when a student indicated more than one pace preference.

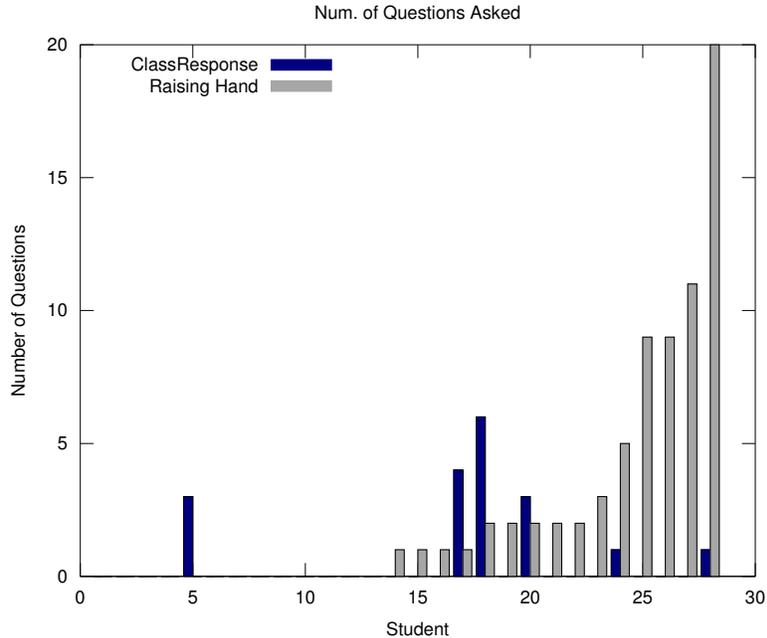


Figure 7: Number of questions each student asked throughout the semester.

survey, plus a few additional questions about how the students used CR.

Part of the surveys asked students to indicate the extent to which different factors influenced their decision to use or not use CR. In the list of reasons to not use CR (Figure 8), technological issues (e.g., spotty network connection) and “I forgot about it” are at the top. It is worth noting that one potential limitation of CR—students who do not have a smart phone or laptop—was not an issue for this class, where over 90% of the respondents had smart phones or laptops. Since this is a computer science class, that is not surprising; other disciplines would likely see different numbers.

Anonymity, the ability to submit open-ended questions, and the ability to respond to MCQs are the top reasons that had “a lot” of influence on students’ choice to use CR (Figure 9).

On the end-of-semester survey, the students were asked to rank the different modes of communication. The MCQs was deemed most useful, followed by the open-ended questions, with the “pace of class” mode being the least useful (Figure 10).

I had noticed during the semester that the pace of class feedback was not as effective as I had anticipated, so I included several questions on the final survey to ascertain why that was the case. One question asked how often students actually wanted to speed up in class, but did not indicate that preference in CR. A similar question asked about wanting to slow down in class. Figure 11 illustrates the results. 31% of students wanted to speed up at some point during the semester, but did not indicate that. Almost half of the students, 46%, said they wanted to slow down at some point but did not indicate that.

The 7 students who indicated wanting to speed up or slow down were asked a follow-up question on the survey about why they did not indicate their preferences. Table 4 shows the reasons that students selected, with “I forgot” topping the list.

Similarly, the 11 students who said that they used the “pace of class” mode less than “a lot” were asked their reasons for not using it. Table 5 shows the reasons that students selected, with

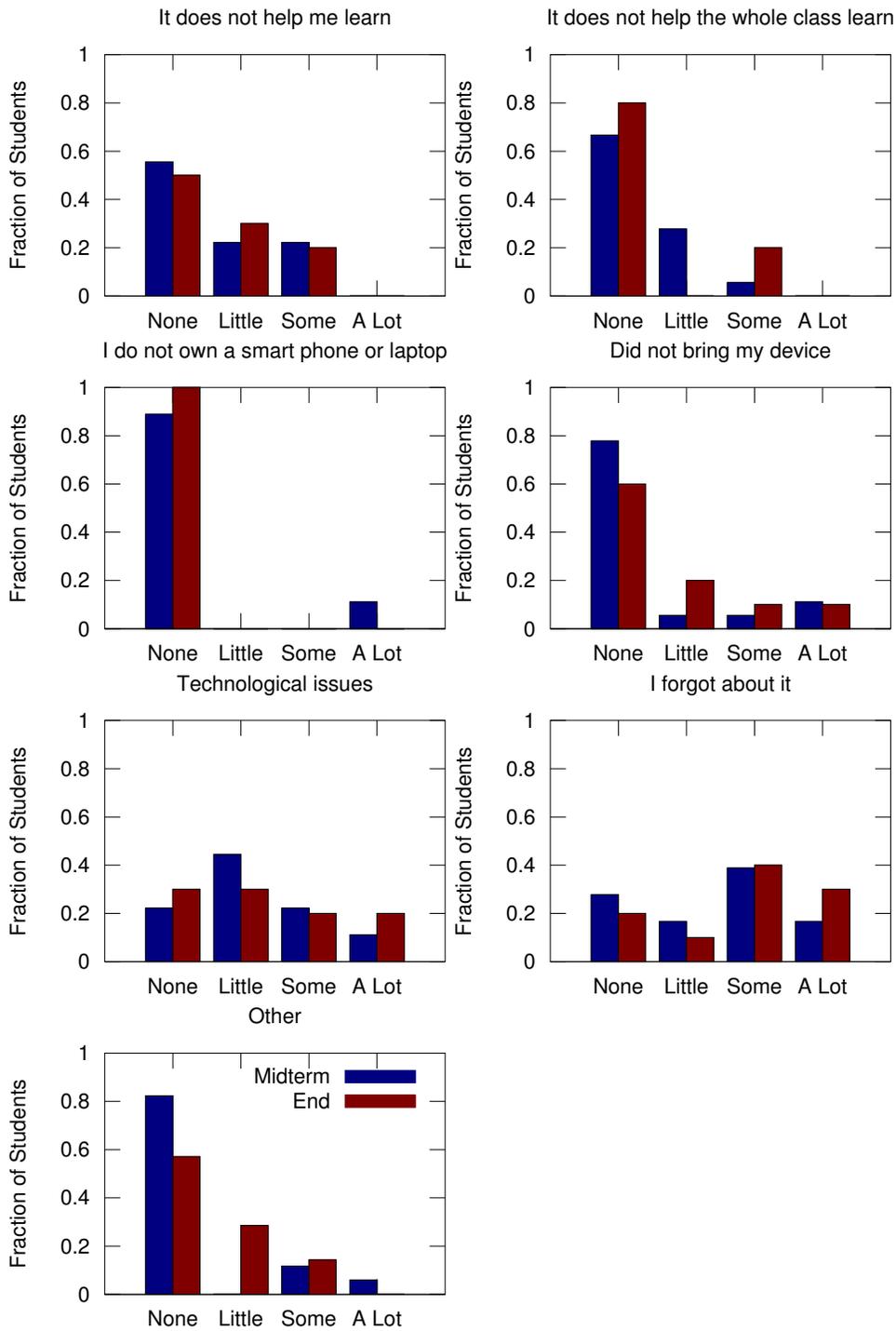


Figure 8: Relevance of different factors for choosing not to use CR

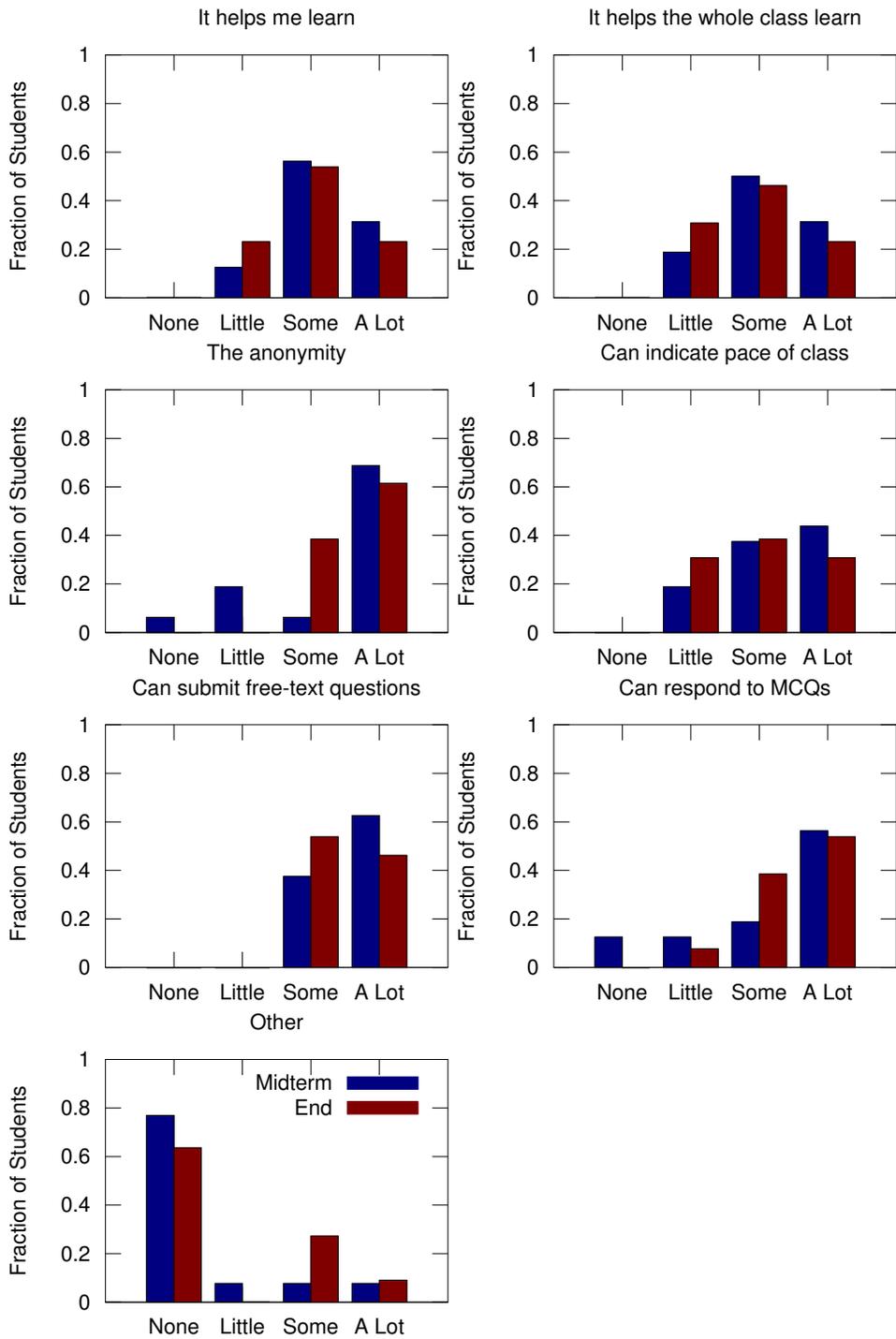


Figure 9: Relevance of different factors for choosing to use CR

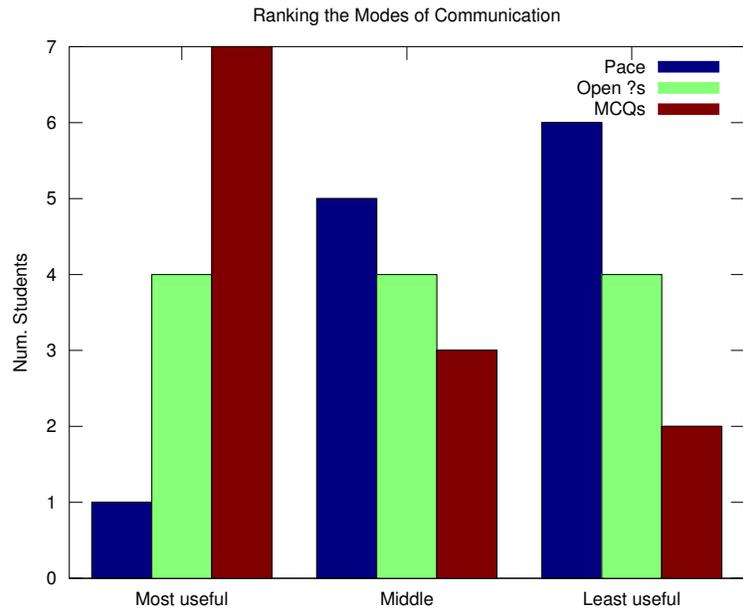


Figure 10: Ranking the usefulness of the modes of communication

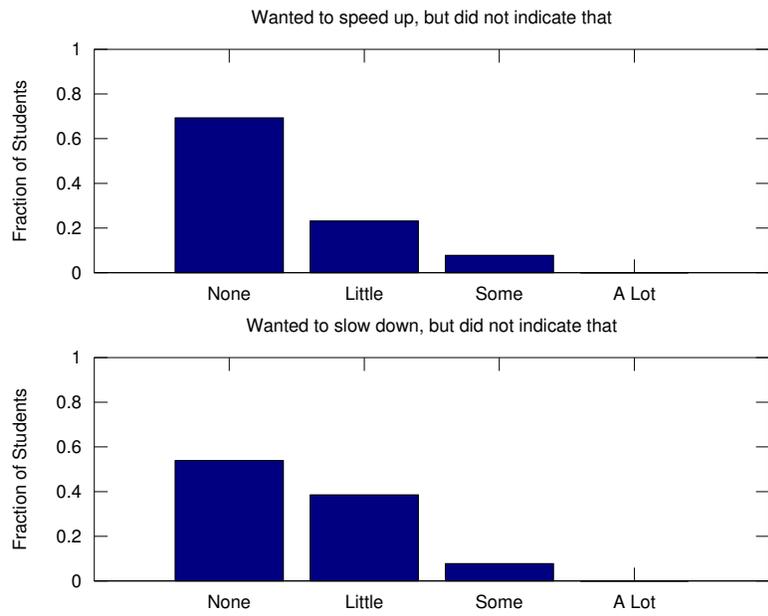


Figure 11: Students who wanted a change of pace but did not indicate that via CR

Table 4: Reasons for Not Indicating Pace Feedback when the Student Actually Wanted the Pace to Change. The counts are out of 7 students. Students could select more than one reason.

Reason	Num. Students
I forgot	4
I thought that my opinion would not actually influence the instructor’s pace	1
Instead, I asked a question by raising my hand	3
Other	0

Table 5: Reasons for Not Using Pace Feedback. The counts are out of 11 students. Students could select more than one reason.

Reason	Num. Students
I forgot	7
I thought that my opinion would not actually influence the instructor’s pace	2
My opinion was “keep going,” which would happen anyway	3
Other	2

“I forgot” again topping the list. The two “Other” reasons were “spaced out” and “didn’t want to slow the class down.”

5 Summary

The CR software was developed and deployed as intended. Differences in the class size between my control group and experimental group prevent a straightforward analysis of the impact of CR on participation and learning.

Thus, my analysis focused on the usage patterns and the survey results. As expected, anonymity was a big motivation for using CR. Technological issues and students simply forgetting to use CR were the two main reasons for lack of use. Overall, the students found the MCQ polls to be the most useful, followed by the open-ended questions, with pace of class being the least useful. However, there was considerable variation in students’ rankings, with each mode of communication being listed as “most useful” by at least one student. Thus, each part of CR contributes to the overall software package.

6 Appendix: A Review of Participation in the Classroom

Actively involving students in the learning process helps the students to learn more effectively [McKeachie, 1970, Carini et al., 2006]. There are several types of “active learning,” including student presentations (e.g., Smith [1996]), collaborative learning groups (e.g., Rau and Heyl [1990]), and verbally participating in dialog with instructors (e.g., Howard et al. [2002]).

The different types of active learning take varying amounts of instructor effort to incorporate effectively into a class. Some types, such as collaborative learning groups, require substantial changes from a traditional lecture-style course, but lead to highly active class sessions. On the other end of the spectrum, encouraging participation in class is a simple way to promote some active learning that does not require substantial course redesign. It is my opinion that active learning techniques from across this spectrum have their place in the current educational environment. From the perspective of a faculty member with limited time, simple techniques for improving an existing course are more practical than techniques that require redesigning a major piece of a course. Thus, one guiding principle behind CR’s design is to broaden the impact of this project by minimizing the barriers to instructor use. The vision is to encourage many instructors to take a step in the direction of active learning, rather than a few instructors taking a large leap. Therefore, this project focuses on encouraging participation in class as a specific form of active learning.

6.1 Relating Participation to Student Learning

Simply put, *participation in class is positively related to student learning*. For example, Kember and Gow [1994] found that interactive teaching has a significant positive correlation with *growth* in students’ usage of deep and “achieving” approaches to learning during their time at university. Smith [1977] found that student participation has a positive relationship with the *improvement* of students’ critical thinking abilities over the course of the semester. Garside [1996] also found evidence that participation encourages higher-level/critical thinking by students. In another study, Handelsman et al. [2005] found that the level of students’ participation/interaction engagement was a statistically significant predictor of their exam scores in a freshman-level mathematics course. Even simple forms of participation like using IRTs to answer multiple-choice questions correlate with an increase in exam scores [Poirier and Feldman, 2007, Morling et al., 2008]. In addition to improving student learning, active/collaborative learning experiences are correlated with students’ self-reported gains in character [Kuh and Umbach, 2004].

Participation can be subdivided into instructor-initiated, student-initiated, and direct questions⁴ (e.g., Cornelius et al. [1990] and Constantinople et al. [1988]). The student-initiated communication best embodies the principles of active learning, so it is the focus of this project. This specific type of interaction is directly associated with enhanced student learning: students who initiated an average of at least one question or comment per class session had significantly higher levels of course achievement and creative originality [Williams, 1971]. Furthermore, Smith [1980] studied participation in a variety of disciplines and found that student participation is “consistently and positively related” to critical thinking scores on the Watson-Glazer test.

6.2 A Lack of Student Participation

Since participation in class is linked to improved student learning, one would hope that our classrooms are filled with students who are participating. However, there is a substantial amount of evidence that this is not the case. Karp and Yoels [1976] were among the first to point out the “consolidation of responsibility” that occurs in the classroom: a few students are responsible for the vast majority of the participation in class. These few students are called the “talkers,” defined

⁴Direct questions are where the instructor asks a specific student to answer a question.

as students who make (on average) two or more comments in a class session. In small classes (less than 40 students), 25% of the students were talkers, and they accounted for 75% of the interactions in class. In large classes (more than 40 students), the consolidation of responsibility is even greater: only 6% of the students were talkers, accounting for 51% of the interactions. Furthermore, many students did not participate at all: 52% and 76% for small and large classes, respectively.

The consolidation of responsibility has been confirmed in several other studies since that time, highlighting the persistence of this problem. Nunn [1996] found that, on average, only 26% of the students participated in the classroom discussion. Over half of the students who Howard and Henney [1998] observed “did not contribute a single interaction to class discussion.” Fritschner [2000] found that an average of 28% of students participated verbally in class, with the talkers accounting for 79% of the students’ comments overall. Howard et al. [1996] found that 28% of the students account for 89% of all the student comments. In another study, Howard et al. [2002] found that the talkers, who made up 26.1% of the students, accounted for an overwhelming 92% of all student participation. The consolidation of responsibility is *particularly troublesome for STEM educators*, because several studies have found that participation in natural science classes was lower than social sciences or humanities [Constantinople et al., 1988, Cornelius et al., 1990, Crombie et al., 2003]. Data from my initial, exploratory study confirm this lack of participation in STEM classes: on average, only 28% of the students attending my class sessions participated at least once.

6.3 Reasons for Not Participating

The consolidation of responsibility occurs even though students recognize that participation improves their learning. For example, Fritschner [2000] found that “all of the students interviewed considered verbal participation as essential to the learning process.” In addition, Howard et al. [2002] found that over 60 percent of students surveyed listed “I learn more when I participate” as one reason they choose to participate in discussion.

So why are students not participating in class? More importantly, what reasons can we as instructors directly address in order to encourage more participation? There are many factors that impact student participation levels, including some student traits (e.g., age, personality), instructor traits (e.g., gender, invitations for questions), and class traits (e.g., class size) [Rocca, 2010].

Of the myriad of contributing factors, when students are asked about their reasons for not participating, the following four types of insecurity are consistently among the top reasons they cite: (1) Fear of appearing unintelligent to other students; (2) Fear of appearing unintelligent to the teacher; (3) My ideas are not well enough formulated; and (4) I do not know enough about the subject matter. In several studies, these four reasons are among the top five [Howard and Henney, 1998], six [Crawford and MacLeod, 1990, Howard et al., 1996, 2002], or seven [Karp and Yoels, 1976] reasons students list for not participating (they could choose several reasons).⁵ Furthermore, a significant fraction of the students cite these reasons, ranging up to 80% in some cases. For each of these four reasons, Crawford and MacLeod [1990] found a statistically significant difference between males’ and females’ response rates, with females listing each reason significantly more than males.⁶ Thus, by addressing these insecurities, *CR can promote diversity in STEM by encouraging more female participation.*

The consistent results across all of these studies (as well as Fritschner [2000] and Weaver and Qi [2005]) highlight how great of an impact these forms of insecurity have on students’ participation.

⁵Other popular reasons are “have not done the assigned reading” and “large class size.”

⁶This was not true of all the reasons on the survey. Some reasons were cited more by males.

7 Appendix: The Design of ClassResponse

For the CR software to have the largest impact on student education, it must be easy to install and maintain, it must support a wide range of devices and web browsers, it must scale to multiple classes with many users, and it must be easy for both students and instructors to use. Using a web application (instead of an application that must be installed) with a simple interface for both students and instructors helps to achieve the latter property. The rest of this section describes how the technical features of CR help to achieve the other desired properties.

There are three software components for CR: the server and the two in-class client interfaces (instructor and student). The clients are written using HTML, JavaScript and CSS. Built upon these well-established technologies, CR supports all major web browsers and hardware platforms, which is important for widespread adoption.

The server is also written in JavaScript, using the node.js platform to actually serve the web pages to the clients. Node.js uses “an event-driven, non-blocking I/O model that makes it lightweight and efficient, perfect for data-intensive real-time applications that run across distributed devices” [Joyent, 2012]. This technology fits well with the CR usage profile because both are geared toward efficient communication between server and client. In particular, CR involves lots of short messages traveling between the clients and the server (e.g., student presses a “pace” button, instructor opens a multiple-choice question, etc.). Virtually every action performed in the student client generates some message to send to the server, which then triggers a message to the instructor that updates their display. Similarly, instructor actions generate messages that get sent to the server, which in turn sends out messages to the students of that class. Node.js eliminates the need to set up blocking or locks in order to handle concurrent connections; the platform handles them underneath the hood. Furthermore, node.js is designed to scale efficiently to many users, as it does not use a separate thread for each connection (which would require extra memory). Another advantage to using node.js for the web server is that both client and server are written in JavaScript. This is helpful for development, but particularly important for code maintenance: someone with knowledge of JavaScript can understand both the client and server code.

We use socket.io for full-duplex communications between the server and the student or instructor client pages. Socket.io [LearnBoost, 2012] is a freely available JavaScript library that wraps several different communication protocols in a simple interface. The library detects which communication protocols are supported on the current platform, selecting the most efficient. In this way, network traffic is kept to a minimum. In particular, polling—which can waste network resources—is used only if deemed necessary.

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