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Deliberate Engagement of Laptops in Large Lecture Classes to Improve Attentiveness and Engagement

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Abstract

The value of in-class Internet technologies to student attentiveness, engagement, and learning remains both controversial and filled with promising potential. In this study, students were given the option to use LectureTools, an interactive suite of tools designed specifically for larger classes. The availability of these tools dramatically changed the mechanics of the course as over 90% of students attending lecture voluntarily brought their laptops to class. On one hand, surveys over multiple semesters show that students believe the availability of a laptop is more likely to increase their time on tasks unrelated to the conduct of the course. On the other hand, the surveys also ascertained that students felt more attentive with the technology, significantly more engaged, and able to learn more with the technology than in similar classes without it. LectureTools also led to a dramatic increase in the number of students posing questions during class time, with more than half posing at least one question during class over the course of a semester, a percentage far higher than achieved in semesters prior to the use of this technology. These results suggest that while having laptops in the classroom can be a distraction to students, students of today show confidence that they are capable of productive multitasking, showing that they not only can handle this technology when applied through "deliberate engagement" using tools like LectureTools, but thrive with it, as seen through improved attentiveness, learning, and overall engagement even in larger classes.

Keywords: Laptop use; Large classes; Post-secondary education; Student response systems; LectureTools; Clickers

A large portion, if not the majority, of undergraduate students in the United States receive their college-level science training through required science distribution courses. The courses that serve this population are often relatively large, and, in part for this reason, are thus challenged to provide an environment that will increase students' literacy and engagement in science. Large classes can be intimidating for students and reduce the likelihood of engagement, inquiry and feedback (Frederick, 2002; Geske, 1992; Iverson, 2002).

Larger courses tend to be conducted as "lecture-centric", with limited opportunities for students to interact with the instructor (Boyer, 1987). It is generally agreed that a shift in large-class format from "lecture-centric" to "active learning" is desirable for student learning (Bonwell & Eison, 1991; Prince, 2004). Improvements in student engagement and/or learning have been reported through use of more active learning methods utilizing student response systems (Addison, Wright, & Milner, 2009; Cain, Black, & Rohr, 2009; Crossgrove & Curran, 2008; Gauci, et al., 2009; Judson & Sawada, 2002) and collaborative projects (Roberts, 2005; Skala, Slater, & Adams, 2000; Suchman, et al., 2000). Moreover, there is growing evidence that personal response systems (PRS) can improve engagement (Addison,

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Wright, & Milner, 2009; Fitch, 2004; Stephens, 2005) and learning (Addison, Wright, & Milner, 2009; Cain, Black, & Rohr, 2009; Gauci, et al., 2009). Extending the use of PRS to encourage group discussion, Eric Mazur (Mazur, 1997) has developed a strategy for engaging students through use of "Peer Instruction." Peer Instruction has been shown in multiple classes to be an effective strategy for engaging students (Crouch & Mazur, 2001; Hake, 2007).

It has been argued that the use of Internet technology in large classes may help increase interaction between students and instructors and create a more active learning environment (Fitch, 2004; Stephens, 2005). However, this claim has been challenged by those who worry that the introduction of laptops into class may cause more harm than good (Fried, 2008; Kladko, 2005; McWilliams, 2005). The introduction of laptops into classrooms provides students tempting distractions from course material, such as communication channels to their peers and social networks that are often difficult to resist. One need only sit in the back of a large class that is not deliberately engaging laptops to see their potential to distract students to tasks unrelated to the course. The challenge addressed here is to what degree the deliberate engagement of laptops in class can provide pedagogical benefits that outweigh the potential distractions inherent to the introduction of free communication devices in the classroom.

Evidence exists that "deliberate" use of laptops in lecture classes, i.e. where laptops are deliberately engaged in the conduct of the course, can increase constructive discourse between students and between students and instructors (Anderson, 2004; Anderson, et al., 2005; Driver, 2002; Fitch, 2004). This research explores "deliberate engagement," the use of technology in a deliberate and integrated manner to affect learning goals. LectureTools[1], was created initially as a Web 2.0-based PRS system, but evolved through formative assessment in large, introductory undergraduate courses to a more integrated learning environment. In this paper the many effects of *deliberate engagement* of laptops in large lecture classes are explored. Questions to be considered include: To what degree does the deliberate engagement of laptops lead to student distraction? How does this environment affect student attentiveness and engagement? Do the students in these courses learn more or less than students without the technology? These are questions not easily answered but critical to the debate as to whether and how to best integrate Internet technology into a classroom setting.

1. Background

LectureTools was built largely because of an interest to extend Mazur's Peer Instruction approach the field of climate studies. It began as an exploration of how clickers could be used to invite student responses on issues of concern to global change. However, we quickly discovered that clickers, while an excellent first step, allowed for only a limited range of questions. The first step in the evolution of the tools described here was to develop a simple web-based tool where students could answer multiple choice questions, as has been done with clickers, but also with image-based questions that were not possible with clickers. In the geosciences, this allowed the presentation of questions requiring spatial thinking (i.e. where on a map would you expect…?).

While testing these so-called "Image Quizzes," we got feedback from students that they not only enjoyed these kinds of questions, but they started generating new ideas for additional web-based functionalities. Hence, after the initial design, the continuing design was largely driven by the suggestions of students and instructors. This by itself was exciting because, instead of the usual model of

[1] LectureTools (http://www.lecturetools.com) is freely available to all higher education instructors in the United States and Canada.

technology being made available through decisions made higher in the institution, here the technology was being designed, built and implemented by the instructors and students who were using it.

2. Methods

2.1. Design

The LectureTools classroom application is built around the hypothesis that students learn better when they have opportunities to actively assess their understanding as material is being presented, to pose questions and get feedback during lecture, and to reflect on their learning outside of class. Inherent in this approach is a need to facilitate "Concept Tests," a series of questions posed to students, requiring their responses as either a means to introduce a topic or to test their understanding. LectureTools promotes this instructional strategy with the expectation that through a model of "mini-lectures" combined with quizzes to test students' understanding of concepts (Figure 1), the following objectives can be achieved:

Improved Discourse — It is often difficult to engender discourse in large lecture classes, as the environment is impersonal and sometimes intimidating to students. Instructor questions often go unanswered or are answered by a select few. Few students become engaged and learning becomes passive. LectureTools aims to engage more students by offering tools for students to pose questions anonymously and answer a wider range of question types from an instructor than was afforded by clickers. The answers offered by the students to these questions become an opportunity for further discussion, either as a whole class or in small groups.

Peer Instruction — Hand-in-hand with the capability to pose a wider range of questions is the opportunity to challenge students to defend their answers in small groups. The results of these discussions can lead to follow-up votes and allow the instructor to quantify and display changes in opinion.

Reflection — Notes taken during class are stored, synchronized with slides, for reflection after class. Moreover, students can print out their notes with the instructor's slides in PDF format. Animations (Quicktime®, Flash®, etc.) shown in class can also be embedded into LectureTools for study after class.

Metacognition — Using the existing suite of question types, it is possible to create "wrappers" around content segments and challenge students to articulate how well they believe they understand the concept. For example, students rate how well they understand content being presented within LectureTools. These ratings can be compared with how well they can solve a germane problem at the end of a segment. This offers an opportunity to ask the students who performed poorly on the content question but rated their understanding as satisfactory or higher to reflect on the inconsistency.

The objective of this work is to create a more active learning environment in classrooms, with an emphasis on larger classes. Our design integrates several pedagogically desirable functions that hold promise to increase student engagement:

- The ability to take notes synchronized with an instructor's slide,
- The ability to pose questions and get responses in real-time during lecture,
- The ability to reflect on and report confidence in understanding during lecture, and

- The ability to respond to questions posed by the instructor and see aggregated results in real-time.

2.2. Materials and Procedures

The tool created, LectureTools, is a web framework that allows standards-based rapid prototyping of new functionalities and abilities as needs and opportunities arise.

2.2.1. For the Student:

- Once registered/logged-in, the student can choose any course registered by an instructor at that institution.

- Upon selecting a course, the student can choose any published lecture for that course using calendar navigation.

- Within the lecture page, students can 1) type notes synchronized with the lecture slides; 2) self-assess their confidence in understanding the material being discussed; 3) pose questions for the instructor and/or teaching assistant; 4) view answers to questions (with questioners' names removed) as posed by the teaching assistant during or after class; 5) select and enlarge the slide, draw on it (cross-platform on Mac or Windows) and save the drawing; 6) respond to instructor's questions; 7) view podcasts, if any, that are uploaded by the instructor after class; and 8) print the lecture slides and notes for off-line review (Figure 2).

- The instructor's slides, animations, questions and (optionally) uploaded podcasts along with students' notes are stored in the LectureTools database for subsequent reflection and review.

2.2.2. For the Instructor:

- Once registered/logged in, the instructor can choose any course previously registered, or register a new course.

- The instructor can, optionally, define topics to be covered in the course. These topics are used as metatags to organize assets the instructor uploads or questions created by the students.

- Upon registering/selecting a course, the instructor can either edit any published or unpublished lecture, or create a new lecture using calendar navigation.

- Inside a lecture, the instructor can upload their lecture slides (saved as JPG, PNG or GIF in Microsoft PowerPoint® or Apple KeyNote®) and associate them with topics (Figure 3). Once uploaded and saved, slides can be rearranged through intuitive dragging and dropping. The instructor can easily add student response questions (multiple choice, reorder lists, association, free response, and image-based) to the lecture and drag and drop them to the desired order in a lecture. Instructors can search for learning objects from online repositories (e.g. NSDL, MERLOT) and upload these as Flash or Quicktime animations into the lecture sequence. Once completed, the instructor saves the desired ordering and can then publish the lecture for students to access.

- During lecture, the instructor can use either their original PowerPoint® or Keynote® presentation to present lecture, or use the LectureTools presentation tool. With the LectureTools presentation tool, the instructor can draw on the slide (Mac or PC), save the altered slide, and navigate between slides. When student-response questions are posed, the instructor can view and present responses and/or take a "snapshot" of the results. The instructor can then challenge the class to defend their answers in small groups and, ultimately, vote again. Now the instructor can choose to show the original vote, the 2nd vote, or both.

- Also, during or after lecture, the instructor or instructor's assistant can respond to questions posed by the class during lecture. The party responding (e.g. teaching assistant during class or instructor after class) can modify the question for clarity, if necessary, and offer a response. Both the question and response, when posted, will be viewed by all students but without identification of the questioner.

- The instructor also has access to a list of student registrants in the class and can display that list with those who have logged in during class, as highlighted on the list. This list is stored for each lecture should the instructor want to check class participation and attendance.

- The instructor can also add web links to the class if desired, and/or provide a seating chart so students can identify where they are seated in each lecture.

2.3. Participants

The target classroom is a large, introductory science class (*Extreme Weather*, GEOSCI 122/AOSS 102) where the instructor is challenged to support a wide and diverse range of student learners. It is one of the classes that students in the University of Michigan's largest college, that of Literature, Science and the Arts, can select in order to fulfill a natural science distribution course. It is typically dominated by freshman and sophomore undergraduate students who will self-assess that "science does not come easily."

In a survey of students in the winter 2005 Extreme Weather class, it was discovered that about 75% of the students in that introductory class had laptops they could bring to class. While it wasn't clear at that time whether that meant they WOULD bring their laptops to class, this did illustrate that a majority of students would be able to participate in a web-based option if they chose. Moreover, the growing capability of cell phones to be Internet-enabled offers another avenue of potential devices that may already be coming to class and available to participate as part of an interactive, technological student response system.

2.3.1. Course Structure and Assessment

Student achievement in this course was partially based on participating in a pre-test, accounting for 5% of their grade, three exams worth 15% each, 20% for homework, 20% for in-class activities, and 10% for activities of the "common good" for class. The results of the pre-test are stored and compared with similar questions on later exams to quantify growth in understanding. LectureTools is optional for class, and in-class activities can be completed either through LectureTools or handed in on paper. The "common good" points are available for a wide variety of tasks that benefit the class' learning as a whole. As such, this includes attending and reporting on pertinent seminars, participating in focus groups on class design and technology, contributing stories and video assets relevant to class topics, and other activities that merit recognition.

2.3.2. Survey Procedures and Measures

Surveys include a questionnaire on student attitudes about science and technology at the beginning of the semester (Survey #1, surveys are included in the appendix) and an end-of-semester survey (Survey #2) about experiences in the course. On random days throughout the semester, a 'daily' survey is offered at the end of class to quantify what tasks unrelated to the course they engaged in that lecture (e.g. e-mail, Facebook, texting, sleeping, daydreaming, etc.). The daily survey also asks the student to evaluate the nature of the lecture presentation on a Likert scale from "lecture-centric" to "activity-centric."

3. Results

3.1. Response Rate

The response rate on Survey #2 in winter semester, 2009, was 175 of 182 students (96%), which is a similar response rate to other semesters. Survey results for daily survey response rates ranged from 118 to 130 of 182 (65% - 71%) for the three days that data were collected in the winter semester, 2009. It is our intention to offer the daily surveys more often in the future, as their use and response rates were first tested in winter, 2009.

3.2. Course Mechanics

LectureTools, while offered strictly as an option for students, has produced a significant shift in class mechanics. Figure 4 shows the results of a survey that asked the two questions, "How often do you bring your laptop to this class?" (where LectureTools was offered) and, "How often do you bring your laptop to your other classes?" (where LectureTools was not available). These results have been consistent over a number of semesters and suggest that if the technology has sufficient value to the students, they will voluntarily bring their laptop to class. Moreover, it demonstrates that in the absence of deliberate technology, students generally do not opt to bring their laptop.

In some situations, a significant number of students will not have access to a laptop, but our surveys show that 178 of 182 students had access to a laptop that they could bring to class if they chose. Moreover, we make it clear to students that they can still participate in class activities using more traditional methods so long as they hand in their activity responses at the end of class to gain credit for participating.

3.3. Distractions from Laptop Use

Students were capable of distraction long before technology was introduced into classrooms. Here, the levels of distraction in classes with and without technology were compared by asking students to consider the time spent on tasks unrelated to class in the course using a laptop, versus in their other courses where they don't have access to a laptop. Students were asked, "How do you feel that your use of laptops in this class has changed the time you spend on tasks unrelated to the lecture?" The distribution of students in the two semesters surveyed shows that the most common response was that it had no effect, but there is a bias toward students spending enhanced time on tasks unrelated to class (Figure 5). These results support the concerns of those worried about the effect of laptops in a classroom setting on student attentiveness and engagement.

3.4. Effects on Student Inquiry

An outcome of the use of LectureTools has been its positive impact on student inquiry. Large lectures can be intimidating for many students, and sometimes offer logistical issues for asking questions. With LectureTools, Table 1 shows that about half of the students posed at least

Table 1. Number of Days Students Posed Questions Using LectureTools

Questions	Percent of Class
0	49%
>=1	51%
>=2	35%
>=5	17%

one question during class during the winter 2009 semester, and 17% posed at least one question on five or more days. The number of students engaged in questioning and the number of questions asked has increased dramatically from non-LectureTools semesters.

3.5. Effects of Laptop Use on Attentiveness, Engagement and Learning

Understanding that students reported they were more likely to be doing tasks unrelated to lecture with their laptops, they were further asked to evaluate the statement, "My attentiveness in this class has increased due to laptop use." The results were unexpected (Figure 6) in that students reported that they felt they were more attentive because of the use of technology.

Likewise, when asked, "In this class, laptops help me to be engaged during lecture," students reported a dramatic increase in engagement with the use of technology (Figure 7). These results suggest that students perceive themselves to have strong multi-tasking skills and that deliberate engagement of technology may not result in diminished student attentiveness and engagement.

Finally, when asked, "Do you feel that the use of your laptop in class has affected your learning?" Here again, the result was that students in both semesters felt that the technology was having a positive influence on their learning (Figure 8) despite its potential to facilitate distraction.

4. Discussion

Our assessment has revealed that the benefits of LectureTools on student attentiveness and engagement (and self-reported learning) overcomes the potential risk from increased distraction. Student surveys over multiple semesters show that students feel they are actually more likely to be attentive, are significantly more engaged, and learn more than in other classes that don't take advantage of laptop capabilities. In fact, over 90% of students who responded to the question, "Given the option in future semesters which student response system would you prefer?" answered (Figure 9) that they would prefer to use LectureTools rather than clickers in subsequent semesters. Reasons offered by those who preferred LectureTools over clickers included "I feel that LectureTools is a much more interactive system than the clicker," and "LectureTools is very easy to access and use, and provides a multitude of note taking options, unlike clickers."

LectureTools has been designed, built, and tested by instructors and students for use by instructors and students. Furthermore, it is designed as a framework so that other instructors and students will be able to add new applications to expand LectureTools. For example, a first year undergraduate student added a new seating chart functionality in April 2009 that is currently being tested. We will continue to work with interested instructors and students to facilitate the continued growth and evolution of LectureTools as a model for best practices in lecture classes.

We understand that the results presented here are based on student self-assessment and, hence, do not represent objective measures of changes in student attentiveness, engagement or learning. Future research will focus more deliberately on changes in student understanding using pre-test and subsequent-test results cross-tabulated with measures of student participation using the technology. Nonetheless these results illustrate that, at least in the opinion of students, the intentional and directed use of Internet technology in class offers a valid mechanism for expanding and not diminishing student engagement.

5. Acknowledgement

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This paper is dedicated to the late Prof. Eric Dey whose collegiality and insight will be sorely missed.

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6. List of Figures

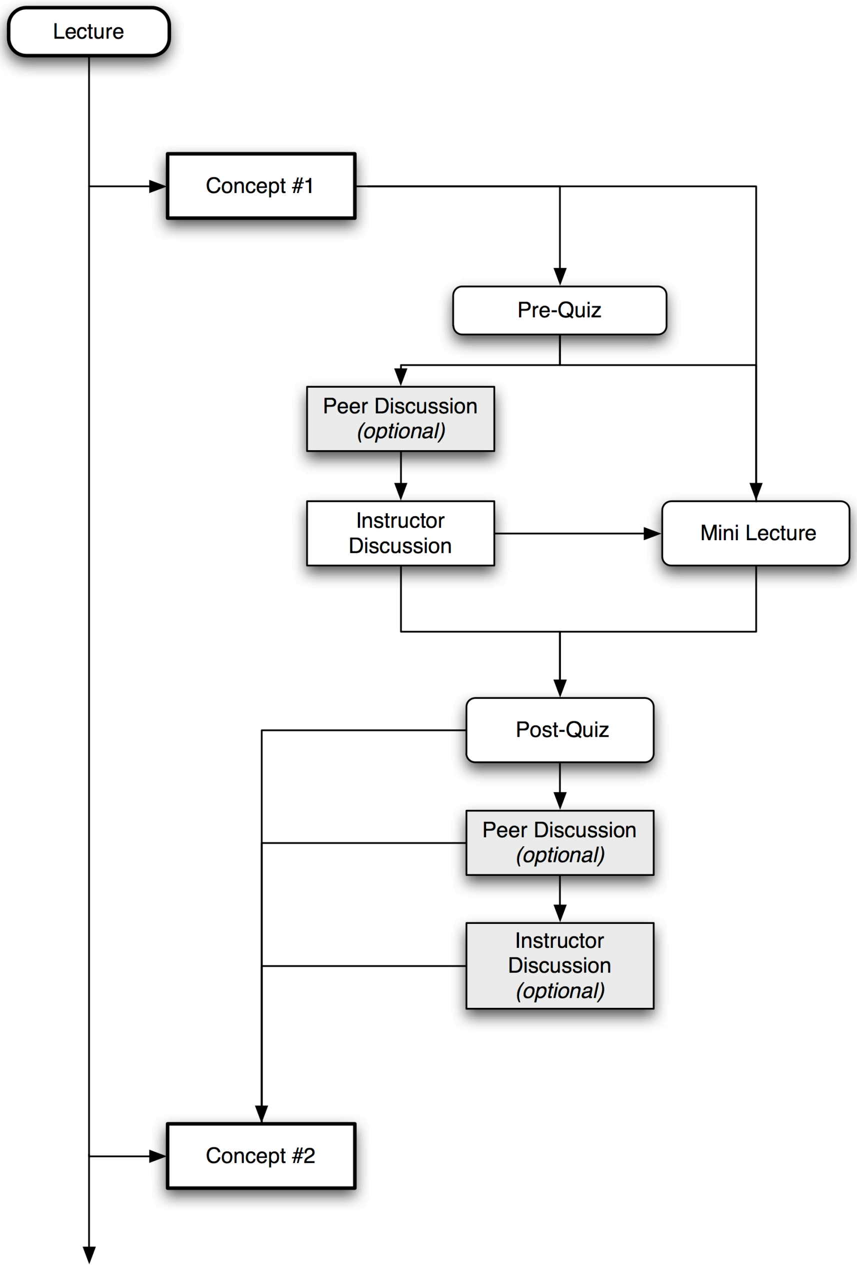

Figure 1. Conceptual design for lecture class. Lecture is broken into concepts and each concept can be initiated through either a pre-quiz or a mini-lecture. If a mini-lecture is used first it is followed by a post-quiz to assess understanding and can be followed by peer- or instructor-led discussion. Alternatively concepts are introduced through a pre-quiz challenge with optional discussion and can incorporate a mini-lecture or not. LectureTools is deigned to facilitate this structure.

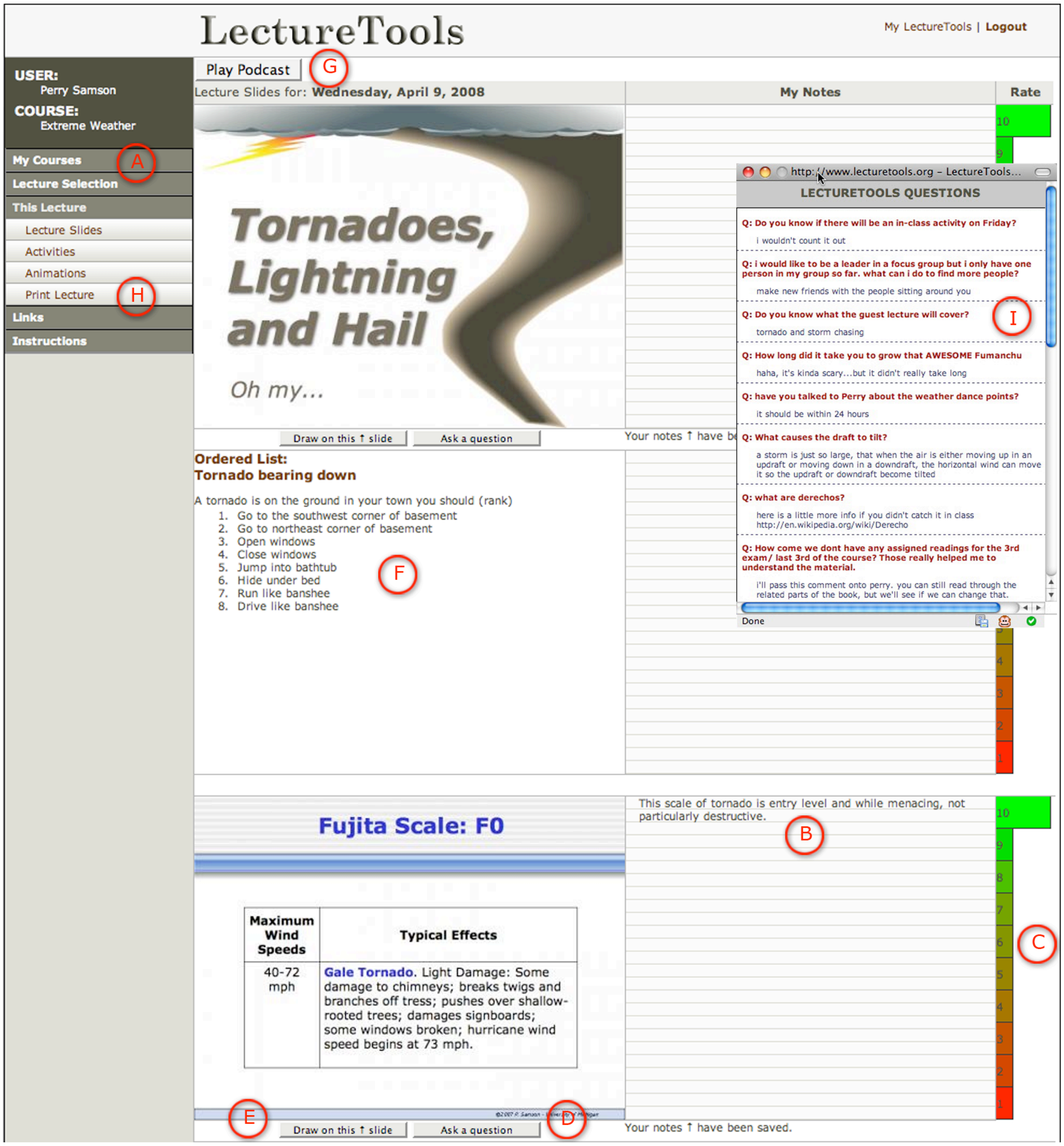

Figure 2. Student view of LectureTools. At Point "A" students can choose for the list of courses that have adopted LectureTools. At "B" (and similar areas) they can type notes, synchronized with the lecture slides. At "C" they are asked to self-assess their confidence in understanding the material being discussed. At "D" they can pose a question during lecture that will stream on the instructor's web site and the web site of the assigned teaching Assistants for which they can post responses without the name of the questioner attached. At "E" the student can pop up the slide, draw on it and save the drawing. "F" represents an opportunity for student response to a question. Clicking there offers the question for consideration. Button "G" become visible if, after class, the instructor uploads a podcast for this lecture. At "H" the student can list the slides and their notes to print (3 slides to a page) for off-line review. Popup window "I" lists questions from students during class as they are answered by the teaching assistant

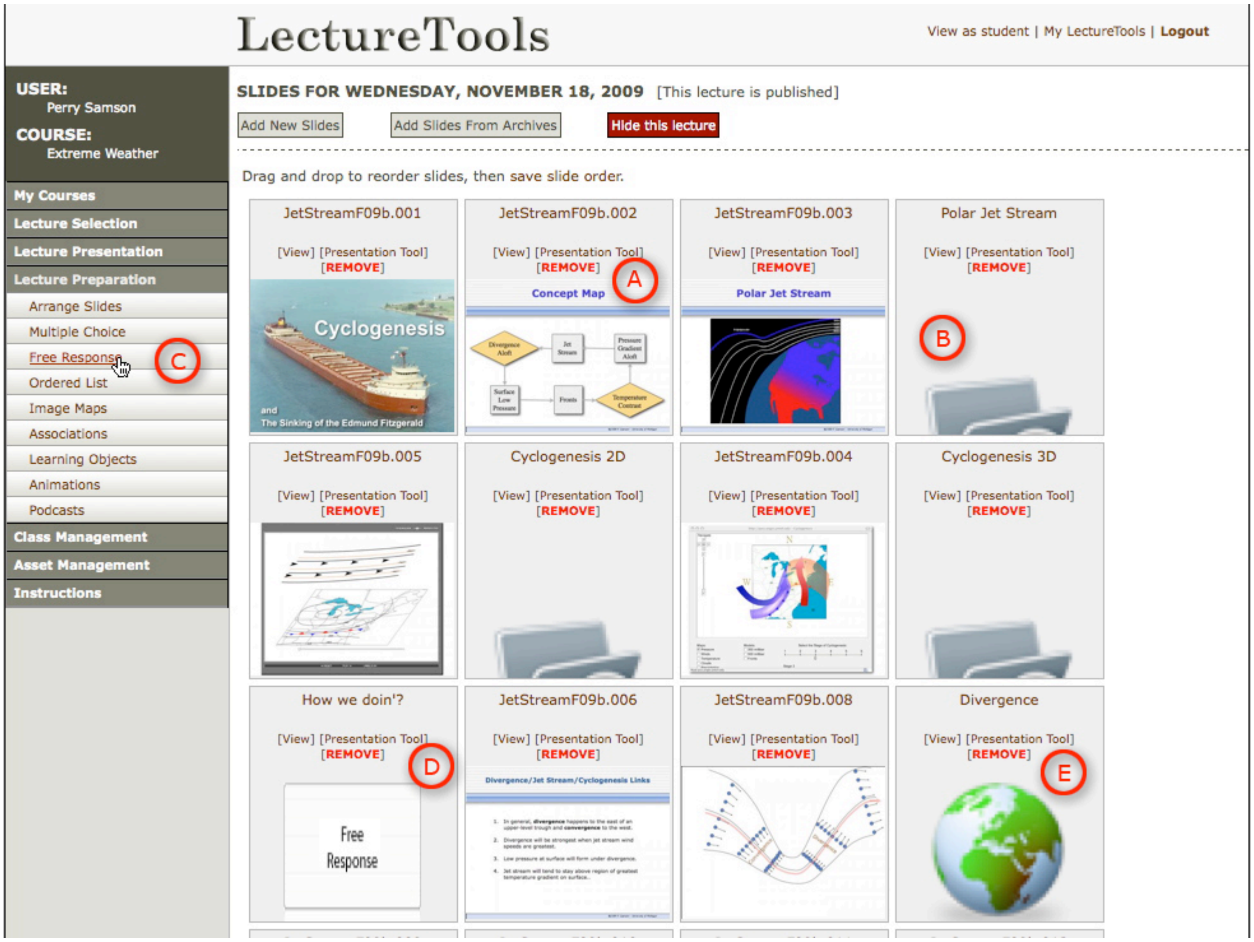

Figure 3. Instructor view of LectureTools. Instructors upload their slides and they are displayed as thumbnails (example, Point "A"). These can be rearranged after upload by dragging and dropping to ne location. Instructor can also upload animations (MOV, MPG, SWF, DCR) they plan to show so students can access them as part of their lecture. These are indicated as at Point "B". Point "C" shows the menu from whih the instructor can select different question types they may want to present as challenges to their class. Point "D" illustrates that a free response question has been created and embedded at that point in the lecture and Point "E" is the same but for an image-based question.

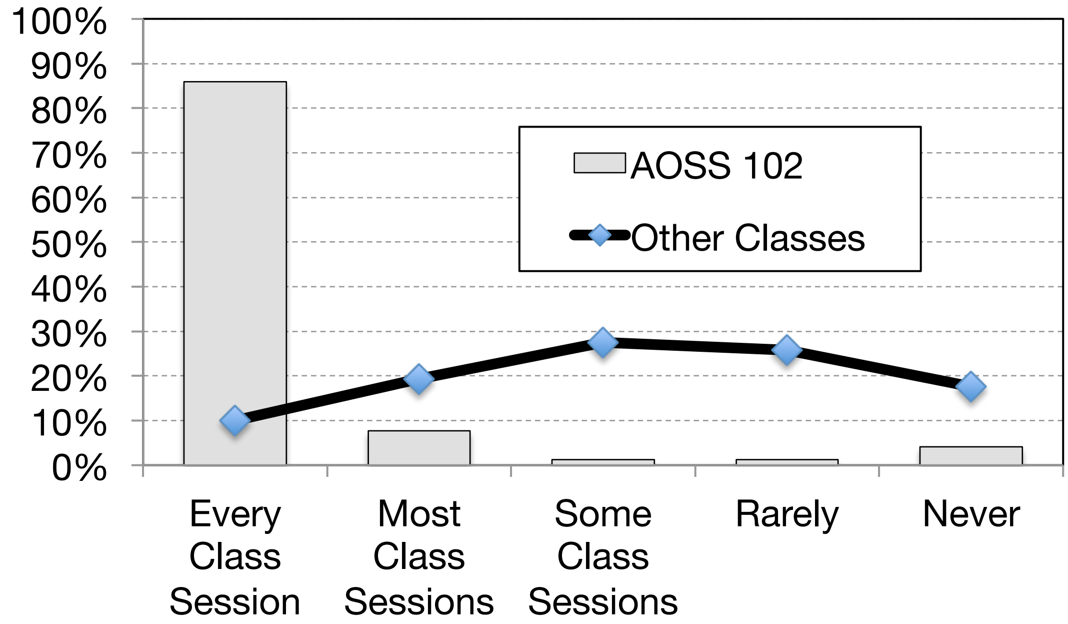

Figure 4. AOSS 102 students were asked how often they brought their laptops to AOSS 102 (w/LectureTools but offered non-mandatory) versus their other classes

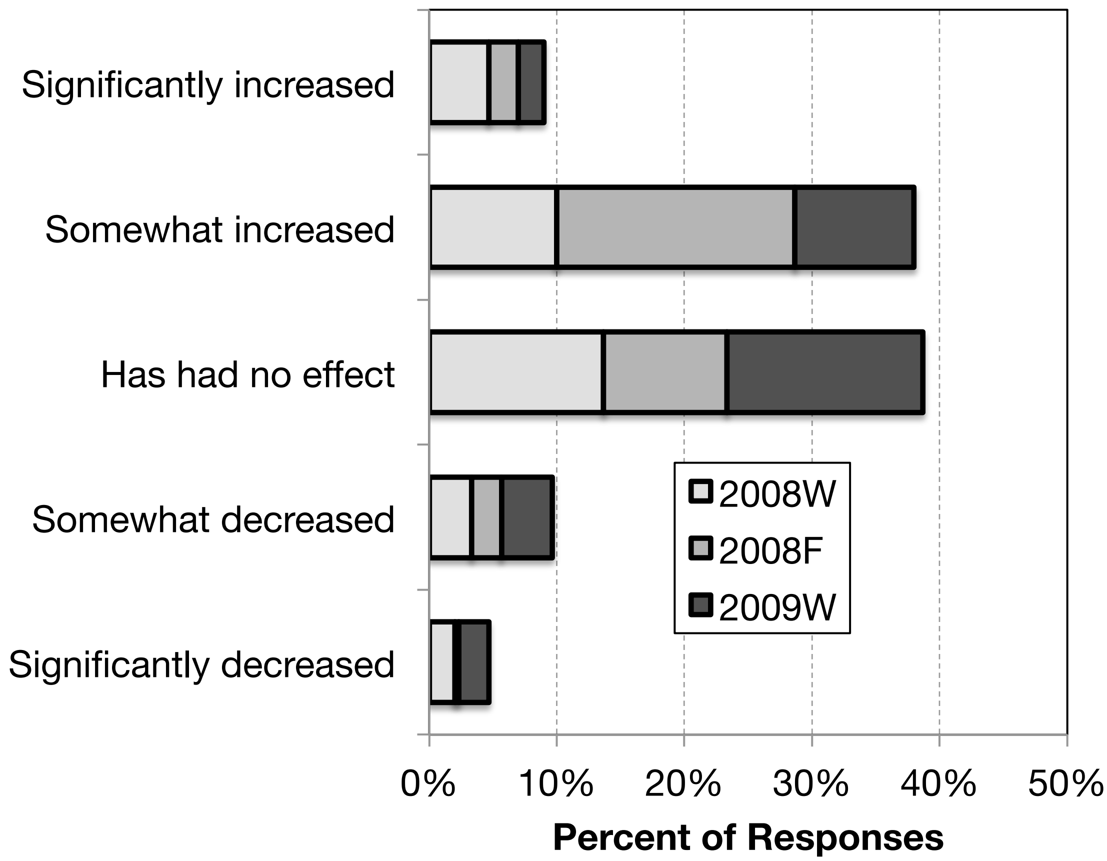

Figure 5. Student response to the question "How do you feel that your use of laptops in this class has changed the time you spend on tasks unrelated to the lecture?"

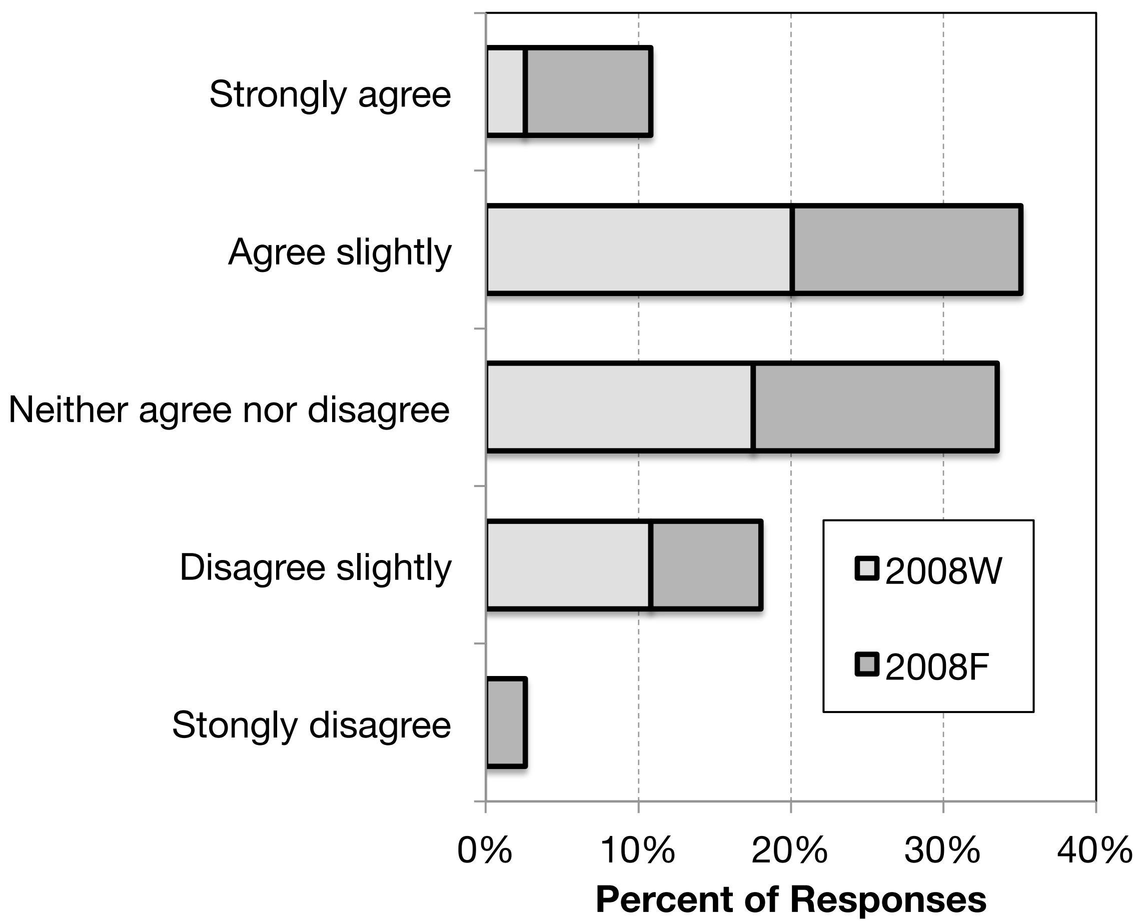

Figure 6. Student response to the statement "My attentiveness in this class has increased due to laptop use."

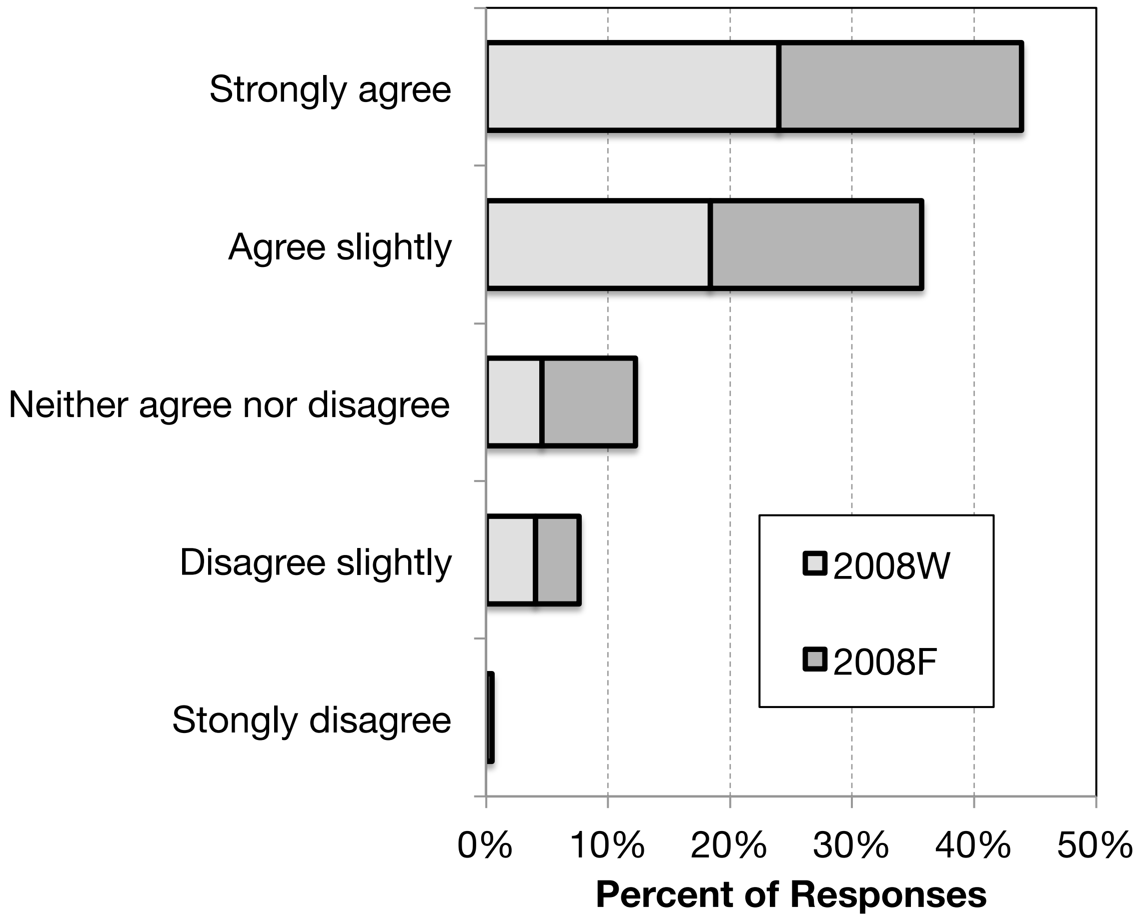

Figure 7. Student response to the statement "My engagement in this class has increased due to laptop use."

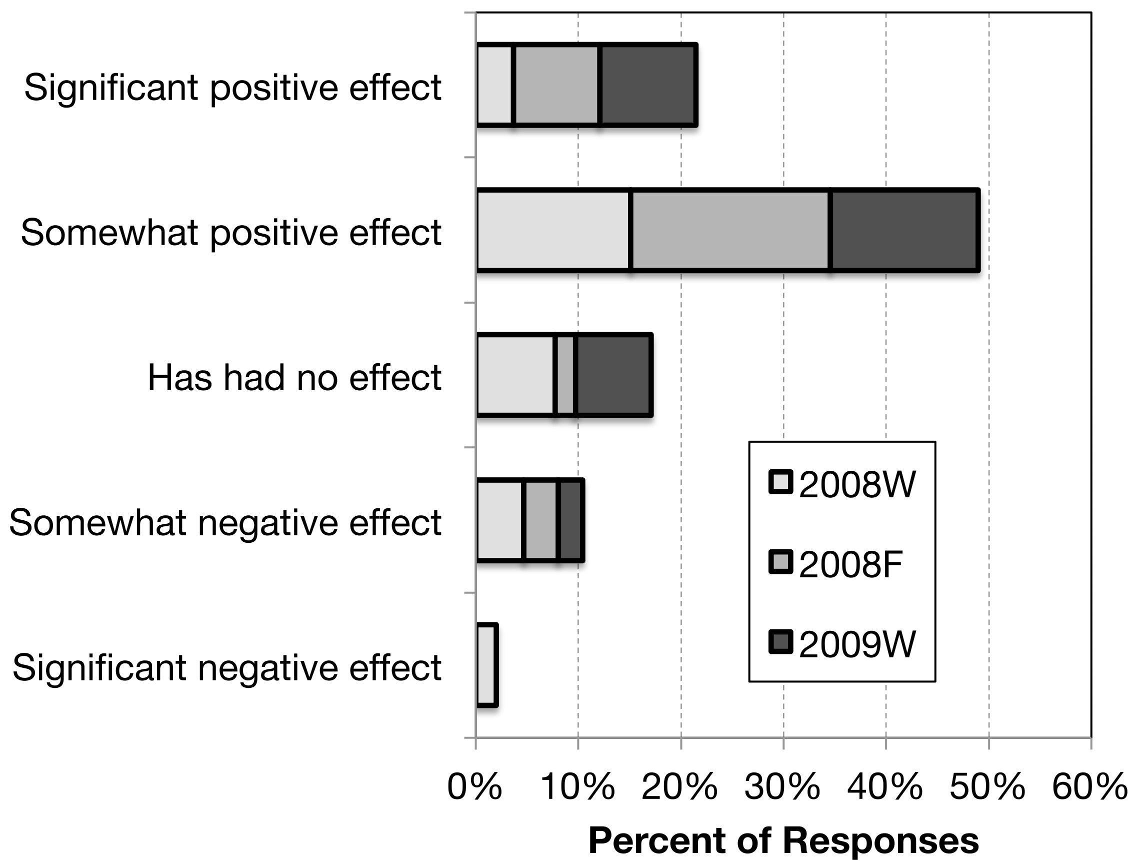

Figure 8. Student response to the statement "Do you feel that the use of your laptop in class has affected your learning?"

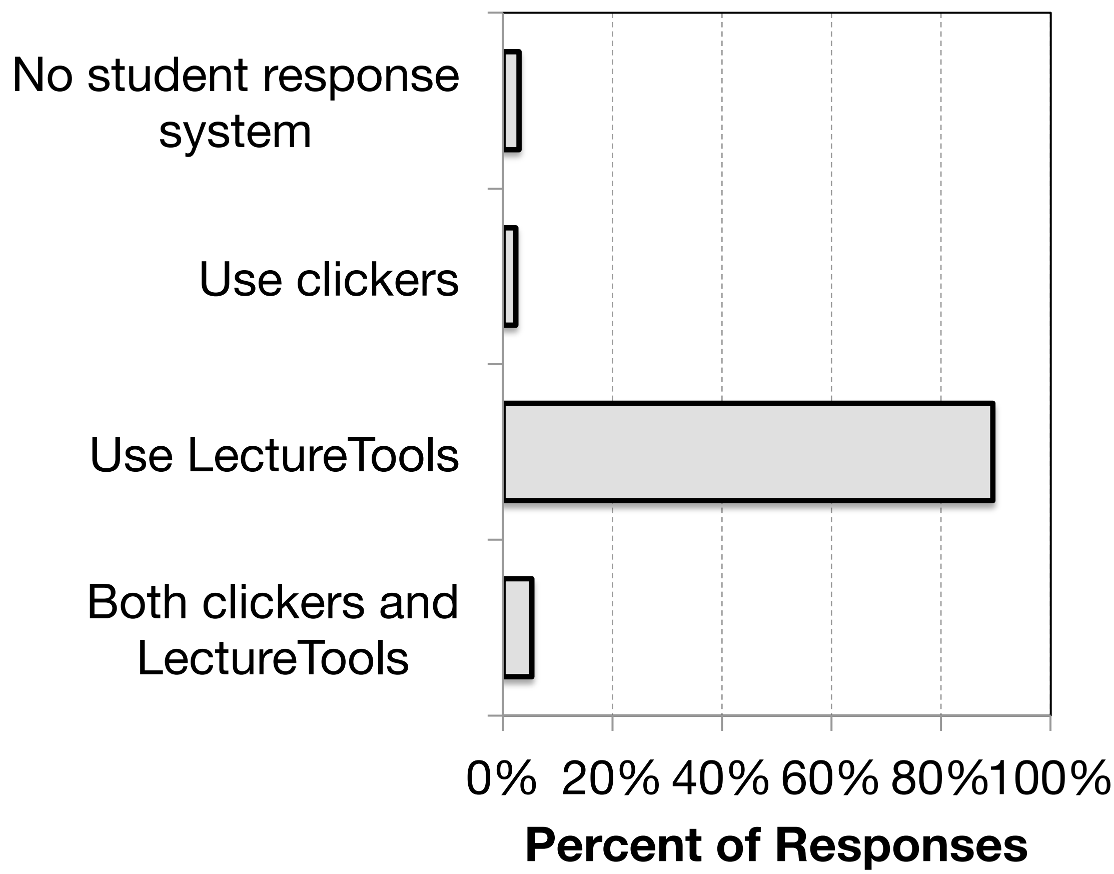

Figure 9. Student response to the statement "Given the option in future semesters which student response system would you prefer?"

7. Appendix

7.1. Appendix A: Pre-Semester Survey

7.2. Appendix B: Daily (Spot) Survey

7.3. Appendix C: End-of-Semester Survey