# The Effectiveness of "Interactive" Slide Presentations for Promoting Student Engagement in University Engineering Courses

Introduction

Instructors of university engineering classes often teach with Microsoft PowerPoint or other slide presentation software. Slide-oriented teaching permits pictures, videos and other supporting materials to be shown to the class that would not be possible in a traditional chalkboard-oriented lecture. Yet, criticisms of slide-based teaching are well-documented [1]. In recent years, a number of non-traditional slide presentation approaches have been developed. The effectiveness of these approaches have not been much studied. This paper focuses specifically on "interactive" slide presentations, which are characterized by the instructor's use of a stylus and a tablet computer (*e.g.* iPad, tablet PC or other device) to annotate and draw on slides during the lecture or classroom discussion. Typically, incomplete (un-annotated) slides are provided to students in advance of the class. These incomplete slides provide the structure for the lecture, and permit advanced diagrams, lists of variable definitions, or other complicated material to be prepared in advance. The use of annotation is intended to build on this information, while also engaging students in note-taking. An example slide from an interactive slide presentation used in a graduate-level engineering class is shown in Figure 1.
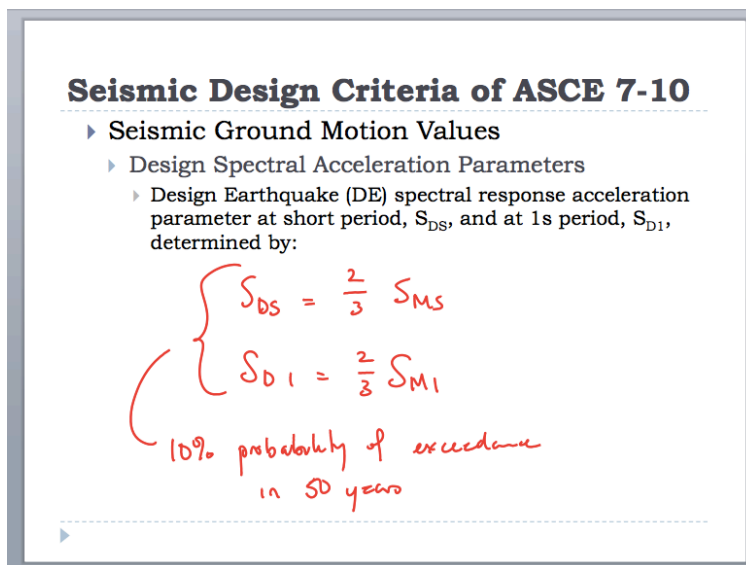
Figure 1. Example slide from recent graduate-level engineering class, showing annotation material (handwritten in red).

Clark et al. [1] provides an overview of the literature on the use of PowerPoint or similar software in the university classroom. This literature is too substantial to comprehensively review here, but it is worth reiterating several of the criticisms of this instructional style. For example, a number of studies have argued that slide presentations enable students to be passive participants in the classroom environment, implicitly discouraging note-taking and other important aspects of student engagement. Other researchers have criticized template

slide formats, saying they discourage the inclusion of original material and encourage instructors to use unconnected bullet points that do not define critical assumptions or relationships [1,2].

These criticisms have been one of the motivating features behind the development of strategies that may use slide presentations more effectively to promote student learning, such as the interactive slide presentations that are the focus of this study. A number of studies support the idea that modified slide design, well-developed handouts to accompany slides, and increased student note-taking can enhance student performance. For example, Alley et al. [2,3] studied how slide design impacts student performance. Traditional slide design contains a short phrase or keyword as the title, and bullet points which relate to the title phrase. Alley et al. [2,3] proposed a new slide design approach, which employs a "succinct sentence headline … supported not by a bullet list, but by evidence presented in a visual arrangement." These two slide design strategies were applied in two sections of the same course. The new slide design yielded 11% higher exam scores in comparison to the traditional slide design. Morgan et al. [4] explored the role of lecture handouts on student learning. Different types of handouts were provided to students: headings with full text, headings with key points, headings only, and a blank sheet. Although Morgan et al. [4] does not focus specifically on slide presentations, the handout styles investigated are often employed by instructors who use presentation software in the classroom. Morgan et al. [4] found that handouts containing only headings, thereby providing structure for independent note-taking, were by far the most effective for short-term retention of material. These handouts with headings, along with full text handouts, had the most positive impact on longer-term (two week) retention. Interestingly, the study showed that handouts with headings and a bulleted list of key points, were not much more effective than the blank page; researchers hypothesized that the bullet points imply to students that they have the complete picture of a subject, implicitly discouraging note-taking and further study. Later, Titsworth [5] examined the effect of student note-taking on their course performance. Results showed that, when students took notes, their test scores were 25% higher on detail-oriented tests, which asked students to recall specific information from the lectures, and 11% higher on concept-oriented tests, which asked students to relate concepts to examples they had not previously seen [5].

This paper assesses the effectiveness of interactive slide presentations for promoting student engagement in the classroom. We adopt Hu and Kuh [6]'s definition of student engagement as "the quality of effort students themselves devote to educationally purposeful activities that contribute directly to desired outcomes." Similar definitions have been adopted by others. Miller et al. [7] reviews the literature on student engagement, reporting that a number of studies showed engagement to be positively correlated with the grade the student received in the course. Past research also revealed that how the instructors interacted with their students, along with what/how they were teaching, were critically important in the engagement of students [7]. In the long term, engagement at the university level (both in and outside the classroom) leads to "higher income levels and increased satisfaction with their careers" and "increased cognitive, emotional and personal growth" [7].

Methodology

Classroom Observation Protocol for Student Engagement

This study takes advantage of the classroom observation protocol developed by Lane and Harris [8], which is designed to produce "quantitative data identifying the teaching practices that most effectively engage students in large university classes." Under Lane and Harris's protocol [8], a trained observer watches ten randomly-selected students per lecture and records their activities in a series of 1-2 minute observation cycles. In each observation cycle, each student is observed for 3-10 seconds. The observer then repeats the process for the other students, and records the number of students (out of 10) who are engaged in the classroom activity. Engagement is identified based on the student's actions during that cycle (note taking, answering questions from instructor, etc.), as described in more detail below. The observer also records the classroom activity (e.g., lecture, discussion, group work, etc.) during that observation cycle. The observer then returns to the first student and collects data for the next observation cycle.

Lane and Harris [8] demonstrated the capabilities of the proposed protocol by studying student engagement in a university science class with approximately 200 students (and, later, also other classes). Specifically, the study found that adding some clicker[1] questions to a lecture greatly improved student engagement. The study also found that long stretches of time in which the professor presents information led to progressively lower engagement levels with time. To validate the protocol definitions of classroom activities and engagement, Lane and Harris [8] engaged multiple observers, finding "excellent inter-rater agreement" and requiring minimal training for the observers.

The Lane and Harris [8] protocol is adopted here because of its emphasis on evaluating instructional method and instructor performance through student actions. Here, the instructional method or classroom activity classifications are carefully refined to explore whether the interactive nature of some slide presentations promotes or detracts from student engagement.

Procedures for Measuring Student Engagement in This Study

In this study, a single observer regularly attended three civil engineering courses at a large public university. The courses were: (1) a masters-level graduate course in structural dynamics, with an enrollment of ~ 20 students (Fall, 2012), (2) a foundation engineering elective taken by seniors and first-year graduate students (~40 students) (Fall, 2012), and (3) a large junior-level required class in probability and statistics for civil engineers (~100 students) (Spring, 2013). These courses were taught by two different tenure-track faculty instructors. Both instructors were already utilizing the interactive slide presentation approach to provide instructional content.

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[1] Clickers are remote survey devices. Instructors ask a multiple choice question to the class, students press the button corresponding to their answer choice, and instructors use a receiver to record the student responses.

In this study, during each two-minute observation cycle, the observer recorded data about the classroom activity and student engagement in an observation form, a portion of which is shown in Figure 2. To quantify student engagement, the observer evaluated six students, rating each student as actively engaged, passively engaged, disengaged or uncertain. Students were identified as "actively engaged" if s/he was performing a physical activity consistent with the instructional content. These physical activities could include taking notes, engaging in question and answer with the instructor, or working with other students. Unlike the approach of Lane and Harris [8], this study distinguishes between active and passive engagement. If the student is passively engaged, the observer finds that the student appears to be engaged, but is not performing a physical activity. This category was selected if students were watching and listening to instructional content, but not taking notes. Students were identified as disengaged if their behavior did not match instructional content. Examples include unnecessary cell phone or computer usage, sleeping, whispering with a neighbor, etc. In some cases, the observer could not assess a student's engagement, and his/her engagement was recorded as uncertain. Students were selected randomly for observation at the beginning of each class period and the same set of six students monitored throughout that class period. A different set of six students was selected in the next class period.

Actively Engaged=	A		Instructor	
Passively Engaged=	P		Class	Dynamics (Course #1)
Disengaged=	D		Date	10-9-2012
Uncertain=	U		Observer	
			# Students	20

	Student						Instruction Content
	1	2	3	4	5	6	
0:01	D	D	D	D	D	D	other
0:03	P	P	P	P	P	P	class intro
0:05	P	P	P	P	P	P	class intro
0:07	P	A	P	A	P	A	PP ex
0:09	A	A	A	A	A	P	PP wr
0:11	A	A	A	A	A	P	PP wr
0:13	A	A	A	P	A	A	PP wr
0:15	P	P	P	PA	A	P	PP ex
0:17	A	P	A	A	A	P	PP wr
0:19	A	A	A	A	A	A	PP wr
0:21	A	P	A	P	P	P	speaking
0:23	A	A	A	A	A	A	PP wr
0:25	P	P	D	P	P	P	speaking
0:27	P	P	P	P	P	P	pics/video

Figure 2. Example observation form. Observation cycles are in two-minute increments. For brevity, only the first several observation cycles are shown.

During each of the two-minute observation cycles, the observer also made note of the instructional method and/or classroom activity according to a pre-defined rubric. The categories of instructional method/classroom activity used to fill out the observational form are listed and defined in Table 1. For the purpose of this study, the classroom activities and definitions defined by Lane and Harris [8] were modified such that lecture activities were

distinguished by whether interactive slide presentations were being used and the relative amount of pre-printed static material in the slide content. As described in Table 1, "slides writing" was used to characterize classroom (lecture) activities when slides are dominated by instructor annotations. On the other hand, "slides explaining" was used to characterize the lecture activity when slides are dominated by previously developed material. The category of "student work" typically involved small group problem solving sessions or class discussion on a focused topic assigned by the professor. Clickers were not used in any of the classes.

Table 1. Categories of instructional method/classroom activity employed in classroom observations.

Activity	Description
Class introduction	Covers the first few minutes of class in which the instructor may be describing learning goals, handing back graded assignments, or setting up equipment.
Slides writing	Instructor is using a tablet (or similar device) to annotate a slide in PowerPoint or similar software. This category is used only when the primary content of the slides is the instructor's writing.
Slides explaining	Instructor is explaining information already present on a slide. This category is used for pre-printed, content-rich slides, even if the instructor adds some small annotations.
Pictures or video	Instructional content dominated by a picture or video. Slides dominated by pictures and annotated by the instructor would fall under "slides explaining."
Blackboard	Instructor is lecturing and writing on the blackboard (or whiteboard).
Speaking	Instructor is speaking to the class, without slide content or other visual aids. Examples include instructors telling students about their own personal experiences or introducing a new project or assignment.
Student work	Students are working by themselves or in a group on problem sets, quizzes, etc.
Q & A	Either of two activities: (1) student asks a question of the instructor; (2) instructor asks a focused question of students. These are relatively focused questions and do not encourage widespread discussion.
Other	Any other classroom activity/instructional method not captured in the categories above.

In total, the observer attended fifteen 75-minute class periods for each of three courses, resulting in over 3000 data pairs relating instructional method/classroom activity and student engagement. Biases associated with observer misinterpretation of student activities are assumed to be minimal on the basis of the observations of Lane and Harris [8] regarding inter-rater agreement with respect to the original protocol. The observer generally had a good view of the entire classroom and the instructor. Before the start of the study, researchers had some concern that students would ask questions about the observer's presence in the

classroom, particularly in the small classes. However, the observer carefully shielded the observation form and told students he was "sitting in on the class", which is not out of the ordinary. Neither the observer nor the instructors observed any change in classroom behavior associated with the observer's presence.

Although the data relating instructional method/classroom engagement and student engagement constituted the majority of the study, two additional studies were also carried out to explore the relationship between student engagement, as recorded by the observer, and student learning. First, in course #1, researchers examined the correlation between student engagement and class performance. To do so, observations of student engagement were initially linked to the student's name (although these names were later redacted). This was possible because the observer knew the name of all the students in this small class. At the end of the semester, the engagement data was linked with student class performance. Student grades ranged from B to A, so class performance was categorized as low (B), medium (B+/A-) or high (A) according to each student's midterm and end-of-semester (final) grades. The second additional study relied on in-class "pop" quizzes, rather than final grades, to measure student learning and performance. In this additional study, which was explored only for course #3, all of the students in the class were regularly given a quiz, with a single short answer open-ended question. For example, one question asked was "Which of the two random variables X and Y do you think would have a higher coefficient of variation? $X =$ height of people in your extended family and $Y =$ height of people in this room. Explain." The quizzes were collected and the instructor selected some of the responses for discussion. In addition, the quiz responses submitted by the six students who were the focus of the engagement observations during that class period were retained and student performance on the quiz was rated as 0 (Answer lacks fundamental knowledge of the material), 1 (Answer is generally correct, but lacks explanation or detail) or 2 (Excellent answer). The students were aware the quizzes were being conducted, but not of the observer's presence and relation to the study of engagement. The quiz responses did not factor into the calculation of student grades for the course because they had not been included in the course grading rubric handed out to students at the beginning of the class. In total, quizzes were administered in 5 separate class periods in this study.

Finally, students were asked to respond to survey questions about the "interactive" slide presentation type of instructional content. These short-answer questions were asked through an anonymous mid-semester survey seeking feedback on the class. In addition, some students chose to comment on the "interactive" slide presentation instructional content on university-administered end-of-semester evaluations.

Findings

Student Engagement with Different Instructional Methods

The student engagement data collected with the classroom observation protocol are summarized in Figure 3. In this diagram, the average engagement is computed for each instructional method by determining the percentage of students who exhibited each level of engagement during each observation cycle and averaging over all of the observation cycles.

The data indicate that the highest levels of student engagement were observed in the instructional method categories of "student work" and "slides writing". "Slides explaining", "blackboard" and "pictures and video" showed moderate student engagement, while engagement levels were low during observation cycles in which other instructional methods were used. Before getting into the detail of the results, it is worth noting that the data also measure how the class time was used in the three different courses (Figure 4). In all three courses, the instructional methods associated with slides, and corresponding to either "slides writing" or "slides explaining" constituted the majority of the class time (> 67%). Note that the instructor teaching courses #1 and #3 incorporates small group problem solving ("student work"), whereas the instructor teaching course #2 does not, which accounts for most of the differences in time allocation between the three courses.
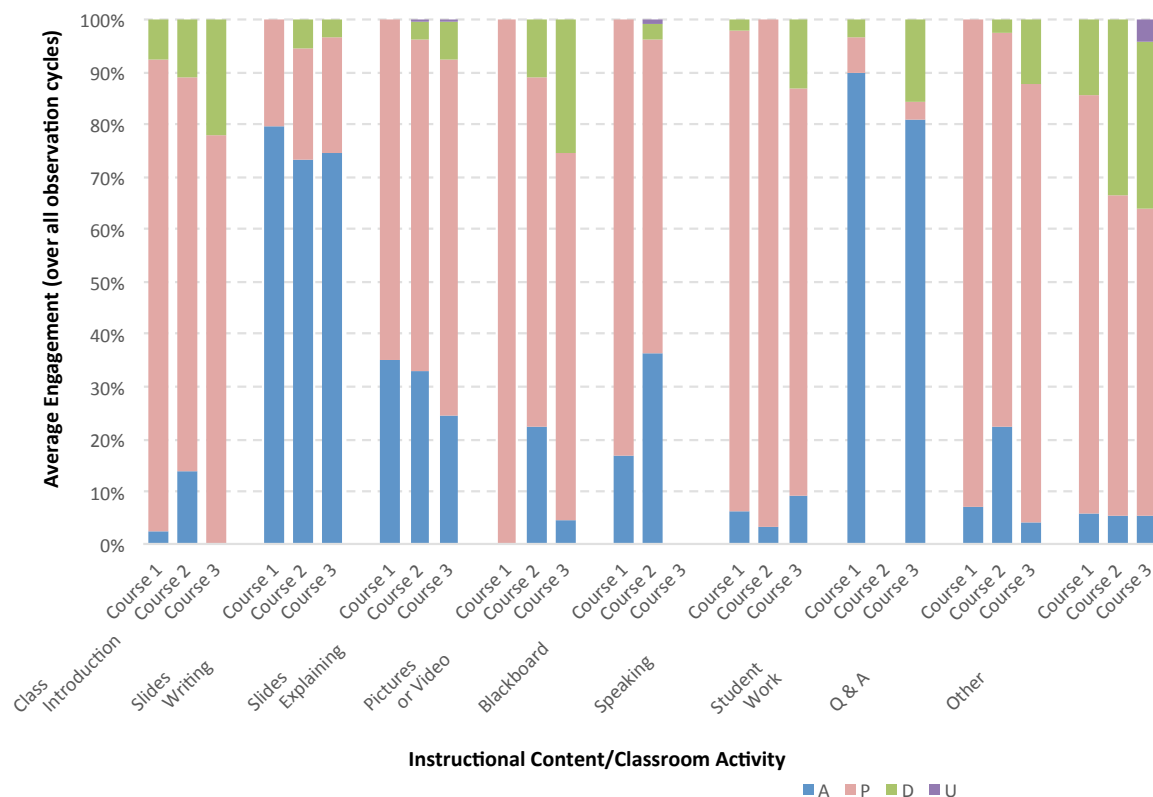
Figure 3. Observed engagement levels for courses #1, #2, and #3, categorized by instructional method in the corresponding observation cycle.

The findings in Figure 3 were remarkably consistent across the different courses and instructors. Critically, the results reveal large differences in student engagement between "slides writing" and "slides explaining", with approximately 45% more students being observed as actively engaged when the slides involve heavy instructor annotation. In fact, the only other classroom activity scoring as high as "slides writing" in terms of student engagement was "student work", which typically involved small group problem solving activities. Researchers were surprised that students were less engaged during observation cycles classified as "blackboard" as compared to observation cycles associated with "slide writing", since both involve the instructor taking the time to write something down for the students, while simultaneously explaining the concepts. However, in all three courses,

"blackboard" was an incidental method of instruction employed as a supplement to provide extra explanation for students. We therefore hypothesize that this material may have seemed less critical to students, and that the finding that students are less engaged when the instructor is using the blackboard is likely not broadly transferrable.
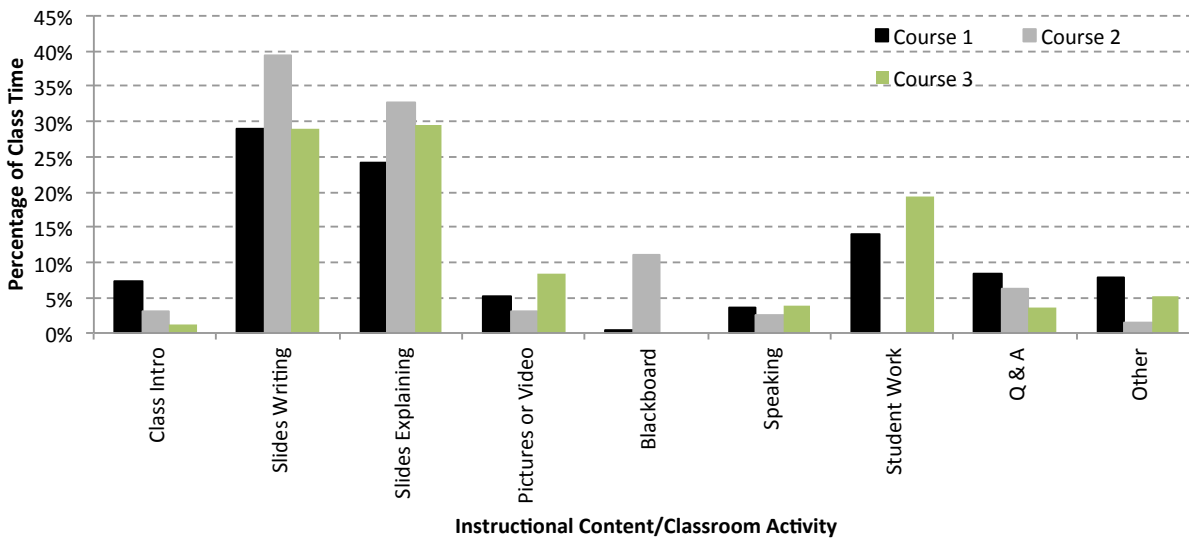

Figure 4. Percentage of class time in each of the three courses spent among the various categories of instructional methods/classroom activities. In course #1, one week was spent on student presentations; this time is not counted in the totals.

Relationship between Student Engagement and Learning

As mentioned in the Methodology section, two special studies were employed to investigate how the observed engagement data correlates to student performance in the class, as measured by the grades student earned, and to student learning, as measured by short answer responses to in-class pop quizzes.

The relationship between engagement and course grades are investigated for course #1 in Figure 5 for both mid-term and final grades. Precisely speaking, these charts relate the average engagement of students over the second half of the semester, with students grouped by their performance in the class. In the left-hand panel of Figure 5, student performance is grouped into categories of "low", "medium" or "high" according to their midterm exam grade. In the right-hand panel of Figure 5, student course performance is grouped according to the final (cumulative) course grade, including exams, homework assignments and other components of the grade. The results appear to indicate that those students who scored relatively lower on the midterm exam exhibited higher levels of observed engagement during the second part of the semester. However, when student performance is measured by the end-of-semester grade, there is no appreciable difference in student engagement for the high, medium or low performing students. This may be because student grades are relatively closely clustered together in this graduate course (ranging only from B to A) or because success is also highly dependent on out-of-class engagement, representing effort expended on *e.g.* homework assignments, which is not measured in the observed engagement scores.
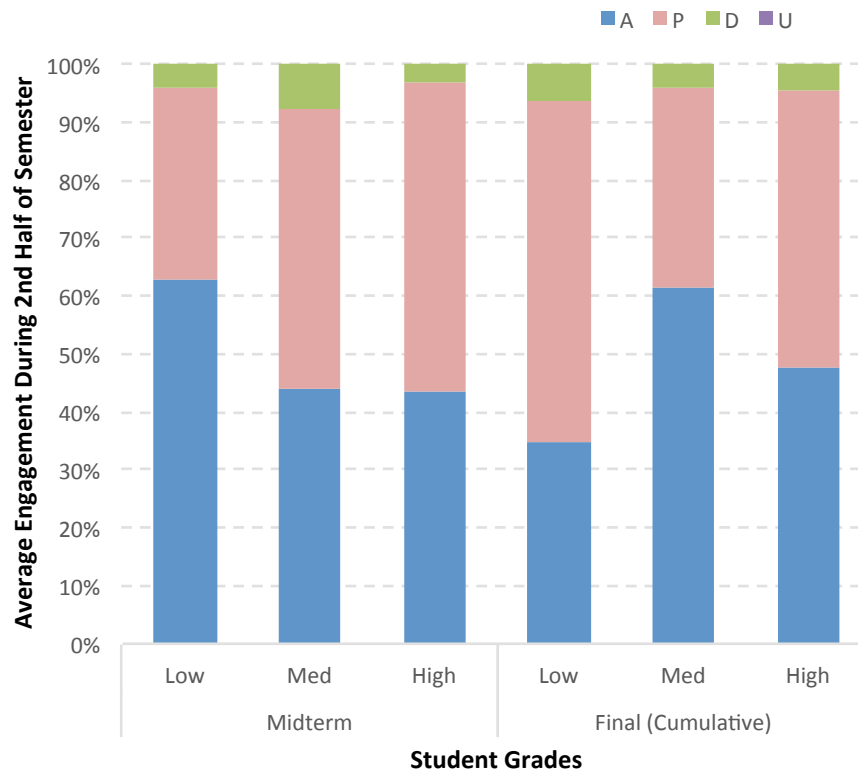
Figure 5. Student engagement vs. course performance for course #1.

For course #3, a more targeted examination of the relationship between the observed student engagement and student learning was attempted by administering short quizzes during each class period. Recall that engagement is observed for six students for each class period, so the results in Figure 6 relate each of these six student's average engagement over a particular class period (rescaled to range from 0-2) to their quiz grade (also scaled from 0-2). Quiz questions and grades were intended to test conceptual understanding, focusing on material discussed during that particular class period. Different groups of six students were observed during each class period. Figure 6 shows a relatively strong trend between student engagement and student learning, as quantified by the quiz grade. The quizzes were discontinued due to difficulties in matching student engagement and quiz grades in a large undergraduate class without revealing the motivation behind the quiz to students. A broader examination of engagement and student learning is outside the scope of this study.

Student Feedback on "Interactive" Slides

In the mid-semester and end-of semester course evaluations, students gave mixed reviews of the interactive slide presentation method. On the one hand, student comments were favorable about the interactive slide presentation approach. Some representative examples include:

"Professor X has good teaching, good examples, the laptop/PowerPoint method worked well." Comment on course #3, from university administered end-of-semester evaluation

"Very effective teaching method." *Comment on course #3, from university administered end-of-semester evaluation*

"Availability of notes to write on is great." *Comment on course # 1, from instructor administered mid-semester evaluation*

"The general [instructional] method that Prof. X uses has been the best I've experienced so far. *Comment on course # 3, from instructor administered mid-semester evaluation*

On the other hand, the most prevalent negative comment is represented by this statement:

"I would prefer more work/notes on the board." *Comment on course #3, from instructor-administered mid-semester evaluation*
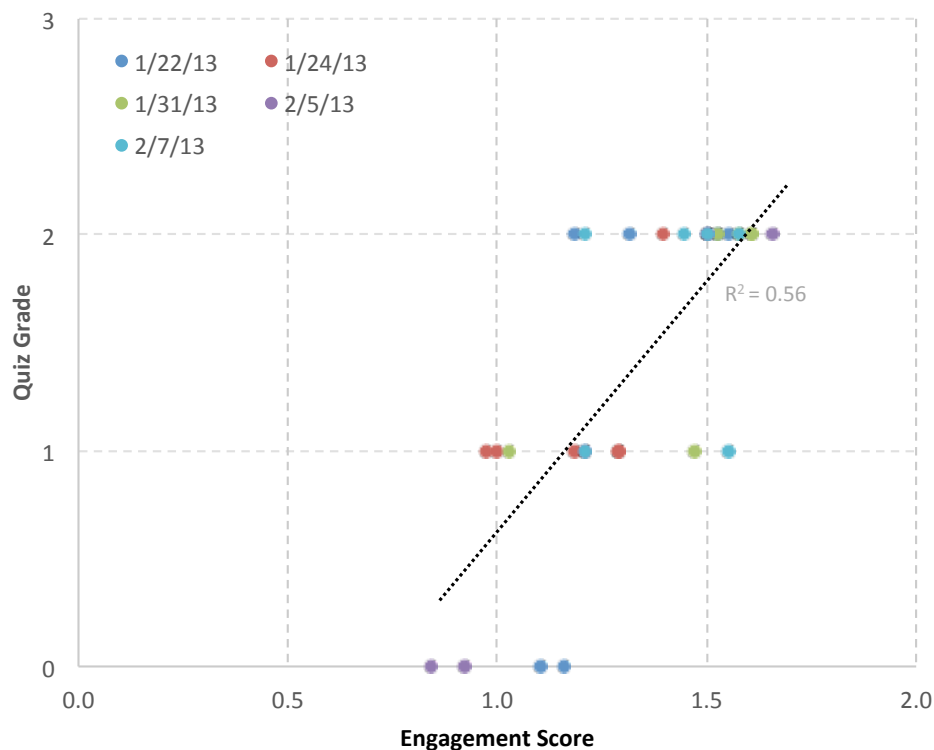
Figure 6. Student engagement vs. pop quiz scores for course #3 during 5 selected class periods between 1/22/2013 and 2/7/2013. Each class period has six data points, although in some cases, the data points overlap so not all are visible.

In addition, the criticisms tended to focus on specifics of the interactive slide presentations rather than the overall approach. For example, many students felt that instructors' handwriting, particularly on a tablet, is poor:

"Better handwriting [needed] on tablet." *Comment on course #1, from instructor-administered mid-semester evaluation*

Students also complained that, while the slides were made available at the beginning of the semester, they were not provided in hard copy form by the instructor, so students needed to print the slides to have access to the static material.

"I don't like how you require us to print the lecture slides (about $15 [for the entire semester]). There is not enough time to copy everything (sic.) material" *Comment on*

This comment indicates that students who do not print the notes or use an iPad or other tablet device to take notes feel disadvantaged because they need to take notes on the pre-printed slide materials *and* the instructor annotations. One approach to mitigate this problem would be to provide the incomplete slides to the students at the beginning of the semester as a mandatory course packet, although the course instructors felt it was better to let students decide for themselves. Other students mentioned that they thought it was important for the instructor to provide annotated electronic versions of the notes online after the class.

Student Engagement throughout Class Period

The observer data also revealed trends in student engagement throughout the class period, which, while not directly relevant to the objectives of the study, provide insight into the student attention spans and classroom time management. Notably, for all of the courses, and regardless of how the different categories of instructional methods were distributed over the course period, student engagement was lowest during the first 1-5 minutes of the class period and around 30 minutes into the class. This suggests that engagement may benefit from either a break around 30 minutes into the class, or a classroom activity designed especially to spark engagement at that time.
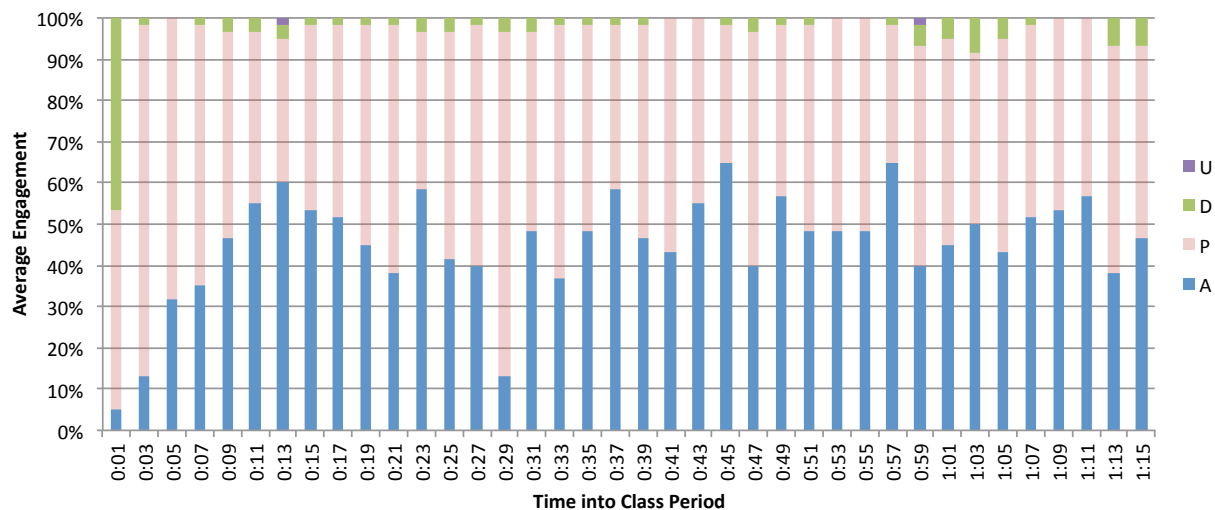
Figure 7. Student engagement over 1 hr. 15 min. class period. Results are averaged over all class periods for courses #1 and 2.

Conclusions

The past two decades have seen a dramatic increase in the use of slide presentation software (*e.g.* PowerPoint) as an instructional method in university engineering classes. More recently, the development of innovative approaches to employ this software more interactively in the classroom have changed the way that slide presentations are used. This study examines the effectiveness of "interactive" slide presentations, which are characterized by instructor annotations on the pre-developed slide materials, in fostering student engagement, and

compares the engagement observed during interactive slide presentations to other instructional methods. Engagement was measured utilizing a classroom observation protocol for student engagement developed and validated by Lane and Harris [8]. In this protocol, during each two-minute observation cycle, the observer records the instructional method/ classroom activity and records the engagement of six students in the class according to a predefined rubric. These observation cycles were repeated for three university civil engineering courses in approximately fifteen 75-minute class periods per course, resulting in about 3000 observations linking instructional activity to student engagement.

In the three courses forming the basis for the engagement observations, about 70% of the class time was spent on two forms of slide presentations: "slides writing" and "slides explaining". "Slides writing" constitutes the "interactive" part of interactive slide presentations, in which much of the slide is dynamically annotated while the professor discusses the salient points with the class. "Slides explaining" is more traditional use of slide presentation software, and most of the material on the slides is static. In all cases the instructor provided an electronic version of the static material on the slides before the class, although not all students brought a copy of the incomplete notes to the class.

Observations of student engagement reveal that engagement during instructional activities including annotation of slides is much higher than during other classroom activities, with the exception of "student work" (*i.e.* small group problem solving). In addition, engagement during observation cycles of "slides writing" is substantially larger than engagement during observation cycles of "slides explaining". Note-taking and other activities used to define active engagement in the observation protocol have been previously shown to be powerful predictors of learning. This conclusion points to a successful slide design strategy that incorporates headings and minimal (especially visual) supporting evidence, with substantial instructor annotations.

Researchers also examined correlation between observer-measured student engagement and learning as measured by two metrics: (1) grades earned for a) the midterm exam and b) the final course and (2) student performance on short conceptual quizzes. After the midterm exam, there seemed to be slightly higher engagement among students who performed the lowest on the midterm exam. The quiz results show correlation between engagement and the quiz score. These findings provide additional confidence that engagement as measured by the observer is a meaningful measure of student learning.

On the basis of the anecdotal information from the student evaluations, the interactive slide presentation instructional style seems to work best when students have a hard copy of the static slide material in front of them (or are using the electronic version on a tablet device themselves). In addition, the instructor must take care must to write neatly, as it is slightly different from writing on a non-electronic surface.

Future research could examine slide design strategies that may lead to optimal discussion of static material and what information is optimal information to provide via annotation. In future studies, it may also be instructive for the classroom observer to make a note as to whether or not students are making use of slide materials provided in advance of the class.

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