2006-1329: INTEGRATING A NEW DESIGN OF TEACHING SLIDES WITH ACTIVE-LEARNING MEASURES IN A LARGE CLASS

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Integrating a Sentence-Headline Design of Teaching Slides With Active-Learning Measures in a Large Class

Abstract

In large classes, instructors often project and then post presentation slides to communicate important information. As recently shown, using teaching slides that have a succinct sentence headline supported by visual evidence, rather than the traditional phrase headline supported by a bullet list, has led to statistically significant increases in knowledge transferred and retained. The increases are even more pronounced when the assertion to be retained by the students appears in the slide's sentence headline. Having such a design for the teaching slides, though, has two disadvantages. One is that since the sentence headlines state the key assertions of the class, the instructor does not have as many opportunities to ask questions and therefore engage the class in an active way. A second is that because these slides stand as a complete set of notes, some students mistakenly assume that they need not attend class—they can just review the class by viewing the posted slides. This paper assesses a new approach that integrates this new design for teaching slides with two active learning measures in a large geosciences course (200 students) at Virginia Tech.

One active learning measure consisted of creating two versions of the slides: a pre-lecture version and a post-lecture version. Because the pre-lecture version contained blanks to be filled in, the instructor had more opportunities to ask questions. In this study, the average number of questions that the instructor posed to the students increased from fewer than 5 (for previous semesters) to more than 20 (for this study's semester). Moreover, because of the blanks to be filled in during class, this version of the slides promoted note taking. Surveys of students indicate that 88 percent of enrolled students printed out these slides and brought them to class for taking notes.

To promote attendance and to emphasize key concepts, a second active-learning measure was adopted: a multiple-choice quiz at the end of class that queried students on the information in the blank spaces of the pre-lecture slides. This measure encouraged students not only to attend class, but also to pay attention and take notes. The first goal was met, as indicated by the increase in attendance from an average 69% for sections taught in a traditional fashion to an average of 83% for the section taught with this new approach. A chi-square analysis showed that this difference is statistically significant ($p \leq .001$). The second goal was also met, as indicated by the high scores on the end-of-class quizzes: an average of 95%.

To assess how much students retained information with this new approach, we compared the first examination scores on 20 questions for this class of 200 students with the scores on the same questions for similar-sized classes of students that learned with a traditional approach. Ten of these questions required the students to recall knowledge on the slides, and ten of these questions required students to comprehend information on the slides. The average on the 20 questions increased from 72% correct for students taught by the traditional approach to 79%

correct for students taught by the new approach. A chi-square analysis showed that this difference is statistically significant ($p \leq .001$). On eight of the 20 questions, the increases of test scores were statistically significant, while on only one question was there a statistically significant decrease. Given the success of the new approach, we intend to use it in a large mechanical engineering course during the Spring 2006 semester.

Introduction

It is common practice in large lecture-based classes to present projected slides and then post the slides online after class. Because Microsoft PowerPoint dominates 95% of the market share of slide-making software, PowerPoint's defaults greatly affect the design of most presentation slides [1]. These default settings for typography and layout lead presenters to create slides with phrase headlines that generally identify the topic of the slide, which leaves the slides' main assertions to be placed in the body of the slide. Guided by PowerPoint's defaults, the body of the slide usually consists of a list of bulleted points [2]. According to many recent critics, however, this phrase-headline/bullet-list design is neither based on solid educational research nor effective for students to learn science and engineering. A new design of teaching slides that challenges PowerPoint's default design has been shown to produce statistically significant increases in audience recall of key information found on the slides [3]. The new design features a succinct sentence headline that gives the main assertion of the slide. That headline is then supported by visual evidence in the slide's body.

This paper presents an experimental study that investigated methods for incorporating active learning techniques with the new slide design into large science and engineering classes. The study was conducted in a large geosciences class of 200 students at Virginia Tech: Resources Geology. Presentation slides were a large part of the instruction in the course, with projected slides used during every lecture. These slides were then made available to students online after class. To enhance the benefits of the new slide design, two active learning measures were added to the class: (1) a set of fill-in-the-blank lecture notes that were available to students online before class, and (2) a short quiz given at the end of each class.

Advantages and Disadvantages of the New Design of Teaching Slides

The new design of teaching slides features a succinct sentence headline that provides the main assertion of the slide as has been advocated by Lawrence Livermore National Laboratories [4]. However, this new design also calls for visual evidence to support this assertion as well as some specific formatting guidelines as described in *The Craft of Scientific Presentations* [5]. The guidelines for the new design, as outlined in Table 1, were developed through critique sessions of more than 400 graduate research and senior laboratory presentations over four years, primarily at Virginia Tech [3]. Shown in Figure 1 is an example of a transformation from the traditional slide design to the new slide design.

Table 1. Guidelines for new design of teaching slides for a technical class [5].

Style
For every slide, but the title slide, use a sentence headline that states the slide's main assertion; left justify the headline in the slide's upper left corner
In the body of each slide, present supporting evidence in a visual way—with images, graphs, or visual arrangements of text (such as a table or text blocks connected by arrows)
Avoid bullet lists, because such lists do not show the connections among the listed items
Limit the number of slides so that at least 1 minute can be spent on each slide (preferably more time in a longer presentation such as an hour seminar)
Typography
Use a bold sans serif typeface such as **Arial**
On a typical slide, use 28 point type for the headline and 18–24 point type for the body text (larger type is appropriate for the title on the title slide)
Avoid placing text in all capital letters
Layout
Keep blocks of texts, including headlines, to one or two lines
Keep lists to two, three, or four items
Be generous with white space

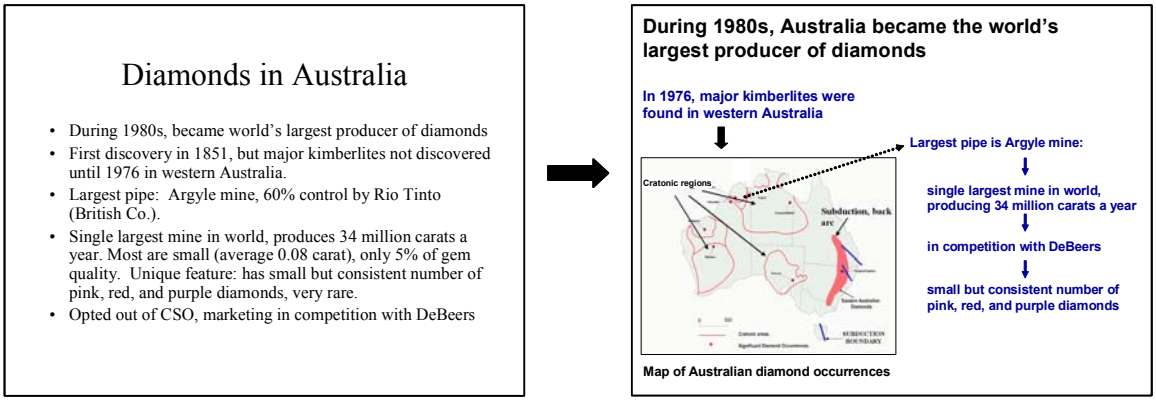

Figure 1. Contrast of a traditional slide (left) with a slide (right) that uses the new design [6]. The new design shows relationships among the details in a visual way. In addition, the headline of the new design emphasizes the key detail on the topic.

Several advantages exist to using a sentence headline rather than a phrase headline [3]. Primarily these advantages result from the clarity and emphasis that a sentence headline can provide for giving the key assertion of each slide. Such a headline more readily orients students during the lecture to the purpose of each slide. It also allows the professor to clearly emphasize the most important information for the class by making those assertions with more emphasis in the headline than they would receive in a bullet list in the body of a traditional slide. Third, sentence headlines can explicitly state the key assertions and assumptions of a presentation which makes the argument more persuasive because audiences are more likely to believe an argument if they recognize the assertions and assumptions of that argument [7]. The sentence-headline design has gained support over the past few years from communication experts, including Jean-luc Doumont [1] and Cliff Atkinson [8]. The format guidelines for the headline

follow from the recommendations of Gottlieb [4]. Note that Doumont [1] has independently supported many of these format guidelines, including the guideline to limit text blocks on a presentation slide to no more than two lines.

Visual evidence support for the main assertions of the slides also has advantages over the traditional bullet list. According to Richard Mayer's principles [9] for multimedia, students learn better from relevant images coupled with words than from words alone. The guidelines for this new slide design also follows Mayer's principles that students learn better from images placed close to and presented simultaneously with corresponding text. Overall, visual evidence makes the slides' assertion more memorable to the audience [2]. The other guidelines for formatting and typography in the new design allow the slides' assertions to be grasped quickly by the audience.

Recent studies looking at the effects of using the new design to present material in large classes have shown statistically significant increases in students' ability to recall key information from the slides [3, 10]. However, revealed through these studies have been the disadvantages of the design. As is common in large classes, the slides were available to students online and, in the new design, the slides serve very well as notes because they clearly state the most important assertions from the lecture. This availability of such a study aid has caused some students to assume that they do not need to go to class to learn the material. These students could simply download the slides after class and use those slides as notes to prepare for the exams. However, while the slides do serve as a good way for students to review before tests, student attendance is important for success in a course [11].

Another problem arises from the main assertions being already stated on the slides; these complete statements provide fewer opportunities for dialogue between the students and the professor. Moreover, this form of slides gives the false impression that students need not take notes during class. With little interaction between the students and the professor and little motivation to take notes, few students are actively learning during the lecture. By passively sitting through class, students do not gain the amount of knowledge and understanding that they would if they paid attention and participated in class by answering questions and taking notes [12].

Effect of Posted Slides and Attendance at Lectures

As mentioned, to enhance the benefits of the new slide design, two active learning measures were added to the class. The measures were as follows: (1) a set of fill-in-the-blank lecture notes that available to students online before class, and (2) a short quiz given at the end of each class. These lecture notes, which were a special set of slides created from the slides that were presented during class, were available before class for students to print out and bring to class for taking notes. Presented in Figure 2 is an example of a pre-lecture slide and its accompanying teaching slide. The professor's lecture was then presented using slides following the new design, and at the end of each class, the quiz was given as a short assessment on that day's material. The slides that were presented in-class were then posted online after class for the students to study. The effectiveness of the additional active learning measures was evaluated by how well students could recall key information from the slides.

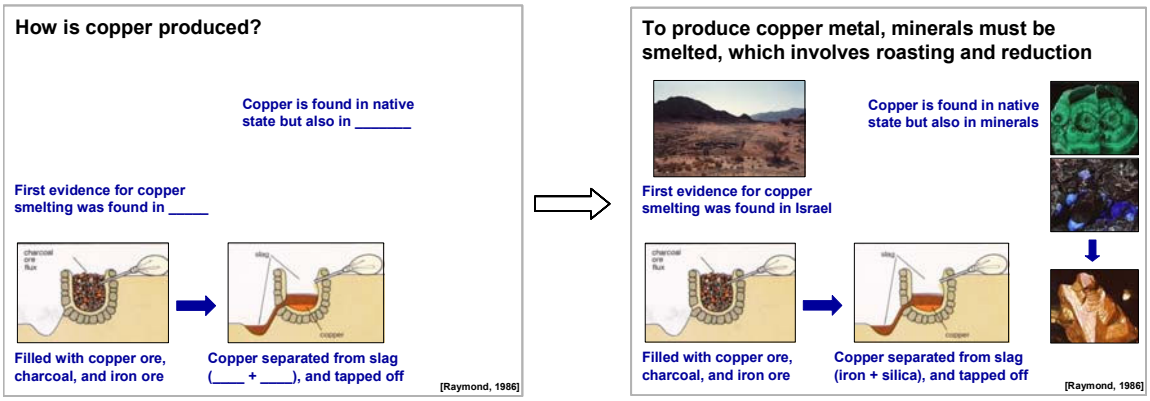

Figure 2: Sample lecture slides [6] from the study: pre-lecture slide (left) and post-lecture slide (right).

In recent years there has been a push for instructors to incorporate technology, including the internet, into their courses by posting their notes online [13]. Web-based course management systems such as Blackboard and WebCT allow course materials to be distributed on the internet where students can download notes or view them as web pages. Providing instructors' notes to students has been shown to improve students' effectiveness at note taking and note reviewing [14]. Consequently, students who utilized instructors' notes performed better on examinations.

Two processes are involved in note taking and reviewing: encoding and external storage functions [14]. The benefits of encoding come from the cognitive process of creating a written record of the material. However, if the quality of the encoding function is not high, then the effectiveness of the external storage process is automatically limited. Since notes taken by college students typically include less than fifty-percent of the material that was presented, many students start at a disadvantage when reviewing their notes [15]. Students perform better on tests when reviewing with a complete set of notes, which can be provided by instructor notes or slides online. Instructor notes can further assist students' learning by demonstrating relationships between key concepts that may not be readily apparent to students in lecture [16]. Also, having a set of instructor notes would allow students who had difficulty taking notes while simultaneously trying to comprehend the lecture to focus their attention on listening and understanding rather than making a written record of the lecture [17]. However, providing easy access to instructor notes online may also lead to students skipping class because they would not have to record their own notes for reviewing [18].

The importance of class attendance has been shown in a multitude of research studies that have demonstrated a negative correlation between class absences and overall course grades [11]. This relationship between class attendance and course grades has been investigated studied for decades. In the 1930s, Jones found that having fewer absences leads to a higher grade point average [19]. Recently, Clump showed that class attendance is important for both immediate test scores and overall scores [11]. Clump's study, along with numerous others, continues to demonstrate that class attendance is important for overall test scores and achievement in the class. Clump recommends that faculty include contingencies in their courses to ensure that students attend.

Justification of Active Learning Measures

In our study, we added two active learning measures to the class to utilize the advantages of the new design in improving students' recall of important assertions. These measures were pre-lecture notes and in-class quizzes which were designed to increase the level of active learning and improve the quality of time in the classroom so that students were able to retain more of the information that was presented.

Previous work has shown the need to find a balance between providing too much and too little information on notes that are supplied to students. Writing too little information makes the notes of little value, but writing too much information makes it difficult for the instructor to ask leading questions and generate discussion [20]. DiBattista offers fill-in-the-blank notes as an approach that provides this balance with partial rather than complete notes [21]. He asserts that fill-in-the-blank notes eliminates problems caused by providing complete instructor notes, including students "tuning out" during lecture or not attending at all. Also, these partial notes force students to use the notes in an active rather than passive way, and his students have said that they preferred these partial notes because these notes made them feel more engaged in active learning and stay focused during lectures. In our study, we designed pre-lecture notes with goals similar to DiBattista's fill-in-the-blank notes.

Our pre-lecture notes were made from the slides that were to be presented during the lecture with three important changes. The first of these changes was that the sentence headlines that provided the main assertions were often replaced with questions that could be answered with the headline. These questions were initially shown on the teaching slides projected during class—the question would appear first and then the sentence-headline that answered the question would be animated in to cover the question. This feature both gave the professor an opportunity to pose questions to the class and gave the students an opportunity to contemplate the question and examine the evidence in the body of the slide before offering an answer. The goal of this exchange between the students and professor was to keep the students actively participating in the class by thinking about and answering questions.

The second difference between the pre-lecture notes and those that were available after lecture was that important details on the slides were replaced by blanks on the pre-lecture notes. This feature, like the question headings, was designed to keep the students paying attention and listening for the missing information. Both the questions and blanks on the pre-lecture slides also gave the professor another opportunity to emphasize key information during class, especially since the questions were answered with the main assertion on each slide.

The third difference, which was spawned by student feedback from the previous semester, was that we deleted some of the images that appeared on the final slides from those posted before class. This deletion made it easier for the students to print the slides because pre-lecture did not require as much printer ink as the final slides did. Grabe found that students printing notes and bringing their notes to class to support their own note taking and comprehension of the lecture was primarily the way in which students used online notes [14]. The questions, blanks, and ease of printing for the pre-lecture slides encouraged students to stay active during the lectures.

The second addition to the class to encourage active learning was a five-question multiple-choice quiz given at the end of each class. The quiz reinforced the most important assertions from that day's class. As shown by Sporer, this emphasis also provided feedback on where students should focus their effort in studying for the exam [22]. Because the quizzes were turned in and graded and made a small part of the students' final grades for the course, the quizzes encouraged students to come to class every day. The quizzes also encouraged students to pay attention and remember important information during class. Quizzes on material that would be covered on the next test have also been shown to increase scores on that test [23]. The quizzes were designed to increase the level of active learning in the class by not allowing students to skip class and by providing immediate feedback on whether the students were picking up on the main assertions of that day's lecture.

Experimental Methods

As mentioned, for the class in our study (Fall 2005), the instructor used both teaching slides that followed the new design for teaching slides and two active learning measures to improve incorporation of those slides: (1) a set of fill-in-the-blank notes available to students before lectures, and (2) a short quiz given at the end of class. The scores from certain questions on the first exam in the course were then compared in a historical control with the scores on the same questions from previous semesters' classes that had learned from traditional slides. These traditional slides were available online for the students both before and after class. In contrast to the Fall 2005 semester's section, though, the slides posted before class in the previous semesters were the same slides presented during class—with no fill-in-the-blank spaces. In addition, the sections from previous semesters did not have any end-of-class quizzes.

The geosciences course in which we conducted the testing was excellent for this study. Because the class fulfilled one of the university's general education requirements, it was a popular course and had a 200-person enrollment, which provided a large sample size of diverse students for results. The structure of the class was also appropriate for this intervention because the teaching primarily occurred through lectures that relied on projected slides. For that reason, the slides were an important part of the instruction. Also the exams in the course were multiple-choice and graded electronically. Given that, data on students' performance on certain questions in past semesters could be easily obtained.

The course professor, who has taught several times in the past three years, presented the same lecture to four different semesters' sections of the class. In the class this semester, Fall 05, she used the new, transformed slides during lecture and implemented the active learning measures of pre-lecture notes and in-class quizzes. In previous semesters (Spring 03, Fall 04, and Spring 05), she had presented the same lecture using traditionally designed slides. The students' retention of material from the class was assessed by analyzing the scores of certain identical questions on exams in the course. Questions from previous semesters were repeated on this semester's exam, and the scores on those questions for the different semesters were compared. A diagram representing the procedure for the study is shown in Figure 3. For the study, the professor did not know which questions were going to be used for the exam until after she had she taught all the classes leading up to the exam.

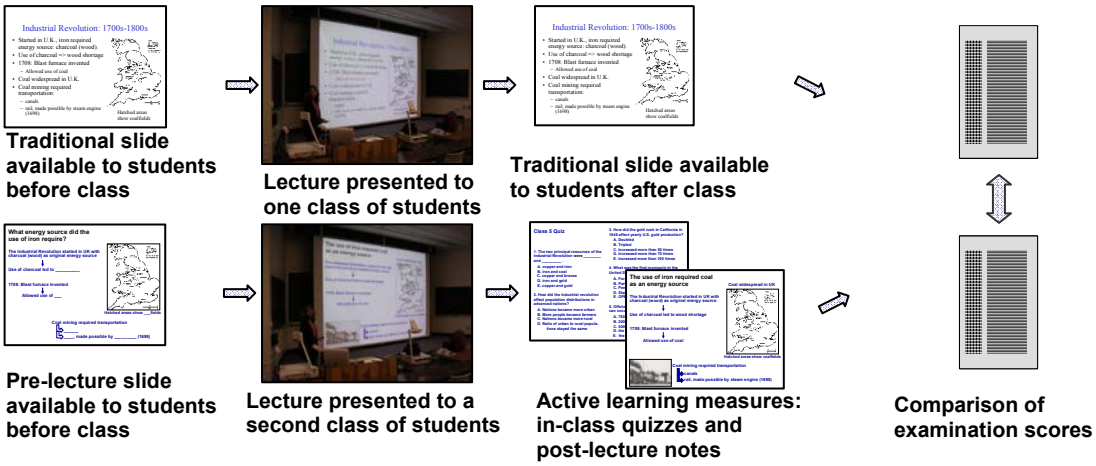

Figure 3: Visual depiction of the strategy for the study.

Results and Discussion

The results from using the new slide design in conjunction with the two active learning measures were positive. First, from observation of the class periods, we witnessed that students were kept involved during the lecture because the professor was able to ask more questions during the class. In fact, *the average number of questions that the professor posed to the students during class more than quadrupled this Fall 05 semester*—that number rose from five or fewer questions per class in previous semesters to more than 20 for this Fall 05 semester. Much of this increase in questions posed by the instructor resulted from the questions on the teaching (and pre-lecture) slides. Second, surveys found that 88% of the class printed the pre-lecture notes and brought them to class, which showed that students were indeed taking advantage of the pre-lecture slides for note-taking. During class, the students answered questions and filled in blanks on the slides, which kept them focused on what was being taught and on what was most important. On another question, the survey revealed that 82% of the students found that filling in notes on the pre-lecture slides was effective at helping them learn the course material. Third, the attendance this Fall 05 semester increased to 83% as compared with 69% for previous semesters—an increase that is statistically significant ($p \leq .001$). We attribute this increase in attendance to the quizzes given in each class.

Fourth, as shown in Table 2, students in the class indicated that both the new design of slides and the active learning measures were effective in helping them learn the course material. In a survey in which 182 of the 200 students responded, 80% of the students either agreed (50%) or strongly agreed (30%) that compared with teaching slides for other courses, the slides projected in this class helped them learn the course material. For that same question, 17% responded that they were unsure on this question, and only 2% either disagreed (1%) or strongly disagreed (1%). On another question, the survey revealed that 81% of the students either agreed (37%) or strongly agreed (44%) that the end-of-class quizzes encouraged them to take notes during the lectures.

Fifth and most important, the overall score on the 20 questions in the study increased from 74% correct in previous semesters to 80% correct this Fall 05 semester. This increase was

statistically significant ($p \leq .001$) as determined by a chi-squared analysis. With the assumption that these large classes were academically equal, this increase in the students' scores implies that the students better retained information from the class with this approach. On 8 of the 20 questions, the students' retention of material increased significantly with five of these questions at the 99.9% confidence level. The scores on 10 of the 20 questions did not change significantly and the score on only one question in the study significantly decreased. Table 3 shows a comparison of scores on the nineteen questions for this Fall 05 semester which had the new slides, pre-lecture notes, and in-class quizzes in comparison with scores from previous semesters in which students learned from the traditional slides. Figure 4 shows a graph of this data.

Table 2: Results from survey on slide design and active learning measures (182 out of 200 responding).

Effectiveness of new teaching slide design, compared with traditional slide design, at helping me learn course material	Strongly Agree (50%) Agree (30%)	Disagree (1%) Strongly Disagree (1%)
Effectiveness of end-of-class quizzes at motivating me to take notes during class	Strongly Agree (44%) Agree (37%)	Disagree (6%) Strongly Disagree (3%)

Table 3: Comparison of test scores of those taught with traditional slides versus those taught with the new slide design, pre-lecture notes, and in-class quizzes.

Question	Level in Bloom's Taxonomy	Percentage correct for traditional approach	Percentage correct for approach including new slide design and active learning measures	Confidence level of statistical difference
1	Knowledge	54%	86%	**99.9%**
2	Comprehension	60%	84%	**99.9%**
3	Comprehension	56%	75%	**99.9%**
4	Knowledge	58%	75%	**99.5%**
5	Comprehension	70%	89%	**99.9%**
6	Comprehension	77%	93%	**99.9%**
7	Knowledge	71%	82%	**97.5%**
8	Knowledge	86%	94%	**99.0%**
9	Comprehension	81%	87%	not significant
10	Knowledge	80%	85%	not significant
11	Comprehension	60%	64%	not significant
12	Comprehension	87%	91%	not significant
13	Comprehension	45%	47%	not significant
14	Knowledge	83%	83%	not significant
15	Knowledge	73%	72%	not significant
16	Comprehension	98%	96%	not significant
17	Knowledge	92%	90%	not significant
18	Knowledge	79%	70%	not significant
19	Comprehension	59%	52%	not significant
20	Knowledge	78%	56%	**99.9%**
Average		72%	79%	**99.9%**

As given in Figure 4, in 8 of the 20 questions, students in the Fall 05 semester achieved statistically significant increases in the test scores. In this study, none of the 20 questions involved a question that had been on one of the end-of-class quizzes. For that reason, we attribute the increase in test scores for these eight questions to improvement in the teaching slide design, active participation through the pre-lecture notes, and increased attendance. Presented in Figure 5 is an example of one of the slide transformations that led to a significant increase in the test scores. Given in Figure 6 is a sequence showing the pre-lecture slide and teaching slide for this case. The corresponding question was to identify what metals bronze contained.

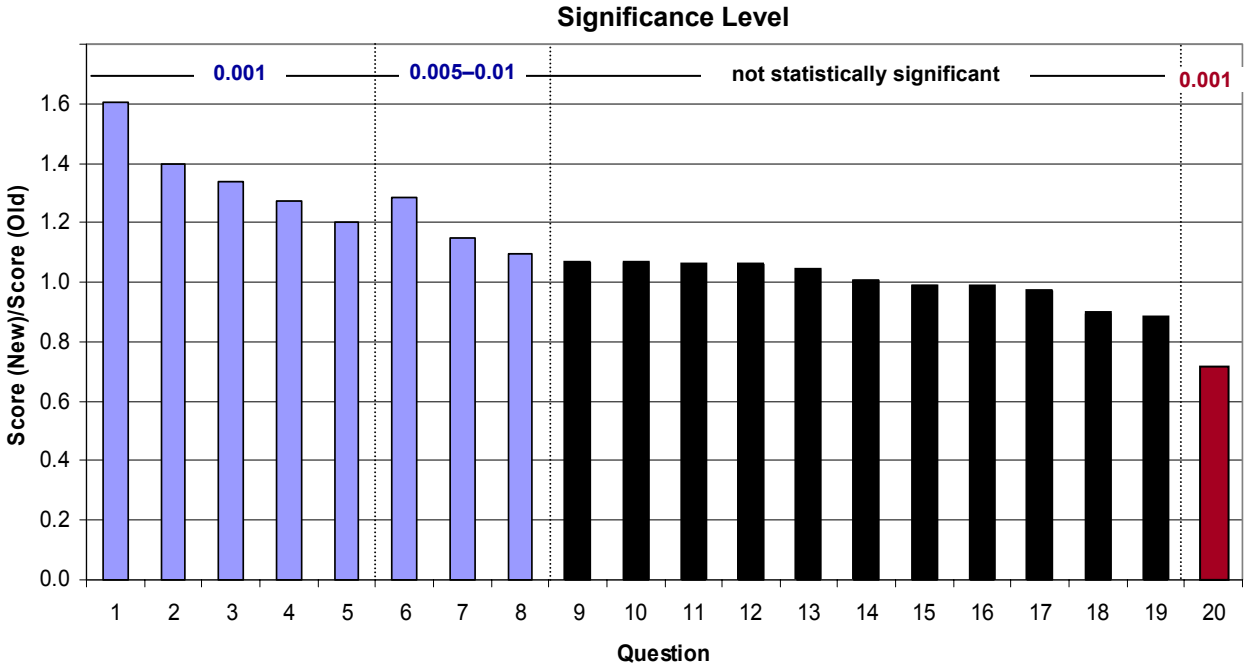

Figure 4: Ratio of the test scores for the group that was taught from new slides, pre-lecture notes, and in-class quizzes to the test scores of a group that was taught with traditional slides. Blue bars (1-8) represent significant increases, black bars (9-19) represent differences that were not significant, and the red bar (20) represents a significant decrease (confidence levels given above).

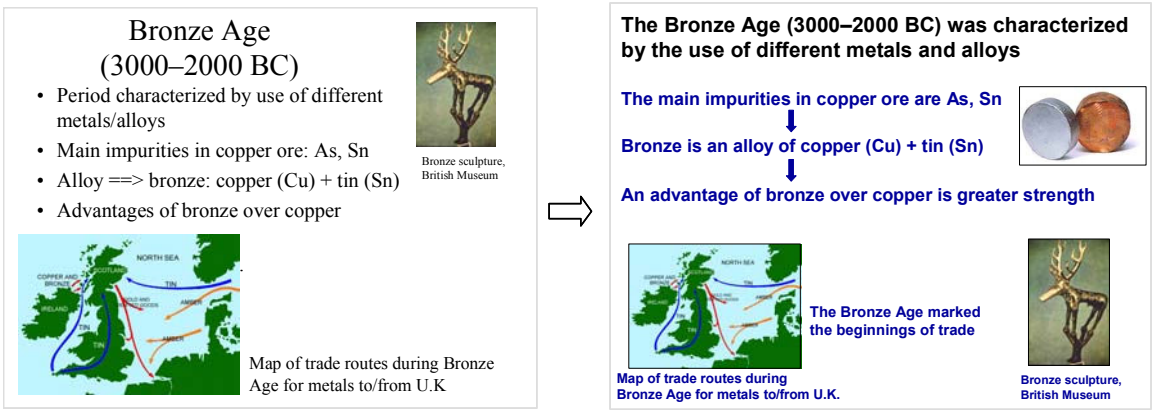

Figure 5: Comparison of test score of 77% correct for a slide with phrase-headline/bullet-list design, shown at the left, with a test score of 93% correct for the sentence-headline/visual-evidence slide at the right [6]. The test question asked the students to recall what metals formed the alloy bronze.

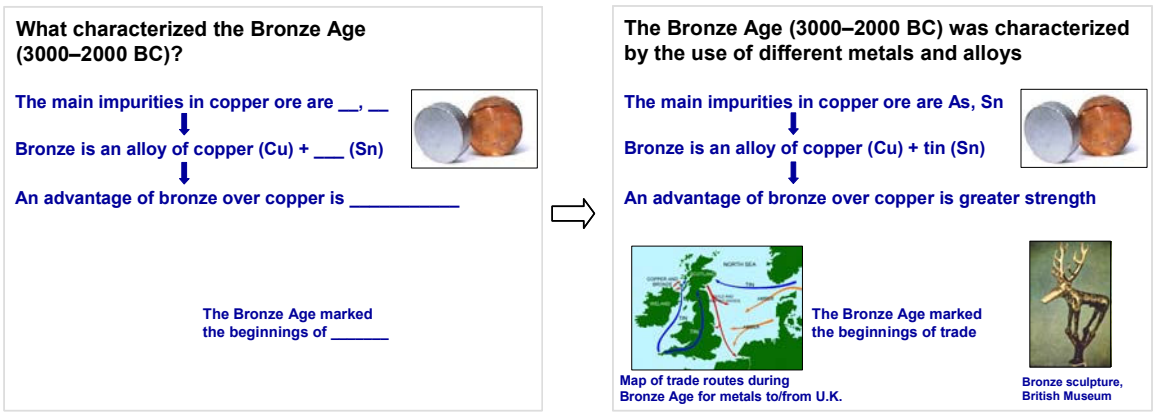

Figure 6: Corresponding lecture slides [6] from the question in Figure 5: pre-lecture slide (left) and post-lecture slide (right).

For the one question that showed a significant decrease in the test scores, the students had to recall which continent (Africa) that Europe focused its exploration during the 19th century. The transformation of the slide to the new design did retain that information, but refocused the slide's content to the effects of European exploration on that continent. Given that, the students in Fall 05 might have actually learned as much or more from this slide as students in previous semesters learned from the phrase-headline/bullet-list slide, but the test question might not have captured what they learned.

Although the decreases on questions 18 and 19 were not statistically significant, the transformations of the slides corresponding to those two questions produced a slide body that had a more dense arrangement of information than in the original slide designs. The increases in density arose from the inclusion of images, which followed one of Mayer's principles that students learn better from relevant images coupled with words than from words alone [9]. However, the increase in density countered one of Mayer's principles that students do not remember as much when extraneous information exists. In the future for these two slides, we plan on retaining a visual arrangement of evidence, but reducing the density of information, and then retesting another section of students to see if the recall on these two questions increases.

Conclusions

This paper has presented an experimental study that investigated methods for incorporating active learning techniques with a new teaching slide design into a large science class. This study had the following four conclusions:

1. The addition of the active learning measures along with the new slide design led to statistically significant increases in the students' recall of important material in the course.
2. The active learning measure of posting pre-lecture notes promoted note-taking and gave the professor more opportunities to ask questions during the lecture.

3. The active learning measure of an end-of-class quiz encouraged students to attend lectures and kept the students focused during class.
4. The students perceived the new slide design and active learning measures to be effective at helping them learn the course material.

This approach incorporating the new slide design of presentation slides along with pre-lecture notes and daily quizzes will be further studied in a large mechanical engineering class in the Spring 2006. For three semesters, students in this engineering course have learned from slides that follow the new design. Given that, the study in the large mechanical engineering course should be able to isolate the effect of the active learning measures from the effect of the new slide design.

Acknowledgments

We would like to thank the Center for Excellence in University Teaching (CEUT) at Virginia Tech for their support of this work. We would also like to thank Beth Diesel for her help in keeping track of attendance, gathering quiz scores, and recording the number of instructor questions.

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