Pilot Testing of a New Design for Presentation Slides to Teach Science and Engineering

Michael Alley, [1] Madeline Schreiber, [2] and John Muffo[3]
Virginia Tech

Abstract – **Pilot testing in a large geology course shows that a new sentence-headline design of presentation slides was more effective than the traditional phrase-headline design at teaching science to undergraduates. Rather than having a phrase headline supported by a bullet list, the new design relies on a succinct sentence headline supported by visual evidence. In the new design, bullets are *not* used. The testing of the new slide design involved comparing test scores between a prior section that viewed the traditional design and the test scores of a current section that viewed the new design. On 7 of the 20 questions, the section viewing the new design achieved improvements in test scores that were statistically significant at the 99.9% confidence level. On no question did the prior section viewing the traditional design achieve a higher test score that was statistically significant. The mean test scores on the 20 questions were 71% correct for the earlier group (traditional design) and 82% correct for the latter group (new design). In addition to analyzing the test scores, we conducted surveys that indicate the students preferred the new design over the traditional design by a more than 7-to-1 ratio. These test scores and survey results have implications in the way that presentation slides should be designed not only for science and engineering classrooms, but also for forums of scientific and engineering research.**

Index Terms – PowerPoint, presentation slides, sentence headlines, slide design, large classes.

INTRODUCTION

Each year, more than 250 million copies of Microsoft PowerPoint produce trillions of presentation slides worldwide [1]. Many of these presentation slides, which include overhead transparencies and computer projections, are used to teach science, technology, engineering, and mathematics (STEM). This method of teaching occurs in K-12 and in universities—especially in large university classes. Even in courses that incorporate active learning techniques such as think–pair–share, presentation slides often play a role in introducing new topics, framing questions, and serving as posted notes for what was learned. In addition to their role in the classroom, presentation slides are also the medium of choice for presenting STEM research. Because of its dominant 95 percent of market share [2], Microsoft PowerPoint and its defaults have greatly affected the design of these presentation slides. For that reason, many slides that are shown in STEM classrooms and STEM conferences have phrase headlines supported by bullet lists. Is this type of design, which this paper will refer to as the traditional design, the most effective design for helping students learn STEM subjects? Is this type of design for slides grounded in solid educational research? According to many recent critics, the answer is no.

In the past three years, harsh criticism of the traditional design of presentation slides has surfaced in several popular publications: "Shuttle Inquiry Uncovers Flaws in Communication," *The New York Times* [3]; "Absolute PowerPoint," *The New Yorker* [4]; "PowerPoint Is Evil," *Wired* [5]; and "Is PowerPoint the Devil," *The Chicago Tribune* [6]. A common theme in these articles is that the presentation slides that follow the defaults of PowerPoint oversimplify the subject matter, sometimes with serious consequences. For instance, in an investigative report about the Space Shuttle Columbia disaster [7], Yale professor Edward Tufte argues that traditional slides failed to characterize the risk that the ill-fated Columbia faced from its collision with debris at lift-off. Another common theme of these articles is that the design quickly becomes monotonous for audiences, thus making it difficult for the audience to recall information.

According to Larry Gottlieb of Lawrence Livermore National Laboratory, a specific failing of traditional slides lies in the use of phrase headlines that leave unclear the purpose of the slide [8]. Since the 1980s, Lawrence Livermore National Lab has rejected the phrase headline and, instead, has advocated a short sentence headline that states the main assertion of the slide. Another failing of the traditional design of presentation slides, according to Edward Tufte, is the reliance on bullet lists to provide cogent evidence for assertions [9]. As Shaw and others point out in a *Harvard Business Review* article [10], bullets are "too generic," they "leave critical assumptions unstated," and they "leave critical relationships unspecified."

Arising in the past four years has been a new design that addresses both of these weaknesses. The new design calls for a

[1] Michael Alley, Associate Professor, Engineering Education Department, Virginia Tech, alley@vt.edu
[2] Madeline Schreiber, Assistant Professor, Geosciences Department, Virginia Tech, mschreib@vt.edu
[3] John Muffo, Director of Academic Assessment, Virginia Tech, muffo@vt.edu

succinct sentence headline, as was advocated at Lawrence Livermore Lab, but also adds a requirement that this headline be supported not by a bullet list, but by evidence presented in a visual arrangement [11]. Specific stylistic, typography, layout, and animation guidelines for this new design have arisen from more than 150 critique sessions of graduate research and senior laboratory presentations over four years—primarily at Virginia Tech [12]. The students making the presentations were first taught a sentence headline/visual evidence design of presentation slides and then asked to incorporate that design into their presentations. After the presentations, the audiences consisting of engineering faculty, graduate students, and seniors discussed how easily the slides were comprehended, how memorable the slides were, and how persuasive they were. The lessons learned from these critique sessions were then incorporated into the teaching of the slide design for the next semester of students. The product of four years of these critique sessions has been a specific new design, for which a summary appears in Table 1. Given in Figure 1 is a visual contrast of this new design with the traditional design.

TABLE I
SUMMARY OF GUIDELINES FOR NEW SLIDE DESIGN [11]

Style
For every slide but the title slide, use a sentence headline that states the slide's main assertion;
In the body of each slide, present supporting evidence in a visual way—with images, graphs, or visual arrangements of text
Avoid bullet lists, because such lists do not show the connections among the listed items
For a class period, limit the number of slides so that at least 2 minutes can be spent on each slide
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, especially sentence headlines, to one or two lines
Keep lists to two, three, or four items
Be generous with white space, especially between elements within the slide

This paper presents the methods for performing a test of the slide design in a large geology course. Following that is a comparison of test scores achieved by students who viewed the traditional design of slides and test scores achieved by students who viewed the new design of slides. The paper concludes with results of surveys to determine which design the students preferred.

METHODS FOR TESTING

During the Fall 2004 and Spring 2005 semesters, we performed a pilot test of the new design of presentation slides in a large geology course (201 and 136 students, respectively) at Virginia Tech. The course, Resources Geology, is a physical science course that discusses the origin, distribution, and use of the earth's mineral resources. Because the course satisfies one of the university's general education requirements, it is a popular course for non-majors. The course was excellent for this test because the instructor used computer-generated projections of slides as the principal visual aid in most class periods. For that reason, the slides played a large role in the instruction. Other reasons that the course was excellent for this study were that the examinations had multiple-choice questions, the students took examinations on sheets that could be scored by a computer, and the instructor had examinations graded through the university testing center, where much historical data exists on the results of these tests. Given that, the assessment specialist for the study was able to extract statistics directly linking test questions to presentation slides across sections.

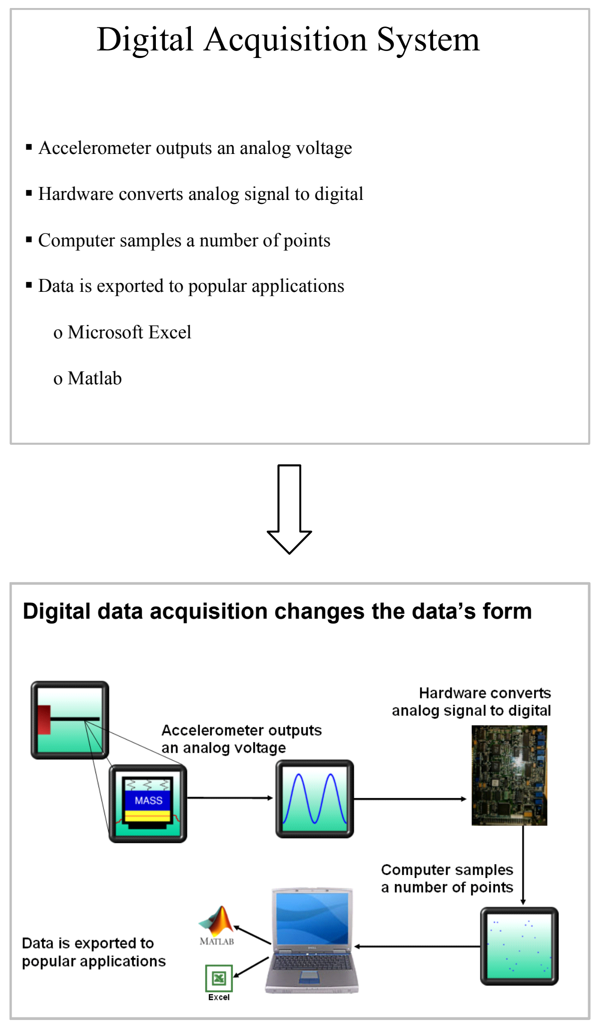

FIGURE 1
COMPARISON OF TRADITIONAL SLIDE DESIGN AND NEW DESIGN [13].

The study sought to determine if using the new slide design, as opposed to the traditional slide design, had a significant effect on how much students learned. Students not only saw the slides presented in class, but also had access to a posted version of the slides before and after class.

For the study, the teaching slides were transformed to the new slide design in six class periods. Not all the transformations involved the same types of changes. In the instructor's original design of slides, about 80 percent of the slides had a phrase headline—the remaining 20 percent either had no headlines or had headlines written as questions. In addition, about 40 percent of the original slides contained the traditional bullet list, with the remaining 60 percent having at least one image. In the transformed versions, 100 percent of the slides, except for the class period's title slides, contained succinct sentence headlines, and 100 percent contained evidence for those assertions presented in a visual way. Figure 2 and Figure 3 show transformations for two of these slides.

In most cases, the transformation called for changing a phrase headline to a sentence headline. Also, in almost every case, the transformation involved a number of specific and sometimes subtle format changes: switching to a boldface Arial typeface, which is easier to read than a Times typeface; having the headline begin in the same position (upper left corner), so that the students know where to begin reading each slide; placing white space within the slide rather than at the edge's; and making consistent the sizes and colors of the body text of each slide.

In many instances, the transformation called for replacing a bullet list with a visual representation of evidence, such as in the examples of Figure 2 and Figure 3. In most cases, the transformation called for reworking the provided slide body with a bullet list and neighboring image into an image/text arrangement that showed better connections between the images and the supporting text. In many cases, the number of words in the slide's body was significantly reduced. In addition, title slides were altered to map what would occur in the class period, and conclusion slides were added to provide emphasis. Shown in Figure 4 is an altered title slide, and shown in Figure 5 is a conclusion slide from one set of transformed slides.

Using the transformed slides, the instructor taught the six classes in the same way that she had done in past semesters. For instance, as she had done in past semesters and in the other lectures of that semester, she posted her slides on the web so that students could download them before the lecture and so that students could use the slides as study notes after the lecture.

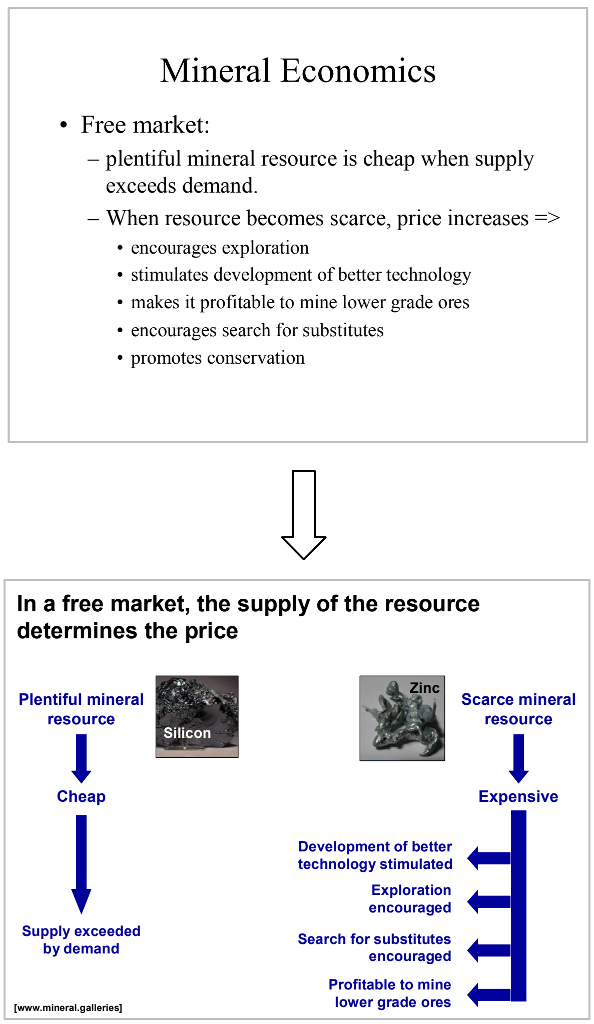

FIGURE 2
TRANSFORMATION OF A PHRASE HEADLINE AND BULLET LIST.

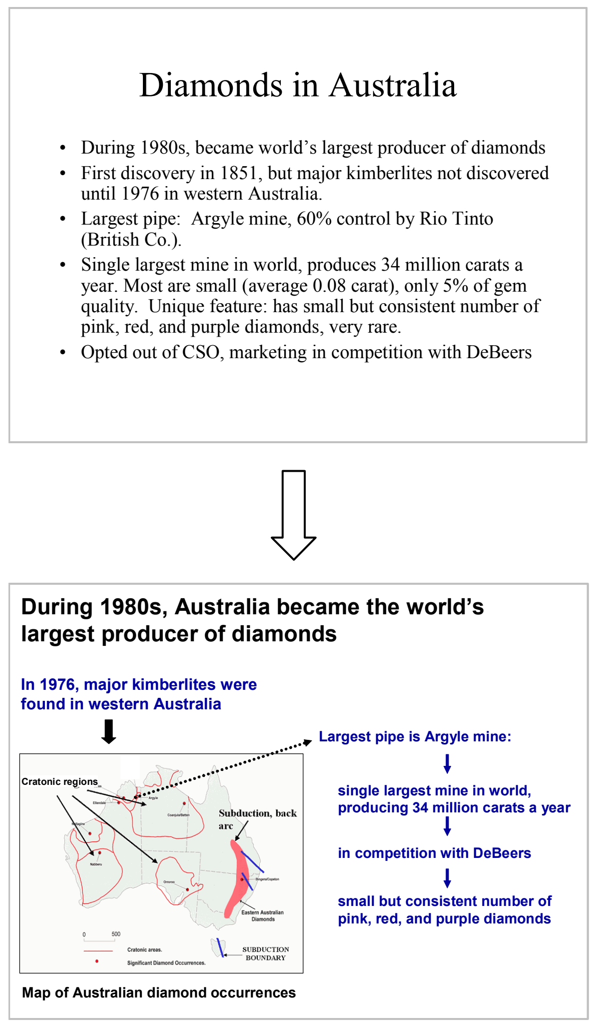

FIGURE 3
TRANSFORMATION OF A PHRASE HEADLINE AND BULLET LIST.

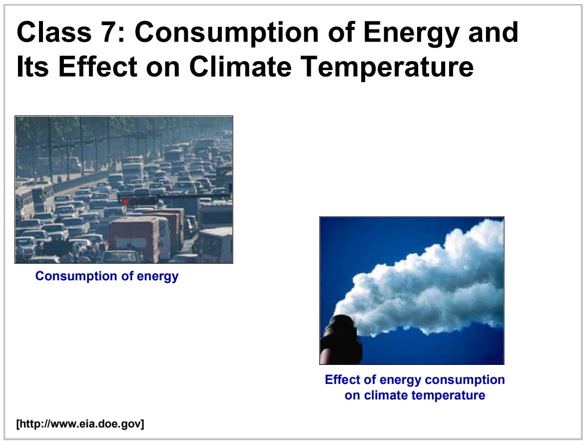

FIGURE 4
TRANSFORMED INTRODUCTION SLIDE FOR ONE CLASS PERIOD.

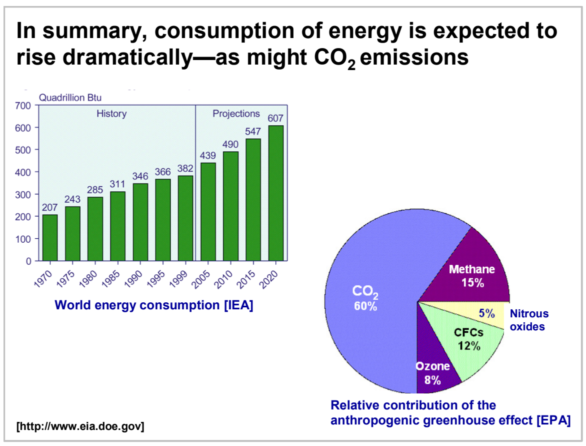

FIGURE 5
ADDED CONCLUSION SLIDE FOR ONE CLASS PERIOD.

As occurred in past semesters, the faculty member prepared her final examination as a multiple choice final. In the final examination, she selected twenty questions for which the answers explicitly appeared on both the original and transformed slide designs. Using historical data that had been gathered on how well students performed on those specific questions, she compared how well the students in Fall 04 and Spring 05 did on those questions. The difference was that in Fall 04 and Spring 05, the students had learned the information with slides that followed the new design.

RESULTS OF PILOT TESTING

This study found that in 9 cases the students learning with the new design achieved improvements in test scores that were statistically significant. In particular, the test scores on 7 questions had an increase that was statistically significant at a 99.9% confidence level, and on 2 questions the test scores had an increase that were significantly significant at a 99% confidence level. On no questions did the students viewing the traditional design achieve scores that were significantly higher than the group learning with the new design. The mean scores on the 20 questions were 71% correct for the earlier group (original slides) and 82% correct for the latter group (transformed slides). As a control, the mean test scores on forty questions in which the earlier group and latter group simply had to answer questions given on previous tests showed that the earlier group actually performed better than the latter group (86% correct to 80% correct). These results show that the latter group was not inherently "stronger" than the earlier group.

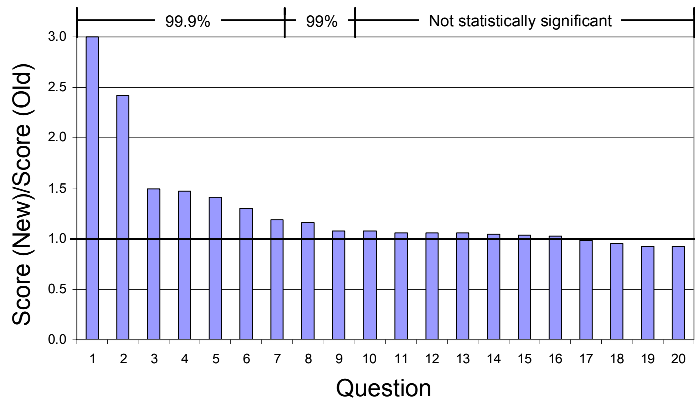

FIGURE 6
TEST RESULTS, WHICH SHOW BETTER SCORES FOR THE NEW SLIDE DESIGN.

What exactly about the new slide design led to the higher scores? From a formatting perspective, in all of the questions, typography changes occurred that made the slides easier to read for students. Also, changes in layout opened up white space within the middles of the slides that allowed for more emphasis of different elements in the slide.

From a cognitive science perspective, in several of the transformed slides, an image representative of the content was added. According to Paivio's dual-correlation hypothesis [14], having a representative image on each slide should increase the retention of details by the audience. Paivio's hypothesis states that, in the brain, verbal codes and pictorial codes are processed and stored in different ways. In his experiments, the retention of details that are processed through both codes is roughly twice as high as the retention of details in which the processing occurs in only one code. Along these same lines, the work of Carney and Levin confirms that representative images, as opposed to decorative images, should increase the audience recall of information [15].

Although we altered the format of all the slides and added images to several of the slides, the change that appeared to have had the largest effect in increasing the test scores was the replacement of a phrase headline with a sentence headline. Figures 7 and 8 present two example transformations (with corresponding test questions) that show this effect. For both of these transformations, the improvements in test scores were statistically significant at a 99.9% confidence level.

Having a sentence headline in a teaching slide benefits the student in a number of ways [16]. Probably the most important is that unlike a phrase headline which simply identifies the slide's topic, the sentence headline emphasizes the main assertion of the slide. An example occurs with the definition that appears in the headline of the transformed slide of Figure 7.

A second way that a sentence headline benefits the student is that the sentence headline provides emphasis to assertions that in a traditionally designed slide would most likely be subordinated in a bullet list. An example occurs with the detail in Figure 8 about iron constituting 5% of the earth's crust. Because this detail appeared in the headline of the transformed slide, the students when viewing the slide in the lecture and studying the slide before the exam gather that the detail about the abundance of iron ores in the crust is more important than the details placed in the body of that slide.

RESULTS OF STUDENT SURVEYS

To determine the students' reactions to the new slide design, we conducted surveys. The surveys occurred in the Spring 2005 offering of the geology course, which had 136 students. During the first six class periods of the course, the students saw slides that followed the traditional design. As noted previously, these slides were characterized by phrase headlines and a mixture of either images and text in bullet lists or just text in bullet lists. The students had access to posted versions of these slides before and after the lecture. After the six lectures, the students were surveyed with Likert-scale questions on a number of variables in the course. This first survey revealed that the students overwhelmingly felt (50% strongly agree and 46.5% agree) that the instructor's traditional slides were effective in helping them learn the course material both as visual aids projected during the class periods and as notes posted on the web.

For the next six class periods, the students saw sets of transformed slides. After these six class periods, the students were asked to respond to the assertions given in Figure 9.

Q: What is the chemical representation for nuclear fusion?

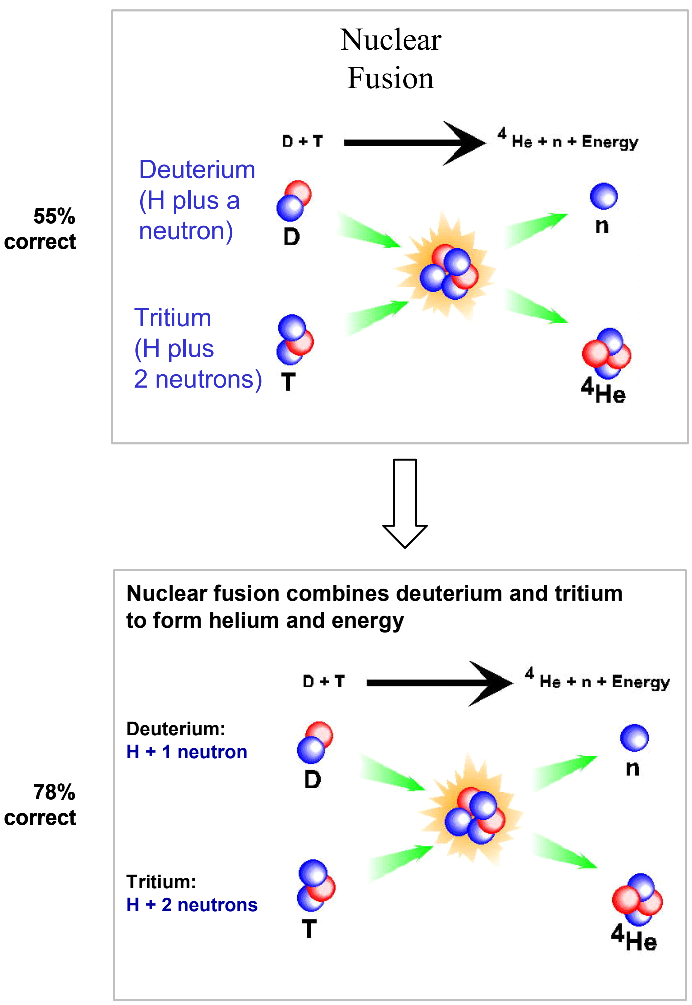

FIGURE 7
TRANSFORMATION LEADING TO IMPROVEMENT OF TEST SCORES (55% TO 78%).

Q: How abundant is iron in the earth's crust?

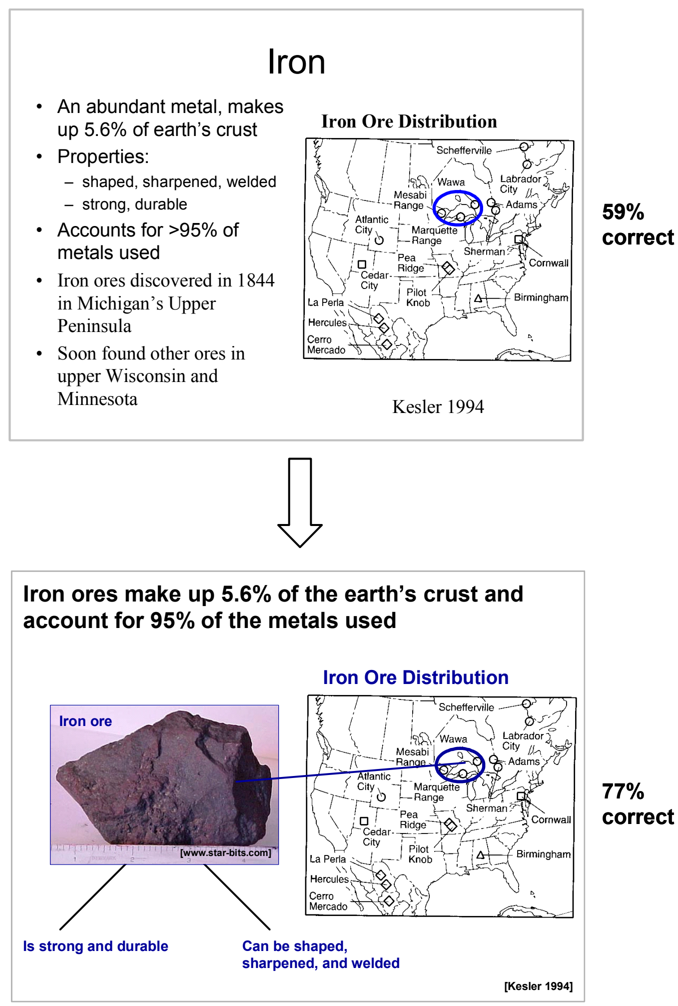

FIGURE 8
TRANSFORMATION LEADING TO IMPROVEMENT OF TEST SCORES (59% TO 77%).

As seen from this figure, although the number of neutral responses ("Not Sure") was considerable, the percentage of students who preferred the new design was more than seven times as high as the number of students who preferred the traditional design. That preference was true both for the comparison of the slides presented in class and for the comparison of the slides posted as notes. The one common complaint about the new design was the amount of ink required to print out the notes. One response to that criticism is to post a "light" version of the slides that either does not include the dark pictures or replaces them with line drawings.

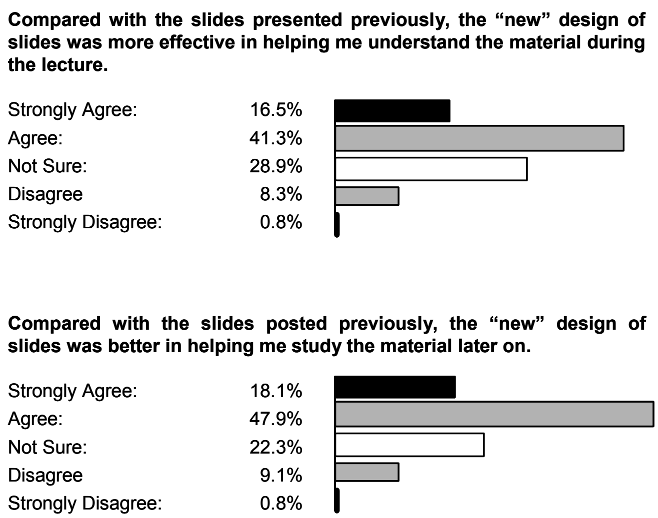

FIGURE 9
RESULTS OF SURVEY ON NEW SLIDE DESIGN (121 STUDENTS RESPONDING).

CONCLUSIONS

This paper has presented pilot-study results of a new design for presentation slides in a large geology class. The results show that this design led to improvements in test scores that were statistically significant. The average improvement in test scores for the 20 questions in the study was from 71% correct to 82% correct. These results not only have implications in the way that slides should be designed for the teaching of science and engineering subjects, but also in the way that slides should be designed in presentations of science and engineering research. What is needed is testing in courses from different subject areas to see if similar results occur.

One potential drawback to the design is that it could lead to fewer classroom questions from the instructor, particularly if the slides are downloaded by students ahead of class. The reason is that the students could simply look down at their notes and answer the questions. However, that situation could be avoided by posting a pre-lecture version of notes that replaces many assertions on the original slides with questions.

Another potential drawback is that some students will mistakenly assume that they need not attend class—after all, they have this excellent summary of the class period that they can download. One way to maintain attendance would be to include an in-class exercise each day that counts in the final course grade. Ideally, this exercise would be one that would promote active learning—perhaps answering questions in a group—and that could be graded quickly. We are planning tests to assess the effects of both of these measures.

A third potential drawback of this new slide design is that it requires too much time on the part of the instructor (transforming the twenty or so slides in each lecture took about 4 hours). For lectures given to large classes, though, the increased learning demonstrated by the students in this pilot study was well worth the additional time invested by the instructor.

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