AC 2011-900: ASSERTION-EVIDENCE SLIDES APPEAR TO LEAD TO BETTER COMPREHENSION AND RECALL OF MORE COMPLEX CONCEPTS

Dr. Joanna K. Garner, Old Dominion University

Dr. Joanna Garner is a Research Assistant Professor with The Center for Educational Partnerships at Old Dominion University, Virginia, USA. Dr. Garner holds a Ph.D. in Educational Psychology from Pennsylvania State University, USA, and masters and baccalaureate degrees in Psychology from the University of Surrey, UK. She has over a decade of experience teaching social science courses to undergraduate and graduate students. Dr. Garner's research interests center on the application of cognitive psychology to educational practices with a view to improving learning during classroom instruction and independent learning episodes. Her current research includes learning from multimedia presentations and the connection between self-regulated learning, executive functions and academic achievement.

Michael Alley, Pennsylvania State University, University Park

Michael Alley is an associate professor of engineering education in the College of Engineering at Pennsylvania State University. He teaches and conducts research on engineering presentations through the Leonhard Center. He is the author of The Craft of Scientific Presentations (Springer, 2003) and has taught workshops on scientific presentations across the United States and in Chile, Jamaica, Norway, Romania, Saudi Arabia, and Spain.

Lauren Elizabeth Sawarynski
Keri Lynn Wolfe, Pennsylvania State University, University Park

Keri Wolfe is a rising senior Chemical Engineering student at the Pennsylvania State University. She is also a Leonhard Scholar and a German minor. She has been inducted to XE Chemical Engineering Honors Society and A German Honors Society. She is active in Engineering Ambassadors and the Society of Women Engineers. Keri is conducting engineering education research to fulfill her Schreyer Honors College Thesis requirement.

Sarah E. Zappe, Pennsylvania State University, University Park

Dr. Sarah Zappe is Director of Assessment and Instructional Support in the Leonhard Center for the Enhancement of Engineering Education at Penn State. She holds a masters and a doctorate in educational psychology, where she specialized in applied testing and measurement. Her current research interests include the use of qualitative information, such as think-alouds, to enhance validity evidence for a test. She is also interested in developing instruments to measure engineering professional skills such as global awareness, communication, and leadership.

Assertion-Evidence Slides Appear to Lead to Better Comprehension and Recall of More Complex Concepts

Abstract

In a sampling of several thousand slides from engineering and science, almost two-thirds had a topic-phrase headline supported by a bulleted list of subtopics.[1] Because slides are used so often by engineering educators to communicate research, to teach students, and to have students demonstrate what they have learned, the question arises how effective this topic-subtopic structure is, compared with other slide structures, for helping audiences understand and remember the information. This paper compares students' learning from a presentation that relies on this commonly used topic-subtopic slide structure versus students' learning from a presentation that follows an assertion-evidence slide structure. In the assertion-evidence structure, the heading is a succinct sentence assertion and the body of the slide supports that heading with visual evidence.[2] Theoretically, from communication and cognitive psychology perspectives, the assertion-evidence slide structure should be more effective at fostering student learning.[3]

In the experiment, two audiences heard the *same recorded* presentation, but one audience (55 participants) viewed topic-subtopic slides and another (56 participants) viewed assertion-evidence slides. The presentation, which took about 6 minutes to view, explained the process of how magnetic resonance imaging can detect cancerous tumors. Both sets of students were tested immediately after the presentation and then again about one week later. On the questions testing for comprehension and retention of more complex concepts, students learning from the assertion-evidence slides scored higher than did students learning from topic-subtopic slides. These higher scores (some of which achieved statistical significance) occurred on both the essay test given immediately afterwards and the multiple choice test given one week later.

What might be most important here is that those learning from topic-subtopic slides did *not* score significantly higher than those learning from assertion-evidence slides. In other words, even though learners of topic-subtopic slides viewed markedly more written information during the presentation, those learners did not understand and remember more of that written information. That finding is important because using assertion-evidence slides has additional benefits. In particular, theory says that a presenter creating a talk with an assertion-evidence approach will create a more focused and overall stronger presentation than that same presenter using a topic-subtopic approach.[4,5]

Introduction

In engineering conferences, meetings, and classrooms, presentation slides are often used to communicate key principles, concepts, and details. About two-thirds of such slides follow a topic-subtopic structure—that is, a topic-phrase headline supported either by a bullet list or by a bullet list and a graphic.[6] This topic-subtopic structure dominates presentations in engineering education—stretching from student presentations in capstone

design courses[7] to teaching slides in engineering classrooms to research talks at engineering education conferences[8] to presentations by program managers at the National Science Foundation.[9] Little doubt exists that the source for the predominance of this topic-subtopic structure is the slide master default (see Figure 1) of Microsoft PowerPoint, which has about 95% of the market share of presentation slideware.[10] For instance, Figure 2 reveals how closely the slide template required for presentations in the student presentations at the NSF funded EPICS program at Purdue follows the default of PowerPoint.[11] Because this default did *not* arise from research,[12] it is important that we question its efficacy. That questioning is especially important because given how often slides occur in engineering presentations and how often engineers present, even a small improvement in the effectiveness of communication could lead to large gains in the amount of information communicated.
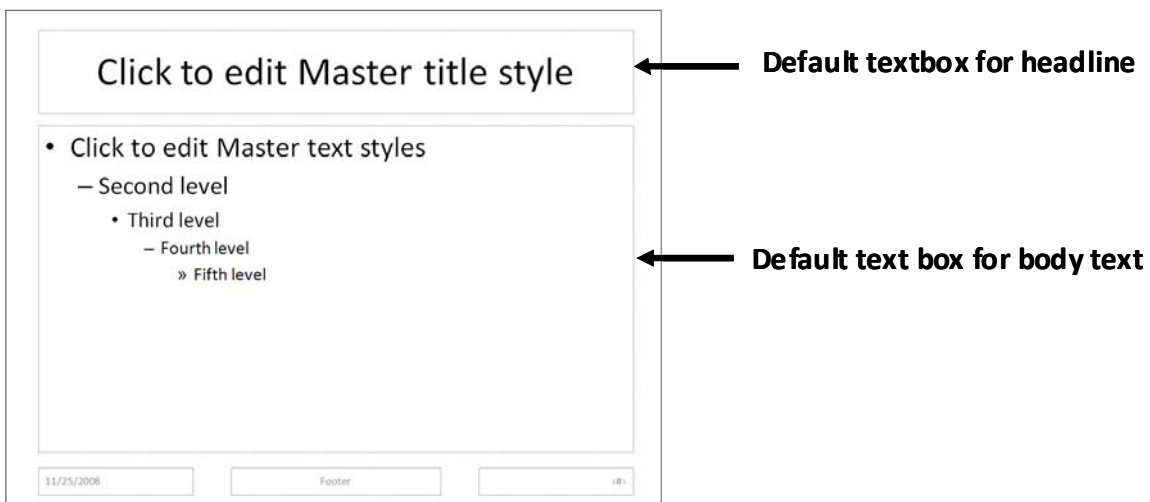

Figure 1: Default settings of PowerPoint's slide master.
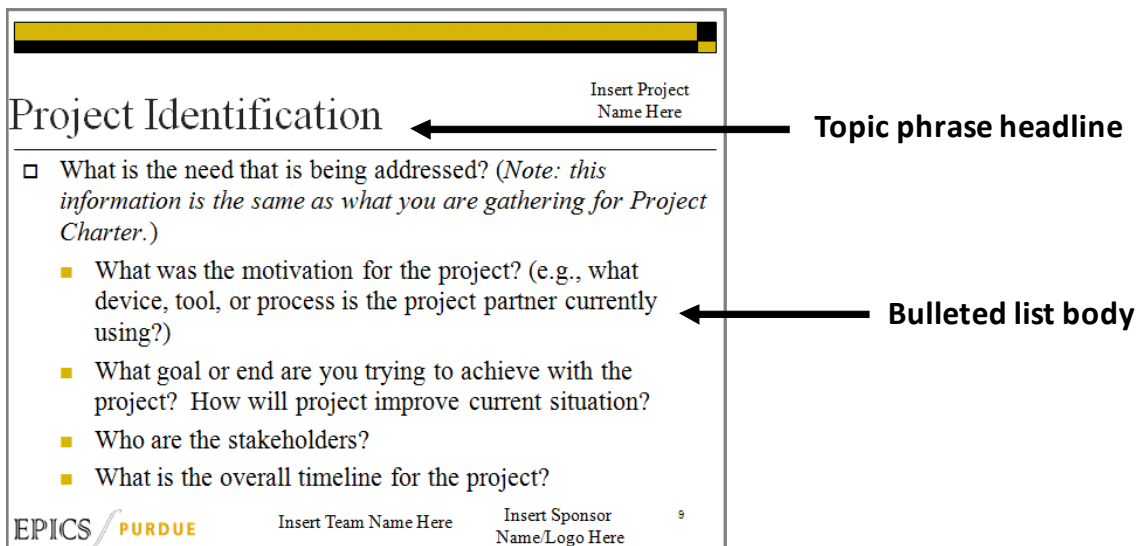
Figure 2. Example slide from template that is required for one of the design presentations in Purdue's EPIC's program.[13] This program, which is a high profile program in engineering education, has received more than $5 million of federal funding, much of that coming from the National Science Foundation.[14]

The topic-subtopic structure is not the only structure used for slides in engineering and science. Another is the assertion-evidence structure. In this structure, the heading is a succinct sentence assertion and the body of the slide supports that heading with visual evidence.[15] Figure 3 shows a contrast between a slide that follows the topic-subtopic structure and one that follows the assertion-evidence structure.
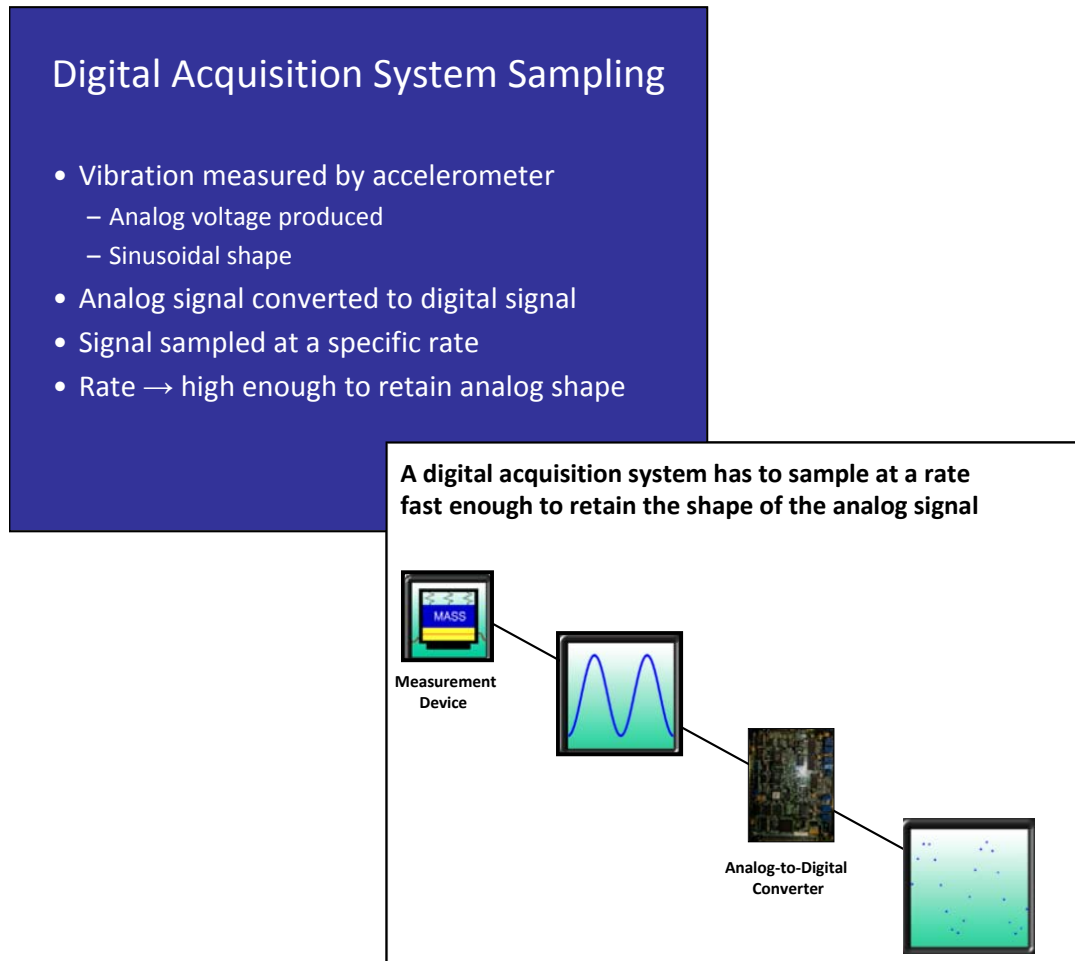
Figure 3. Comparison of two slides that present the same technical principle: the top slide follows the commonly used topic-subtopic strategy, and the bottom slide follows the assertion-evidence structure.[16]

The way a slide is designed can affect the success of the presentation in three ways. First, the way that a presenter designs the slides can affect how focused the presentation is. For instance, a theoretical advantage of assertion-evidence slides is that because the presenter thinks of the presentation in terms of assertions (insights, features, results, and conclusions that the audience needs to know) rather than topic phrases, the presenter is more likely not to include extraneous details. [17, 18] A comparison of the slides in Figure 3 illustrates this point. In the bottom slide, the presenter focused on the most important principle that the students were to take away from the discussion—that principle is stated in the headline. Second, the design of slides can affect the delivery of the presentation. For instance, if the presenter continually turns to the slide to read items, as often happens in presentations with bulleted lists, the presenter breaks eye contact with

the audience. Third, the way that slides are designed affects how much the listener understands.

Our research considers only the third effect with the following general question: Will audiences comprehend and recall the key information better with assertion-evidence slides than they will with the commonly used topic-subtopic slides? To answer this question, we performed an experiment in which two audiences listened to the *same* narrated technical presentation, but viewed different types of slides. One audience viewed assertion-evidence slides, and the other audience viewed topic-subtopic slides. After this presentation, participants were tested on their comprehension and recall of the information. This experiment parallels the learning situation that occurs when audiences attend a technical presentation at a conference. In both situations, the audience has one chance (the presentation) to understand the information.

Two specific research questions arise from our experiment:
(1) Will audiences comprehend more complex principles differently with assertion-evidence slides than with topic-subtopic slides?
(2) Will audiences recall facts differently with assertion-evidence slides than with topic-subtopic slides?

In 2006, Alley et al. showed that students are more likely to recall key principles placed in the sentence headline of an assertion-evidence slide than those principles placed in the bulleted list of a topic-subtopic slide.[19] However, that test is quite different from our test because the participants not only viewed the presentations slides, but used the slides as study notes before taking the test. Moreover, in that test, the participants were tested for recall and comprehension strictly with multiple choice rather than open-ended questions. Third, in that test, a speaker gave the presentations live, introducing the possibility that the increased recall and understanding from the assertion-evidence slides was influenced by the differences in the delivery. Finally, that test did not challenge the participants on their understanding of more complex concepts, such as a multi-step process.

Our paper first discusses the methods for testing our hypothesis, with particular emphasis given to the creation of the script and two sets of slides, the selection of the two participant groups, the types of questions for the two participant groups, and the evaluation of the participant responses. Then the paper presents theoretical arguments for why each of the two possibilities (the commonly practiced topic-subtopic and the assertion-evidence approach) would lead to more learning of the material. Next, the paper presents the results of the experiment and a discussion of those results. The paper concludes with directions for future research.

Theory

In this section, we present theoretical arguments for why each of the two slide structures should lead to more learning. One of these two slide structures is the commonly used topic-subtopic structure, which is characterized by a topic phrase headline supported either by a bulleted list or by a bulleted list and a graphic. The other is the assertion-

evidence structure, which has a sentence headline that states the main assertion of the slide and supports that assertion with visual evidence: photographs, drawings, diagrams, graphs, or words and equations arranged in a visual way. This section also presents arguments for a third possibility—that the amount of learning will be the same, no matter which of these two slide structures is chosen.

Why the Topic-Subtopic Slides Should Lead to Better Comprehension and Recall. One reason that topic-subtopic slides should lead to more learning than assertion-evidence slides is that topic-subtopic slides provide more words and therefore more scaffolding for the learner. Typically, topic-subtopic slides typically contain significantly more words than assertion-evidence slides do.[20]

A second reason, which is coupled to the first, is that topic-subtopic slides provide more choices for learning than assertion-evidence slides do. For those learners who prefer to read, the topic-subtopic slides provide more words from the script. For those learners who prefer to learn by listening, they can simply listen.

A third reason that topic-subtopic slides should provide more learning is that topic-subtopic slides are much more commonly used than assertion-evidence slides are. Therefore, audiences are much more accustomed to learning from topic-subtopic slides.

Why Assertion-Evidence Slides Should Lead to Better Comprehension and Recall. One reason that assertion-evidence slides should lead to more learning than topic-subtopic slides is that assertion-evidence slides provide fewer words and therefore have less chance to cause cognitive overload for the learner.[21] Typically, assertion-evidence slides contain significantly fewer words than topic-subtopic slides do and such presentations call on audiences to read much fewer words than topic-subtopic presentations do.[22]

A second reason that assertion-evidence slides should provide more learning is that assertion-evidence slides follow the multimedia principle of learning more often than topic-subtopic slides do. The multimedia principle states that audiences are more likely to learn from words and images than words alone.[23] In an assertion-evidence presentation, relevant images (photographs, drawings, diagrams, graphs, or films) occur on each slide, while in a typical topic-subtopic presentation, relevant images do not occur on at least 40 percent of slides.

Yet a third reason is that assertion-evidence theoretically should have less noise than topic-subtopic slides.[24] The reason for this reduced noise is that writing the sentence-assertion headline, as opposed to the topic-phrase headline, should make the presenter more focused in selecting the details placed in the body of the slide. That focus is important because according to the multimedia principle of coherence, unrelated details on visual aids reduce learning.

Why the Choice of Slide Structure Will Not Affect the Amount of Comprehension and Recall. The main reason that no differences will exist between the audience groups viewing the two different slide structures is that the words spoken are the dominant means by which learning occurs.

Methods to Test Hypotheses

This paper addresses the research question of whether an audience will understand more, less, or the same if the slides follow an assertion-evidence structure, as opposed to if the slides follow the commonly used topic-subtopic structure. To answer this question, we performed an experiment in which two audiences listened to the same presentation, but viewed the two different structures of slides. One audience viewed assertion-evidence slides, and the other viewed topic-subtopic slides. This section discusses the methods for testing our research question, with particular emphasis given to the following: (1) creation of the script and the two sets of slides, (2) the selection and testing of the participant groups, and (3) the evaluation of the participant responses.

Development of Script and Slides. The first requirement was to come up with an identical script that presented information that met three criteria: (1) was interesting for the participants; (2) was new for the audience; and (3) was challenging for the audience. After outlining scripts for several different topics, we decided on the process by which magnetic resonance imaging detects cancerous tumors. The reason for choosing the process of magnetic resonance imaging (MRI) for detecting cancerous tumors was that it met all three criteria stated above. The MRI topic met the first criterion because the process includes principles from three different areas of science: physics, chemistry, and biology. The focus on cancer with the MRI topic allowed the topic to meet the second criterion, because cancer is such a common and deadly disease. The MRI topic met the third criterion because the process consists of several steps.

Developing a script for the presentation involved drafting the script, drafting the slides, then revising the script based on the slides, then revising the slides based on the revised script, and so forth. In this process, we used assertion-evidence slides, rather than topic-subtopic slides. This derivation of a script from an assertion-evidence process is important, because it raises the question whether a typical presenter using a topic-subtopic approach would have created a script this focused. The script appears in Appendix A and contains three main types of information, as summarized in Table 1.

Table 1. Types of information contained in script for experiment.

Type of Information	Description of Information
Recall of facts	Four different health statistics pertaining to cancer
Comprehension of principle	What typically occurs in a cell with a DNA mutation and what occurs in a cell with a DNA mutation that leads to cancer
Comprehension of a technical, multi-step process	How magnetic resonance imaging (MRI) can produce three-dimensional image of the human body: (1) what signals the MRI machine produces, (2) what signals the human body receives and sends, (3) what signals from the human body the MRI receives and processes, and (4) how the MRI machine uses those signals to produce a three-dimensional image.

In developing the assertion-evidence slides, we followed specific criteria that have been outlined in the literature.[25-26] These criteria include having no more than two

lines for the sentence assertion headlines, supporting those headlines with relevant graphics, and having as few words as possible for the bodies of the slides. As shown in Table 2, the average number of words per slide was 19.3, and every slide in the assertion-evidence set had a relevant graphic. Appendix B presents the assertion-evidence slides. Not reflected in this collection is that some of the slides included simple animations which took the form of presentation of additional details of graphics on nine of the ten slides (the animations followed the choice of "Appear," which the assertion-evidence literature recommends).

In developing the topic-subtopic slides, we followed the common practice that was identified in Garner et al.[27] For these slides, we restricted ourselves to two categories: (1) topic-phrase headlines supported by bulleted lists, and (2) topic-phrase headlines supported by bulleted lists and graphics. For each category, the number of words per slide and the percentage of slides with relevant graphics corresponded to practices considered better than the average numbers found in common practice survey conducted by Garner et al. For instance, Garner et al. found that engineering educators nominated for best paper award averaged 33 words per slide and had relevant graphics on 42% of their slides. As shown in Table 2, the number of words per slides in the topic-subtopic set was 30.4, and the percentage of topic-subtopic slides with relevant graphics was 54.5%. Two points about the graphics are worth noting. First the percentage of slides with relevant graphics was higher than the common practice, an aspect that theoretically should have benefitted the learning from the topic-subtopic slides. Also, the graphics for the topic-subtopic slides were derived from the graphics created for the assertion-evidence slides, which raises the question whether a typical presenter using a topic-subtopic approach would have created graphics that were as effective. Appendix C presents the topic-subtopic slides for the test. Although this set of topic-subtopic slides had an additional slide to reduce the amount of text on any one slide, this set did not include animations because many common practice sets do not include them. However, in further work, we intend to include animated details using the same 'Appear' animation in the topic-subtopic slides as we used for the assertion-evidence slides.

Table 2. Statistics on two slide sets for the experiment.

Characteristic	Topic-Subtopic Slides	Assertion-Evidence Slides
Number of slides	11	10
Total number of words on slides	334	193
Average words per slide	30.4	19.3
Total length of presentation	6 m 17 s	6 m 17 s
Projected words per minute	53.2	30.7
Percentage of slides with relevant graphics	54.5	100
Number of slides with animations	0	9
Total number of words in spoken script	1003	1003
Spoken words per minute	159.6	159.6

Selection and Testing of Participants. Participants for the experiment were undergraduate engineering students in a required speech course. As part of this course, students are expected to take part in a research study, and the IRB number for our study was 34361 at Pennsylvania State University. As mentioned, about half of the participants (55 students) viewed the topic-subtopic presentation slides while listening to the recorded speech, and the other half (56 students) viewed the assertion-evidence slides. Participants for our study came from five different sections of the course, and were randomly selected for the two different viewings. In addition, the viewings by each group of participants occurred on the same evening, early in the semester, before any discussion of visual aids in the course.

After viewing the presentation, each group of participants answered questions in a test given immediately after the presentation. This test consisted of three parts: (1) four Likert survey questions (scale of 1 to 7) on how familiar the audience was with the material, how difficult the audience found the material, and how interesting the audience found the material; (2) four fill-in-the-blank questions calling on the participants to recall statistics from the presentation; and six short essay questions, five of which concerned the process of how magnetic resonance imaging identifies cancerous tumors.

A week after the viewing of the presentations, the students had an unannounced multiple-choice test on the presentation. This unannounced test occurred in the class. Two of the multiple choice questions called on the students to recall statistics, and the five remaining questions called on the students to show understanding of principles in the presentation.

Evaluation of the Participant Responses. Participant responses were assigned a randomized number such that scorers of the questions did not know to which group each response belonged. A proportion (25%) of the responses to each question was scored by two evaluators in order to refine the rubric and achieve inter-rater agreement. After this, one evaluator scored the remaining responses for each question. For each question full single or half points were allocated for the inclusion of specific ideas building into a coherent explanation. We then determined statistical significance using a t-test in the case of multiple choice questions and a statistical variance test (ANOVA) in the case of essay questions. Appendix D includes a sample question and rubric from the immediate posttest.

Results

This section presents the results for the immediate posttest and delayed posttest in two groupings. The first is for questions about more complex concepts, and the second grouping is for questions for simple recall of facts (statistics in our case). For both the topic-subtopic (T-S) audience and the assertion-evidence (A-E) audience, no significant differences occurred in their self-assessments of prior knowledge about the material or perceived difficulty in understanding the material. These findings support our claim that the audiences were comparable in ability.

Results for Comprehension of Complex Concepts. Table 3 lists the six short essay questions and the corresponding immediate posttest scores for the 55 participants of the

topic-subtopic (T-S) presentation and the 56 participants of the assertion-evidence (A-E) slides. These questions tested the participants on their comprehension of more complicated concepts in the presentation—in particular, how the process of magnetic resonance imaging works.

Table 3. Test results on more complex concepts: Essay test given immediately after the presentation.

Question	Maximum Score	T-S Scores Mean and σ		A-E Scores Mean and σ	
1. According to the presentation, how does a cancerous tumor form from normal cells?	2.5	1.80	1.19	2.02	1.07
2. What are the main components of an MRI machine?	2.5	1.87	0.63	1.94	0.58
3. What are the roles of these components in the MRI process?	2.5	1.40*	1.02	1.91*	1.04
4. What occurs at the atomic level in the human body during the MRI process?	6.0	1.91	1.58	2.17	1.56
5. What signal does the MRI machine receive from the human body and how does the MRI machine use this signal to form an image that distinguishes between normal tissue cells, cancerous cells, bone cells, and so forth?	1.5	0.55	0.44	0.59	0.38
6. How does the MRI machine form a three-dimensional image of the human body?	1.5	0.48	0.49	0.61	0.47
Total	16.5	8.01**	4.37	9.24**	4.24

*A statistical variance test (one way ANOVA) revealed that the difference in scores for this question is statistically significant at a level of $p=0.010$.
**A one-tailed t-test found that the difference in these summed scores is statistically significant at a level of $p=0.078$, $(t_{(109)} = -1.78)$.

Table 4 presents the questions and scores on more complex concepts from the delayed multiple-choice test given one week later. These multiple-choice questions tested the participants on how well they comprehended and remembered more complex concepts from the presentation. Finally, Table 5 presents the combined scores from the immediate essay posttest and the combined scores from delayed multiple choice posttest for the more complex concepts in the presentation. For the delayed test, we combined scores from the three questions on specific steps in the MRI process.

Table 4. Test results on more complex concepts: multiple choice test given 1 week after the presentation.

Question	T-S % Correct	A-E % Correct
1. What normally happens after a mutation occurs in the DNA of a cell?	68	66
2. In a Magnetic Resonance Imaging (MRI) machine, what is the role of the superconducting magnets?	86	96
3. In the MRI process, what occurs in the patient's body when the transceiver emits radio frequency waves?	34	48
4. In the MRI process, what happens when the radio frequency waves are turned off?	64	73
5. In the MRI process, why is it important to note that the human body is mostly made of water?	64	63
Average	63	69

Because the conceptual nature and difficulty of the questions in Table 4 are not equivalent, a composite score composed of questions 2-4 was calculated. Results differed significantly by condition. Participants who viewed the topic-subtopic slides scored significantly lower (mean=1.84, s.d.=0.84) than participants who viewed the assertion-evidence slides (mean=2.17, s.d.=0.81), $t_{(104)}$=-2.11, p=0.038.

Table 5. Comparison of scores for questions concerning comprehension of more complex concepts.

Type of Information Learned	Topic-Subtopic		Assertion-Evidence		Difference
	Mean	S.D.	Mean	S.D.	
Comprehension of concepts as scored on essays written immediately after the presentation (combined score for 5 essays, maximum is 14)	6.21	3.18	7.22	3.17	p = 0.098
Combined score for comprehension of complex concepts as scored on multiple choice questions answered 1 week after the presentation (questions 2, 3, 4 from Table 4)	1.84	0.84	2.18	0.81	p = 0.038

Results for Simple Recall of Facts. Table 6 lists the scores for recall of statistics for both the immediate posttest and the delayed posttest. In the immediate posttest, the participants had to report the statistic as a fill-in-the-blank. Also, the test challenged the audience on two types of details: details of primary importance and details of secondary importance. *All details were mentioned in the script*, but the details of primary importance appeared on both types of slides, while the details of secondary importance appeared only on the topic-subtopic slides. In the delayed posttest, the participants answered a multiple choice question. The scores for the delayed posttest are shown in light gray. Given in Table 7 are the average percentage scores for the recall of facts from three categories: (1) immediate posttest—details written on both types of slides; (2) immediate posttest—details written on the topic-subtopic slides, but not the assertion-evidence slides; and (3) delayed posttest—details written on both types of slides. In Table 7, individuals in the topic-subtopic group outperformed those in the assertion-evidence only for the immediate recall of statistics that were written on the topic sub-topic and not the assertion evidence slides, $F_{(1,105)}$=28.29, p<0.000.

Table 6. Results on recall of fact: immediate posttest and delayed posttest (dark gray). All details were mentioned in the script.

Question	T-S % Correct	A-E % Correct
1. In 2009, in the United States, about _____ people died from breast cancer. *(Primary fact written on both types of slides)*	89	79
2. In the United States, about 1 in ____ women will be diagnosed with breast cancer in their lifetimes. *(Primary fact written on both types of slides)*	85	95
1. In 2009, in the United States, about _____cases of breast cancer were diagnosed. *(Secondary detail written on T-S slides, but not on A-E slides)*	60	17
2. For women in the United States, about 1 in ____ cancer diagnoses are for breast cancer. *(Secondary detail written on T-S slides, but not on A-E slides)*	78	61
1. What is the approximate ratio of women who will develop invasive breast cancer in their lifetime? *(Primary fact written on both types of slides; delayed posttest; multiple choice question)*	82	79
2. In 2009, about how many people in the United States died from breast cancer? *(Primary fact written on both types of slides: delayed posttest; multiple choice question)*	76	84

Table 7. Average percentage recall of statistics for two groups—all details were mentioned in the script.

Type of Information Learned	Topic-Subtopic	Assertion-Evidence	Difference
Immediate recall of primary statistics that were written on both the T-S slides and A-E slides (average score for two questions)	87%	87%	No statistically significant difference
Immediate recall of secondary statistics that were written on T-S slides, but not on A-E slides (average score for two questions)	69%	39%	p < 0.000
Delayed recall of primary statistics that were written on both the T-S slides and A-E slides (average score for two questions)	79%	82%	No statistically significant difference

Discussion and Conclusions

Two interesting findings arose from the results of this experiment. These findings provide a window into how people learn (or do not learn) when topic-subtopic slides and assertion-evidence slides are projected in technical presentations. This section presents these two findings, analyzes the evidence for these findings, and discusses their significance.

1. Students learning from assertion-evidence slides appeared to have a deeper comprehension and recall of the complex process than did students learning from the topic-subtopic slides. In both the immediate test and the delayed test, the participants learning with the assertion-evidence slides appear to have a deeper understanding of the more complex concepts of the presentation. For every essay question and most multiple choice questions concerned with comprehension of more complex concepts, the scores for those learning from the assertion-evidence slides were higher. In addition, the

increase in combined scores on multiple choice questions that revealed understanding specific steps in the MRI process was statistically significant (p=0.038) for those learning from assertion-evidence slides, as opposed to those learning from topic-subtopic slides.

This finding has important implications for engineering educators who use slides to teach complex principles, for engineers and scientists who use slides to communicate complex principles in conferences and meetings, and for engineering students who use slides to communicate complex principles in their project and classroom presentations. What is needed are more tests to determine if statistically significant differences exist between assertion-evidence slides and the commonly used topic-subtopic slides for other types of processes and for concepts other than in processes—for example, concepts in evaluations.

In addition to testing other types of concepts, another consideration for future testing is to reconsider the placement of the essay questions in the posttest. For example, participants may be less subject to potential fatigue effects if they write their short essay responses first rather than last, as was the case in our immediate posttest. Also, the number of essay questions may have resulted in participants putting forth their best effort for the first two or three questions only. For that reason, we would like to revise the immediate posttest to have fewer essay questions. Moreover, we would like to revise the delayed posttest to present distracters on the multiple choice questions that represent the common misconceptions that we discovered from the essay questions of the immediate posttest. Yet another manipulation to consider is the addition of simple animation sequences to the topic-subtopic slides to ensure that highlighting graphical details is equal for both conditions.

A final consideration on this finding is because the narrative script arose from an assertion-evidence process, the question arises whether a presenter, especially a less experienced presenter, would have created a script this focused. The reason for this question is that theoretical arguments[28] and anecdotes[29] find that creating a presentation with an assertion-evidence approach leads presenters (especially those with less experience) to create a more focused talk. Therefore, a typical presenter who used a topic-subtopic approach to create this presentation would likely *not* have arrived at a script that was as focused as this one or created graphics that were as effective as the graphics in this presentation.

2. No significant difference occurred in either the immediate recall or delayed recall of primary details that were written on both types of slides. As was shown in Table 7, no significant differences existed between those learning from topic-subtopic slides and those learning from assertion-evidence slides for the recall of primary statistics from the presentation. This finding is important because an argument often used for following a topic-subtopic structure is that these slides lead to better recall of details. Granted, the immediate fill-in-the-blank portion of the test did show that participants learning from topic-subtopic slides were better able to recall *secondary* statistics included on the topic-subtopic slides, but not on the assertion-evidence slides. However, for those statistics in the presentation deemed to have primary importance, the recall was the same, both for the immediate posttest and for the delayed posttest. Also, if the recall of secondary details by

the topic-subtopic group occurred at the expense of not understanding the higher order concepts as well, that recall might not be an advantage.

Because the delayed posttest did not contain questions about secondary statistics, we do not know how well that participants from both groups would perform on such recall. Such questions would be an interesting addition for another experiment. In addition, all the statistics for this presentation occurred at the beginning. Another interesting variation would be to have participants recall statistics from different parts of the presentation. It could be that recall of secondary details from the middle or end of a topic-subtopic presentation might not be as high because the audience is fatigued from reading from so much text.

Conclusions

This paper has presented an experiment to test how well audiences learn from slides that follow the assertion-evidence structure, as opposed to the ubiquitous topic-subtopic structure. In general, participants appeared to learn more complex concepts better with assertion-evidence slides, as opposed to topic-subtopic slides. Also, participants were able to recall primary details equally as well with assertion-evidence slides as with topic-subtopic slides. These rates of comprehension and recall were similar for both the immediate test and delayed test. However, people learning from topic-subtopic slides were able to recall secondary statistics better—in this presentation, though, those details occurred at the beginning of the presentation when the audience attention might have been the highest.

This paper recommends follow-up testing to address lingering questions. For instance, this paper recommends reducing the number of essay questions for the immediate posttest and placing those essay questions at the beginning of that posttest so that participants are not fatigued when they answer these questions. Also, the paper recommends placing primary and secondary details for recall at different places of the script, and for testing that recall both in the immediate posttest and in the delayed posttest. Finally, the paper recommends including animations on the topic-subtopic slides to ensure equivalence between the conditions.

Perhaps what is most important about these results is not whether audiences viewing assertion-evidence slides recalled and comprehended significantly more than audiences viewing topic-subtopic slides. Rather, what is most important is that those viewing assertion-evidence slides did *not* recall and comprehend significantly less. The reason for this statement is that theoretical arguments[30] and informal data[31] find that creating a presentation with an assertion-evidence approach leads presenters (especially those with less experience) to create a more focused talk. Therefore, the typical presenter who used a topic-subtopic approach to create this presentation would likely *not* have arrived at a script that was as focused as this one or created graphics that were as effective as the graphics in this presentation. To discern those differences between learning with different slide structures from the creation of a presentation to the reception of information by an audience, we would need a much more involved experiment.

Appendix A: Script for Experiment

[Slide 1] Currently, the American Cancer Society estimates that 1 in every 8 women in the United States will develop a case of invasive breast cancer in her lifetime. Think about all of the women in your life: your mother, grandmothers, sisters, cousins, nieces, aunts, and friends. Chances are that at some point in their life, at least one of these women will be diagnosed with breast cancer. The Center for Disease Control estimates that in 2009, more than 190,000 new cases of breast cancer were diagnosed and that more than 40,000 people died of the disease. [Slide 1a: Topic-Subtopic] Breast cancer is one of the most commonly diagnosed forms of cancer in women, accounting for 1 out of every 3 cancer diagnoses. While the risk for developing breast cancer is much lower for men as compared with women, breast cancer in males is possible and the prognosis is often worse.

[Slide 2] The human body is made up of hundreds of different types of cells which, under normal conditions, divide in a controlled fashion. Occasionally, cells can become damaged by a mutation in the DNA. When a mutation happens, cells are programmed to die so that the mutated cells cannot divide and spread. In a cancerous state, however, the programming that directs a cell to die after a mutation occurs does not function properly. Mutated cells can then divide and spread uncontrollably. When this uncontrollable dividing and spreading happens in breast tissue, cancer has begun and a tumor grows.

[Slide 3] Because these cancer cells are different from the native breast tissue, they have different physical properties. One such altered property is the density of the tissue. The differences between the tumor tissue and the normal tissue are what allow the tumors to be detected.

[Slide 4] The use of magnetic resonance imaging, or MRI, has been one of the most recent developments in early breast cancer detection. MRI can be used together with safe, injectable contrast media to highlight even the tiniest of cancerous tumors. Not only is this method sensitive in detecting extremely small tumors, but an MRI can create a three-dimensional image of the breast tissue and tumor. Such an image is helpful in isolating the exact location of the cancer in the breast tissue so that healthy tissue does not have to be removed during surgery. Magnetic resonance imaging has wide applications in monitoring the recurrence of breast cancer in patients who have previously undergone cancer treatments, and is an effective method of breast cancer detection for the ever increasing number of women who have had breast enlargements.

[Slide 5] The main technical components of an MRI machine are the superconducting magnets and the radio-frequency, or RF, transceiver. As the name "magnetic resonance imaging" implies, magnets are an important part of the function of an MRI machine. Within the MRI machine, three sets of superconducting magnets are positioned to produce magnetic fields in the x, y, and z directions, allowing for the creation of three-dimensional images. The radio frequency transceiver in the machine is able to both transmit and receive radio frequency waves. The importance of this transceiver will soon become apparent.

[Slide 6] If you recall from your general chemistry classes, all atoms have a certain "spin." This spin is essentially an axis through the atom that acts like a vector. At any given moment, the spins of the atoms within your body point in random directions. The superconducting magnets inside the MRI machine function to apply a magnetic field to the body that causes the spins of the atoms in your body to become aligned parallel to the magnetic field.

[Slide 7] Once the atoms are aligned with the magnetic field, a pulse of radio frequency waves is applied to the body at a frequency that specifically targets hydrogen atoms. Hydrogen atoms are targeted because the human body is made mostly of water, and water is made mostly of hydrogen. When this radio frequency pulse passes through the body, some of the hydrogen atoms absorb the wave's energy and are able to overpower the magnetic field. The spins of these hydrogen atoms will no longer be aligned with the magnetic field because the atoms are in a higher energy state.

[Slide 8] When the pulse of RF waves is turned off, the magnetic field takes over again and forces the atoms that had absorbed the radio frequency energy to realign parallel to the magnetic field. In doing so, the atoms are returning to a lower energy state and must release some energy. That energy is emitted as a radio frequency wave which can be detected by the RF transceiver. The exact frequency of the emitted signal is tissue-dependent. This dependency means that signals emitted from dense tissue such as bone and cartilage will have frequencies different from signals from less dense tissue such as fat and internal organs. Hydrogen atoms in cancerous tumors would emit a signal with a slightly different frequency from all of these.

[Slide 9] The radio frequency signals emitted from the body must then be converted into an image. To perform this conversion, the radio frequency transceiver detects the signals and uses a special mathematical transformation, called a Fourier transform, to convert the mathematical signal into an image. The resultant MRI image is extremely detailed. By repeating the MRI process at different locations, successive images from different "slices" of the body can be compiled to create a three-dimensional image that essentially maps out the body, or in this case, the breast tissue. The use of magnetic resonance imaging for the early detection of breast cancer results in clear, sharp images that can show tiny tumors in breast tissue in three-dimensions.

[Slide 10] Magnetic resonance imaging has established itself as an extremely sensitive and safe method of detecting early stages of breast cancer. The use of MRI will provide clinicians with another technique to continue to build a strong defense against the development of invasive, life-threatening breast cancer. For that reason, using magnetic resonance imaging has the potential to prevent many of the 40,000 deaths caused by breast cancer each year in the United States.

Appendix B: Slides from the Assertion-Evidence Presentation

In the United States, 1 in every 8 women will develop invasive breast cancer in their lifetime

Breast cancer killed 40,000 people in 2009

1

Cancer is caused by a DNA mutation in which the cell does not die, but divides uncontrollably
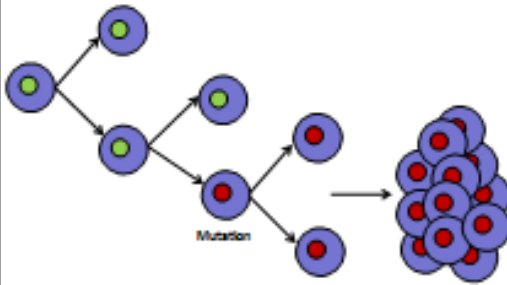

Normal Cell Division

Mutation   Cell death

2

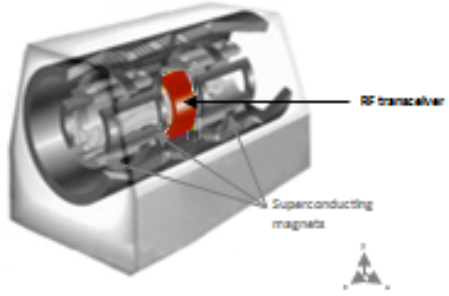Cancer is caused by a DNA mutation in which the cell does not die, but divides uncontrollably

Mutation

Cancerous tumor

3

Magnetic resonance imaging presents a safe and extremely sensitive method of breast cancer detection

4

The main components of an MRI machine are the magnets and the radio frequency (RF) transceiver
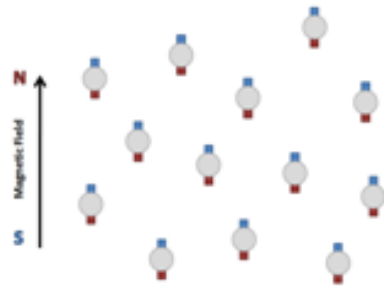
RF transceiver

Superconducting magnets

5

Applying a magnetic field causes the spins of atoms in the body to be aligned parallel to the field

N

Magnetic Field

S

6

Applied RF waves add energy to hydrogen atoms, causing some to fall out of alignment with the magnetic field

7

When the RF wave ceases, the magnetic field forces atoms to realign and release energy

8

A transceiver detects the emitted signal from the hydrogen atoms and synthesizes it in order to create an image

9

In summary, using MRI to detect breast cancer in its early stages has the potential to save thousands of lives

10

Appendix C: Slides from Topic-Subtopic Presentation

Breast Cancer in the US

- One out of every eight women will develop invasive breast cancer in their lifetime
- In 2009:
  - More than 190,000 new cases
  - More than 40,000 deaths

1

Breast Cancer in the US

- 1 out of every 3 cancer diagnoses in women
- Breast cancer in males often has a worse prognosis as compared with females

1a

Cell Mutations: Normal State

- Under normal conditions in the body:
  - Cells divide in a controlled manner
  - Occasionally, cells damaged by mutation in DNA
  - If mutation occurs, cell is programmed to die

2

Cell Mutations: Cancerous State

- In a cancerous state:
  - Programmed cell death after mutation does not function
  - Mutated cells divide and spread uncontrollably
  - Eventually, a tumor grows
  - Cancer cells have different properties such as density
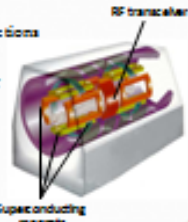
3

Magnetic Resonance Imaging

- Method for early detection of breast cancer
- Can detect extremely small tumors
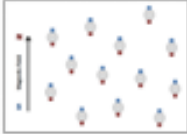- Creates 3-D image of breast tissue

4

How MRI Works

- Superconducting magnets
  - Magnetic fields in x, y, and z directions
  - Allow for 3-D images
- Radio frequency (RF) transceiver
  - Transmit and receive RF waves

RF transceiver

Superconducting magnets
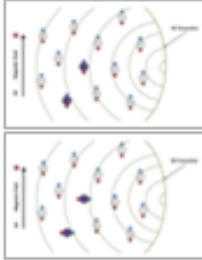
5

How MRI Works

- Atoms have spins, which:
  - Act like vectors
  - Point in random directions
- Magnets in MRI machine apply magnetic field
- Spins of atoms then become parallel to field
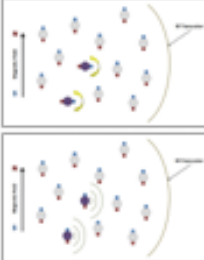
6

How MRI Works

- Applying of RF waves to body
- Hydrogen atoms targeted because so plentiful in body
- Energy added to some hydrogen atoms
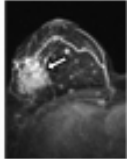- Some hydrogen atoms overcome magnetic field

7

How MRI Works

- RF waves cease
- Magnetic field takes over and atoms realign
- These atoms release energy in form of RF waves
- Detected by RF transceiver and is tissue dependent

8

How MRI Works

- RF signals converted to image using Fourier transform
- Resulting image very detailed
- Process repeated at other places to create 3-D image

9

Conclusion

- MRI has established itself as extremely sensitive and safe method for early detection of breast cancer
- MRI has potential to prevent many 40,000 deaths caused by breast cancer in the U.S. each year

10

Appendix D: Sample Essay Question and Corresponding Scoring Rubric from Immediate Posttest

Essay Question:
What occurs at the atomic level in the human body during the MRI process?

Details receiving credit as stated in script:

1. After the magnets are turned on, the *spins of* (0.5) *atoms align with the magnetic field* (0.5).
2. Then *when the radio frequency transceiver emits energy,* (0.5) *a percentage* (0.5) of the hydrogen *atoms move to a higher energy state* (0.5).
3. When the hydrogen atoms move to a higher energy state, the spins of these hydrogen *atoms are knocked out of alignment with the magnetic field* (0.5).
4. *Hydrogen* (0.5) is targeted by the radio waves *because the body is mostly* water and water is mostly *hydrogen* (0.5).
5. *When the transceiver stops emitting radio waves* (0.5), the hydrogen atoms *return to the lower energy state* (0.5) and *release energy as a radio wave* (0.5).
6. When the atoms return to the lower energy state, the spins of the hydrogen *atoms become realigned with the magnetic field* (0.5).

Total maximum score:
6 points.

Notes and Penalties:

a. Credit given for stating or showing in an illustration the details listed above, but not necessarily using that exact same wording.
b. In several papers, some of these details were found in the answers to earlier essay questions. Having these details in an earlier answer earned credit for this question.
c. Having a misconception led to a penalty 0.5 points per misconception. That penalty was levied only one time per misconception on each question. A sample misconception would be stating that the magnetic field is turned off (in actuality, the magnetic field remains on for the entire process).

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