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How Slide Design Affects a Student Presenter's Understanding of the Content

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Introduction

Engineering faculty often have their students create presentations about projects as a means to have the students learn the content. For example, many design courses, such as Purdue's EPICS,[1] have student teams demonstrate understanding of the design by making a presentation with slides. A question arises whether the way in which students design their slides significantly affects their understanding of the content.

Theoretically, the way that slides are designed could affect the way that the presenter processes the content of the presentation. For example, slides that follow the assertion-evidence structure, which consists of a succinct sentence headline supported by a relevant image or graphic, call on the presenter to identify the main message of each slide (or scene) of the presentation.[2] In contrast, slides following the typical structure of a phrase headline supported by a list of bullet points do not require such a separation of primary versus secondary details. In addition, in the process of choosing to create visual evidence to convey complex information, the presenter may form more integrated and detailed representations of concepts.[3] For instance, according to Paivio's Principle of Dual Coding, the combination of words and images allows the learner to make connections about a concept that words alone do not.[4]

Many slides created by engineering students (and faculty) do not follow the practices mentioned above. For instance, a 2009 study found that 85% of slides in engineering and science begin with a topic-phrase headline that does not identify the main message of the slide.[5] In addition, that same study found that almost half of the slides do not contain visual evidence.

This paper compares how well engineering students learn and retain technical information by creating slides using the topic-subtopic structure versus how well students learn the same information when using the assertion-evidence (AE) slide structure. We hypothesize that students who create assertion-evidence slides as opposed to common practice slides have a deeper understanding of the complex material.

First, this paper presents the methods for testing our hypothesis. In short, that testing consisted of having 130 engineering students create slides about a technical topic and then later having those students take a comprehension test on the content of that topic. Next, the paper presents an analysis of those results. The results include the types of slides created by the students and the comprehension scores of the students.

Methods

In our study, we assembled two groups of undergraduate engineers to test how creating slides in different formats affects the presenter's comprehension of the material. Each group had more than 50 students.

Task. Both groups read the same article explaining a complex engineering process: magnetic resonance imaging. Afterwards, each student was to create 5 slides describing a technical portion of the process. The slides were to serve a classroom presentation on magnetic resonance imaging, and the audience for this classroom presentation was to be undergraduate engineers. Note that the participants were instructed to create slides that served the projection portion of the classroom presentation (rather than to serve as notes for after the presentation).

While the scripts for both groups were identical, the instructions for each group differed—but only by four sentences. These sentences concerned which slide format to use: assertion-evidence or the slide format of their choice. Each group had sixty minutes to complete their slides. After the students completed their slides, the students were asked to answer how well they knew the MRI process from their past studies. Using a scale of 1-7 with 1 indicating no knowledge of the process, both groups had a similar response of about 2.

The student participants in one group designed slides in the way they best saw fit. As a result, for most of these students, the slides followed the commonly practiced structure of a topic-phrase headline supported by a bulleted list of subtopics.[5] In this topic-subtopic structure, fewer than half of the slides included a graphic. The other group of students created slides following the assertion-evidence structure, which the students were introduced to only minutes prior to reading the article. Figure 1 presents two example slides that students from the topic-subtopic group created on the most complex step of the process: how the gradient magnets work. In contrast, Figure 2 presents an example slide that a student created in the assertion-evidence group on this gradient magnets process.

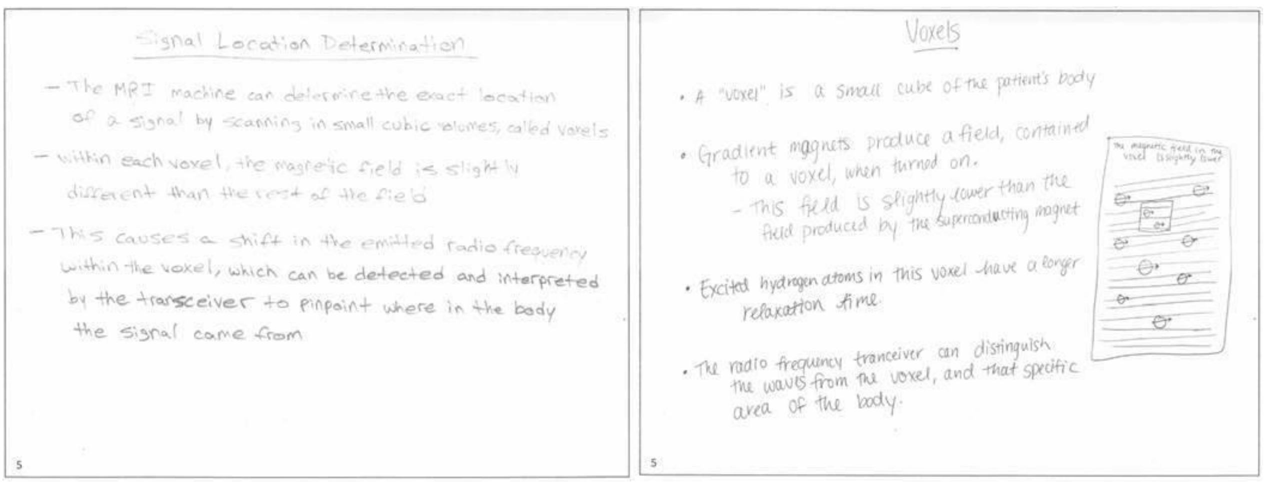


Figure 1: Example topic-subtopic slides from the portion of the script containing the the most complex information in the presentation. The image on the left represents the topic-subtopic slides that consisted only of a topic headline supported by a bulleted list. The image on the right represents the topic-subtopic slides that were created with a topic headline, bulleted list, and relevant image.

Script. The script for this experiment concerned the process of magnetic resonance imaging (MRI) and was based on a script from a previous experiment.[6] Magnetic resonance imagining is a good topic for this study because it involves a series of complex steps, it is an interesting and relevant topic for students to learn about, and most of the students in this study had not yet encountered the process of how MRI machines work in their studies. The script used in the experiment can be found in Appendix A.

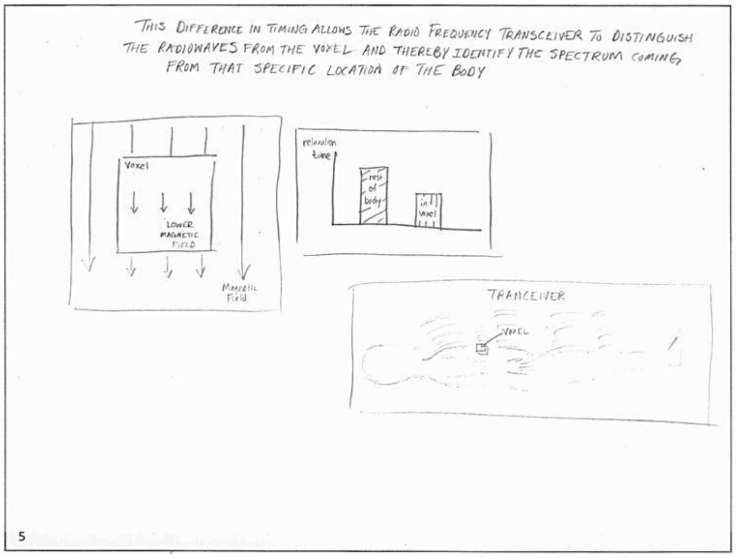


Figure 2: Example assertion-evidence slide from the portion of the script containing the most complex information in the presentation, from the assertion-evidence group. Note the use of a complete sentence headline and supporting images that depict this step in the process.

Means to Analyze Created Slides. To come up with the two categories of slides (assertion-evidence or topic-subtopic), slides from the two groups were analyzed. For instance, we analyzed the headlines to make sure that slide sets chosen for the topic-subtopic group were topic-phrase headlines and slide sets chosen for the assertion-evidence group were sentence headlines. Slide sets that were a mixture of these two headline types were not used. Likewise, the bodies of the slide sets were evaluated. For instance, for the students who were to create assertion-evidence slides, we did not consider students who created bulleted lists. By restricting the comparison to slides that fell into the two categories, we set aside the submissions of only about 10 percent of the overall student participants.

Means to Evaluate Understanding of Content. One day after creating the slides, the students were given an unannounced quiz. This quiz consisted of essay questions about how magnetic resonance imaging works. The essay questions administered to the students can be seen in Appendix B. The first question aimed to show the student's basic understanding of the overall process, while the other questions were developed to allow the student to explain the technical information of the process.

Two raters using the same rubric and blind to which group the essays belonged scored the essays. The rubric, which is located in Appendix C, analyzes 22 different steps or details about the process. Through this scoring, we sought to determine whether statistically significant differences occurred between the comprehension levels of the students from the assertion-evidence group and the comprehension levels of students from the topic-subtopic group.

Results and Discussion

The essay questions tested students on their understanding and retention of both the overall MRI process and the complex steps. An independent t-test revealed that students who created the assertion-evidence (AE) slides scored statistically significantly higher on the total score for the exam questions than those students who created topic-subtopic slides, $t_{(51)} = 2.62$, $p = 0.01$.

Results of the post-essay test are shown in Table 1. As this data shows, the students who created slides using the assertion-evidence method were not only better able to retain the information than those who used topic-subtopic method, but they were also better able to comprehend the material as seen by the lower number of misconceptions. The assertion-evidence group scored an average 12.55 out of 20 on the three questions with an average of .93 misconceptions, while the common practice group scored an average 10.68 out of 20 with an average of 1.12 misconceptions. Another interesting result is the fact that the AE students had a statistically significant higher score than the common practice group on question number three. This finding was revealed using a one-way ANOVA, $F_{(1,52)} = 9.92$, $p < 0.01$. Question three dealt with the most complex and technical part of the MRI process: the gradient magnets. Therefore, by creating AE slides as opposed to topic-subtopic slides, students were better able to understand and remember the most difficult part of a technical process.

One possible reason for the higher scores from the assertion-evidence group is that crafting the slide's main message (the assertion) causes the presenter to develop a deeper understanding of the process. Also, the visual evidence used in the AE method helps a presenter to connect ideas together in a series of pictures, and those pictures aid in the memory of those steps.

Another interesting result shown in Table 1 is the secondary information score. This score represents what relevant information to the process a student was able to recall. From the results, it can be seen that students who used the topic-subtopic method were able to recall more secondary details than those who used the AE method. This result perhaps occurs because topic-subtopic slides typically include many more secondary details than AE slides do because of the bulleted lists. However, even though the topic-subtopic group was marginally better able to remember secondary details, they were not as adept at remembering the concrete steps of the main process.

Conclusions and Recommendations

This experiment has shown that when students create assertion-evidence slides for a technical process they are able to better comprehend and recall that process than if they created topic-subtopic slides. Our results show that the assertion-evidence group scored statistically significant higher on the post-comprehension test. The assertion-evidence group also did not have as many misconceptions as the topic-subtopic group. With both the higher comprehension score and lower number of misconceptions, the assertion-evidence group appears to be a more effective method of slide design for helping student presenters learn the technical content of their presentations.

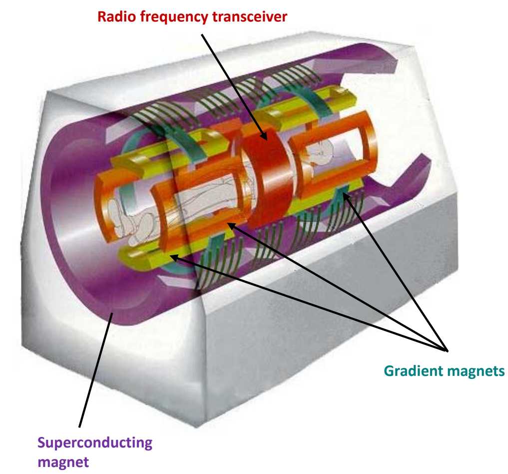
Table 1: Results of Essay Test

Evaluation Factor	Assertion-Evidence Score	Common Practice Score
Average Score on Question 1	5.04 (out of 7)	4.54 (out of 7)
Average Score on Question 2	4.55 (out of 8)	4.16 (out of 8)
Average Score on Question 3	2.96 (out of 5)	1.97* (out of 5)
Average Total Score on All Questions (without misconceptions or relevant secondary information)	12.55 (out of 20)	10.68* (out of 20)
Average Number of Misconceptions	0.93	1.12
Average Score on Relevant Secondary Information	0.19	0.24
Average Total Score (Q1+Q2+Q3) – (Miscon.*.5) + (Score on Secondary Info)	12.28 (out of 20)	10.36* (out of 20)

*** $p<0.05$.**

Appendix A: Script for Test

A magnetic resonance imaging (or MRI) machine has three main technical components. The first is a large superconducting magnet that is turned on before the scanning process begins and remains on for the entire scanning process. The second main component of an MRI machine is the radio frequency transceiver, which can both transmit and receive radio frequency waves during a scan. The third main component of an MRI machine is an array of three gradient magnets that turn on and off many times during the scanning process.



As the name "magnetic resonance imaging" implies, magnets play an important part in an MRI machine. The purpose of the large superconducting magnet is to produce a magnetic field along the patient's body. This magnetic field is extremely strong: on the order of 1.5 Teslas, which is enough to move a car. Because of this strength, patients are not allowed to wear any ferromagnetic material when they enter the room with the machine.

The purpose of the radio frequency transceiver is two-fold. First, it transmits radio frequency waves to the body at a specific frequency. Second it receives radio frequency waves from the body to create an image.

Essentially, the gradient magnets serve to determine the location of radio-frequency waves emanating from the body. The magnets do so by creating a magnetic field in a small volume of the patient's body. This volume, which is called a "voxel," is cube-shaped, with sides as small as 2.5 mm. Although the gradient magnet's field is much smaller than the field of the superconducting magnet (1000 times smaller), it is just large enough to alter the signals from that voxel.

Portion of Script In Which Five Slides Were to Be Created ↓

So how does the magnetic resonance process work to detect cancer in the human body? If you recall from your general chemistry classes, all atoms have a certain "spin." This spin, which is specifically the spin of the protons within the atom, creates an axis through the atom that acts like a vector. Normally, the spins of the atoms within your body point in random directions. However, for a patient placed in the MRI machine, the magnetic field from the large superconducting magnet causes the spins of those atoms to become aligned parallel to the field's direction. Wolfgang Pauli (of the Pauli Exclusion Principle) first identified this spin.

With the patient positioned in the superconducting magnet's field, the transceiver begins sending pulses of radio frequency waves. Typically, the transceiver sends a pulse every 10 microseconds. The transceiver's pulses target a specific type of atom: hydrogen. One reason that hydrogen atoms are targeted is their abundance in the human body. For instance, the human body is more than 55% water, and each molecule of water has two hydrogen atoms. When a radio frequency pulse passes through the body, some of the hydrogen atoms absorb enough energy that they are able to overpower the magnetic field. In other words, the spins of these atoms are no longer aligned with the magnetic field because the atoms have moved to a higher energy state.

During the short time span between each pulse, the excited hydrogen atoms relax back to their original energy state and become realigned with the superconducting magnet's field. In doing so, the atoms return to lower energy states and must release energy. That energy is emitted as radio frequency waves which the radio transceiver can detect. The exact frequency of each released radio frequency wave depends on the type of molecule containing the hydrogen. For instance, a hydrogen atom in a hemoglobin molecule containing oxygen releases a frequency that is slightly different from the frequency of a hydrogen atom in a hemoglobin molecule without oxygen. As you might recall, hemoglobin is important because it carries oxygen from the lungs to the rest of the body.

The transceiver receives many such radio frequency waves from the body. Typically, the most common frequency emitted is about 64 MHz. All these radio frequency waves combine to form a spectrum for each type of tissue. The shape of the spectrum depends on the types and numbers of emitting molecules in that tissue. For instance, the spectrum emitted from bone would be different from the spectrum emitted from an internal organ. A cancerous tumor would emit a spectrum that is different from both of these. Interestingly, an additional 7-minute step in the MRI process can distinguish a malignant tumor from a benign tumor.

So how does the MRI exactly know where in the body the different radio frequency waves come from? Here is where the gradient magnets come in. As mentioned, when the gradient magnets turn on, they produce a field in one small cube, or voxel, of the patient's body. In effect, the magnetic field in this voxel is slightly, but distinctly, lower than the field in the rest of the body. For that reason, the relaxation time of the excited hydrogen atoms in the voxel is slightly longer than the relaxation times in the rest of the body. This difference in timing allows the radio frequency transceiver to distinguish the radio waves from the voxel and thereby identify the spectrum coming from that specific location of the body.

Portion of Script in Which Five Slides Were to Be Created ↑

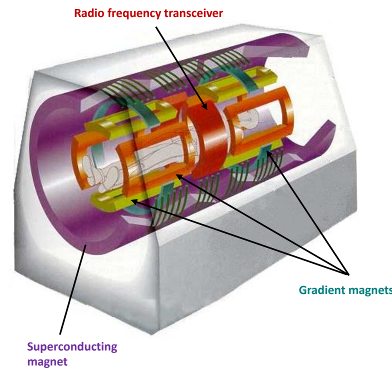
After the resonance imaging process has occurred in one voxel, the gradient magnets turn on again, but now shift their magnetic field to a second voxel. The resonance imaging process then occurs in that second small volume. This detection process occurs from one voxel to the next across a slice of the patient's body being scanned. Typically, the mapping of the voxels across a slice takes about 5 minutes. Because the image of the slice is not complete until all voxels in that slice have been scanned, the patient has to remain still. Otherwise, the image is blurred.

In scanning a slice, the gradient magnets rapidly turn on and turn off in each voxel across that slice. For those who have had an MRI scan, this rapid turning on and off by the gradient magnets is what causes the loud noises that accompany an MRI scan. In essence, the noises arise from electrical current expanding and contracting the gradient coils at a rapid rate. Once one slice is scanned, the MRI machine adjusts to begin scanning a second slice. These image slices can then be stacked to create a three-dimensional image for that particular part of the body.

The clarity and sharpness of MRI images allow physicians to identify cancerous tumors when they are small. Identifying such tumors when they are small (often less than 10 mm in diameter) is important, because that is when the cancer is in its early stages and can be treated more effectively.

Appendix B: Comprehension Test

In the space below, answer the given questions about how magnetic resonance imaging (MRI) produces three-dimensional images to detect cancerous tumors. Do *not* worry if overlap occurs in your first three answers. Please write in complete sentences. Feel free to include images.



Question I: What are the roles of the three main components of an MRI machine?

More space for answer given in actual test.

Question II: In the MRI process, what occurs at the atomic and molecular level within the human body? In your answer, use numbered steps, but do not hesitate to provide images and additional sentences to explain each step.

More space for answer given in actual test.

Question III: How is a MRI machine able to tell what type of tissue (tumor versus bone, for instance) is being scanned and how does the MRI machine know the location of this tissue?

More space for answer given in actual test.

Question IV: What additional information do you remember about the process of how an MRI detects cancerous tumors in the human body?

More space for answer given in actual test.

Appendix C: Score Sheet for MRI Essay Questions

	Items	Pts	Misconceptions	Secondary
1A	Superconducting magnets …produce a ***strong*** **magnetic field**	1.0		
1B	…**that aligns** ***the spins*** of all the atoms (protons)	1.5		
1C	Radio frequency transceiver **transmits** *radiofrequency (rf)* waves *to body*	1.25		
1D	…**receives** rf waves *from body*	1.25		
1E	Gradient magnets provide a **magnetic field**	1.0		
1F	to **small volume** ***called a voxel***	1.0		
	Subtotal for 1 (max = 7.0)		Subtotal	Subtotal
2A	Normally **the spins of atoms point in random directions**	1.0		
2B	**…atoms align with superconducting magnetic field**	1.0		
2C	**Transceiver sends pulses of RF waves that** ***target hydrogen atoms***	1.0		
2D	**S**ome of these	0.5		
2E	…atoms move to a **higher energy** state	0.5		
2F	The spins of these **atoms become unaligned with the magnetic field**	1.0		
2G	**After pulse ceases,** ***the hydrogen atoms*** **(that gained energy) return to their original state**	1.5		
2H	…**realign with the main magnetic field,**	0.5		
2I	…and **release energy in the form of a radio wave**	1.0		
	Subtotal for 2 (max = 8.0)		Subtotal	Subtotal
3A	Each kind of hydrogen molecule emits a different frequency	0.5		
B	Each type of tissue consists of different types *and numbers* of molecules	0.5		
C	**The spectrum of each tissue is unique**	1.0		

D	**The location is determined by the use of the gradient magnets**	1.0		
E	Gradient magnets alter the field in the voxel (or in the small volume)	0.5		
F	**…causing the timing of the release of energy from molecules within the voxel**	0.75		
G	**…to be delayed from the timing of the release of energy from rest of body**	0.75		
	Subtotal for 3 (maximum = 5.0)		Subtotal	Subtotal
	Total (maximum = 20)		Total	Total
4A	MRI can do 7 minute process to see if tumor is cancerous			
B	After first voxel scanned, gradient magnets shift to create a second voxel which is then scanned			
C	This process occurs across a slice			
D	Slices stack up to for a 3D image			
	Total			
	Total score – misconception score =			Total =

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