Michael Alley

The Craft of Scientific Presentations

Critical Steps to Succeed and Critical Errors to Avoid

Second Edition

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Cover Photo by Victoria Fryer: Bria Mattox, a mechanical engineering student from the University of Alabama, making a presentation for the Engineering Ambassadors (engineeringambassadors.org), which recruits talented middle and high school students across the United States into engineering. For their talks, the Engineering Ambassadors, as well as a growing number of respected scientists and engineers around the world, use the assertion-evidence approach and other presentation strategies developed by the author and explained in this book.

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To the memory of
Harry H. Robertshaw—
mentor, colleague,
and
much missed friend

Preface

> *On March 21, 1949, I attended a lecture given by Linus Pauling.... That talk was the best talk by anyone on any subject that I had ever heard…. The talk was more than a talk to me. It filled me with a desire of my own to become a speaker.*[1]
>
> –Isaac Asimov

At the first stop of a tour in Japan, Albert Einstein gave a scientific presentation that, with the accompanying translation, lasted four hours. Although his audience appeared to be attentive the entire time, Einstein worried about their comfort and decided to pare back the presentation for the next stop on his tour. At the end of the second presentation, which lasted two and a half hours, the crowd did an unusual thing in Japanese culture, particularly in that era. They complained. For Einstein, though, the complaint was a compliment—this crowd had wanted him to deliver the longer version.[2]

When was the last time that you sat through two and a half hours of a scientific presentation and wished that it would go longer? Unfortunately, such responses to scientific presentations are rare. Granted, Einstein was a brilliant scientist, but just because one is a brilliant scientist or engineer does not mean that one is an engaging presenter. Consider Niels Bohr, the great physicist who won a Nobel Prize for his proposed structure of the hydrogen atom. Despite being an inspiration for many physicists,[3] Bohr had difficulty communicating to less technical audiences. For example, his open series of lectures in the Boston area drew progressively fewer and fewer attendees because "the microphone was erratic, Bohr's aspirated and sibilant diction mostly incomprehensible and his thoughts too intricately evolved even for those who could hear."[4]

So what is needed to make an excellent scientific presentation? This book addresses that question, but does so with the recognition that the styles of excellent scientific presentations vary. For instance, the delivery of Albert Einstein was humble and soft-spoken, while Linus Pauling's delivery was charismatic. Just because different presentation styles achieve success does not mean that any style is acceptable. For every truly excellent presentation in engineering or science, ten weak presentations take place that leave audiences bored, confused, or exasperated.

One common failing of scientific presentations is that the presenter states too many unnecessary details about the work. What often results then is that the audiences walk away from the talk without appreciating the main takeaways. Another common failing is that many presenters show a host of slides that follow the defaults of Microsoft's PowerPoint program, but that do not help the audience understand or remember the content. For instance, most of these slides lack focus because they begin with topic-phrase headlines such as "Background" that neither communicate much to the audience *during* the talk nor compel the speaker to grapple with the main assertion of that scene *before* the talk. Equally weak, those headlines are supported by subtopics presented in bulleted lists, which are inherently weak at showing connections. Worse yet, with these bulleted lists, many speakers adopt a mind-numbing delivery style in which they continually turn to refer to each listed item.

So how should scientists, engineers, and technical professionals present their work? Given the diversity of audiences, occasions, and topics, establishing a set of rules for how to give a strong scientific presentation is difficult. For that reason, most rules that do exist, such as *tell them what you're going to tell them, tell them, and then tell them what you told them,* have exceptions. This often quoted strategy, for instance, does not fare well with audience members who are strongly biased against the results.

Moreover, other guidelines for presentation slides, such as the often cited 6-by-6 rule, have *no* basis in research and, as this text will show, contradict what we know about how people learn.

Rather than state simplistic rules, this book grounds its advice in the traits of excellent scientific presenters. Included are those widely recognized as excellent presenters: Richard Feynman, Jane Goodall, Brian Cox, and Jill Bolte Taylor. In addition, the book presents the experiences of other scientific presenters, such as Heinrich Hertz, J. Robert Oppenheimer, and Chien-Shiung Wu, whose initial presentations were weak, but who became strong presenters later in their careers.

In addition to examining the styles of successful presenters, this book considers what causes so many scientific presentations to flounder. To this end, this book considers 13 critical errors that undermine scientific presentations at conferences, lectures, and technical meetings. Some errors such as a speaker losing composure (Critical Error 13) are weaknesses that everyone recognizes as errors. Other errors, such as trying to cover too much (Critical Error 3), are more subtle.

A third major contribution of this book is that it proposes a strong alternative to the commonly used, but inherently weak, topic-subtopic structure of PowerPoint. Instead of calling for slides to be built with phrase headlines supported by bulleted subtopics, this book recommends that slides conveying technical information be built with succinct sentence assertions supported by visual evidence. As this book shows, the assertion-evidence approach leads to more informative, memorable, and persuasive presentations. This book not only shows you results from recent tests that reveal the efficacy of the assertion-evidence structure, but also provides you with an array of examples to help you present your work with this slide structure.

By showing you the differences between strong and weak presentations, by identifying for you the errors that presenters typically make, and by teaching you a much more powerful slide structure for scientific presentations than what is commonly practiced, this book places you in a position to elevate your presentations to a high level. In essence, this book aims to have you not just succeed in your scientific presentations, but excel.

University Park, PA Michael Alley

Notes

[1]I. Asimov, Foreword, in *Linus Pauling: A Man and His Science*, Anthony Serafini (toExcel, San Jose, 2000), p. xiv

[2]M. White, J. Gribbin, *Einstein: A Life in Science* (Penguin, New York, 1995), pp. 164–165

[3]R. Sime, *Lise Meitner: A Life in Physics* (University of California Press, Berkeley, 1996), pp. 96–97

[4]D.H. Frisch, private communication to Abraham Pais, Reminiscences from the Postwar Years, in *Niels Bohr: A Centenary Volume*, ed. by A.P. French, P.J. Kennedy (Harvard University Press, Cambridge, 1985), p. 247

Acknowledgments

This book is dedicated to Harry H. Robertshaw, a professor of mechanical engineering at Virginia Tech, who was my mentor, colleague, and close friend. In the early 2000, when my ideas about slide design appeared too radical to be adopted, Harry stood by me. Harry is deeply interwoven in this book—both in the ideas and the spirit.

Also deeply interwoven into this text is my wife, Karen Thole, who is the Department Head of Mechanical and Nuclear Engineering at Penn State. Karen has not only provided me with excellent ideas and honest critiques, but she has helped spread the ideas of this text through her army of graduate students.

Often, this book mentions "our teaching." Such references are to the professional workshops and university classes taught by me and my colleague Melissa Marshall, who is a communication expert at Penn State. Through our teaching, Melissa and I have put the ideas of this book before diverse scientific audiences—from Tromsø, Norway, to Santiago, Chile, from Seoul in the East to San Francisco in the West. Our goal is not just to have our students meet the status quo—our goal is to empower our students such that they set the bar. Also helping teach our professional workshops are Christine Haas and Genevieve Brown. In addition, helping us teach our university classes at Penn State are Lori Miraldi and Veena Raman. All four are valuable members of our team.

Also, this book often mentions "our research." Integral to this research over the past five years has been Joanna Garner from Old Dominion University. Joanna's expertise in educational psychology has connected our slide design work to the theories of multimedia learning and cognitive overload. Also contributing to this work have been my research students Keri Wolfe, Lauren Sawarynski, Shannon Aippersbach, and Allen Gaudelli. Without their energy and careful work, the experiments presented in this book would not have been possible.

Still other collaborators have made valuable contributions on the research: Thomas Litzinger and Sarah Zappe, from the Leonhard Center at Penn State; Madeline Schreiber and Maura Borrego from Virginia Tech; Kay Neeley from the University of Virginia; and Leslie Crowley from the University of Illinois.

As mentioned, many valuable insights have arisen from teaching the ideas of this book to professional audiences. Such institutions include Harvard Medical School, Lawrence Berkeley Lab, Los Alamos Lab, MIT, Rose-Hulman, Sandia National Labs, Shanghai Jiao Tong University, and Seoul National University. No institution, though, has provided more insights than Simula Research Laboratory. In 2003, Are Magnus Bruaset and Hans Petter Lantangen invited me to Norway to teach their post-docs and graduate students and have invited me to teach at Simula almost every year since.

For their stories and insights, I must thank my father who served for a number of years as plant manager of Pantex, my mother who is an organic chemist, my brother-in-law Scott Dorner who is a computer scientist, Dan Inman from the University of Michigan, Kenneth Ball from George Mason University, Patrick McMurtry from the University of Utah, and Patricia N. Smith of Sandia National Laboratories.

Providing me with much encouragement through the years have been other colleagues: Christene Moore, Hillary Hart, and D'Arcy Randall from the University of Texas; Mary Karsada from Virginia Tech; Alberto Pérez Izquierdo from the University of Seville; Rob Milner from the University of Massachusetts Medical School; Michael West from the European Space Organization; Rick Gilbert from PowerSpeaking; Traci Nathans-Kelly and Christine Nicometo from the University of Wisconsin; Barbara Bekins from the United States Geological

Survey; and the film director Ron Galloway. Also, special thanks go to my editors at Springer-Verlag New York. *Vielen Dank.*

Finally, I must thank my students and workshop participants who showed the courage to adopt the ideas of this book that often went against the practices of their institutions. Almost all of you confronted skepticism and criticism from managers and colleagues because you challenged the status quo. Despite that resistance, many of you persevered with your efforts and won over audiences with presentations that were informative, memorable, and persuasive. In this book, your experiences appear in many of the examples. Others of you had your attempts thwarted by managers and colleagues who could not see beyond the mind numbing, bullet-ridden common practice. Your experiences also greatly shaped this book by compelling me to refine the ideas and hone the arguments.

Contents

Chapter 1

Introduction

> *It was very long ago when Richard Feynman had felt nervous at having to give a seminar.... Since then he had developed into an accomplished and inspiring teacher and lecturer, who gave virtuoso performances full of showmanship, humor, with his own inimitable brilliance, style, and manner.*[1]
>
> –Jagdish Mehra

In terms of hours spent, scientific presentations are costly. Even for presentations given on site, the audience members devote valuable time to attend, and the speakers give up valuable time to prepare and deliver. For presentations that require travel, the costs rise dramatically.

Although expensive, scientific presentations are important. The information communicated in presentations is often only a few days old, sometimes only a few hours old. Conversely, the information in a professional journal at publication is typically a few months old. For some areas of science and engineering, advances occur so often that scientists and engineers cannot wait for a publication cycle to learn the latest news. For instance, at Pratt & Whitney, the principal means of communicating new advances about gas turbine engines is not documents, but presentations.[2] There, laboratory and computational results are sometimes directly incorporated into new engine designs.

The way that you present your work can significantly affect your career. Consider the case of the physicist Paul Chu who was searching for a superconductor at a temperature above the boiling point of liquid nitrogen. To help him in this search, Chu brought in his former student, Professor Maw-Kuen Wu of the University of Alabama-Huntsville. Chu, who was a professor at the University of Houston, had already identified a host

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of compounds that offered promise to be such a superconductor, but he needed help testing those compounds.

When Wu and his graduate student Jim Ashburn discovered that one of those compounds was a superconductor, they contacted Chu, and the three held a press conference in Houston. Chu, being the best speaker and the leader of the team, spoke at the news conference that announced the finding. Although Chu clearly acknowledged Wu and Ashburn's contribution at the news conference, the press latched onto Chu's name. In many of the newspaper and journal articles about the discovery, Chu's name was the only one mentioned.[3]

Interestingly, an even more dramatic scenario played out a year later in the same field when Zhengzhi Sheng, a postdoctoral researcher at the University of Arkansas, discovered another superconductor at an even higher temperature. Because Sheng was not a good speaker, the department chair, Allen Hermann, spoke at the press conference. Although Hermann repeatedly acknowledged the contribution of Sheng, Hermann was the one who received most of the accolades, even though all of the scientific work was clearly Sheng's.[4]

Even more important than the credit that we as individuals receive from a presentation is the understanding that we collectively as scientists, engineers, and technical professionals impart to our audiences. If we do not present our work effectively to specialists both in our field and in other fields, then those scientists and engineers will not likely build upon our work. Likewise, if we cannot communicate our work to managers, then those managers likely will not make sound decisions about our work for the institution.

Finally, if we cannot effectively present our work to the general public, including politicians, then those people will not be in a good position to use our work in their decisions. Politicians, in particular, are an important audience, because they create legislation that addresses complex problems in energy, health, security, and the environment. Although these problems and their solutions are grounded in scientific principles, few politicians have backgrounds in science or engineering. Of the current 535 members of the United States Congress, fewer than 10 were educated in science or engineering. For these politicians to make sound decisions that concern science and engineering, we must communicate our work to them.

Excellent scientific presentations are marked by content, passion, and a keen sense of the audience

Stricken with amyotrophic lateral sclerosis at age 21, the Nobel-Prize winning physicist Stephen Hawking has been unable to follow the standard presentation advice for voice, stance, and movements. Yet Stephen Hawking fills auditoriums whenever he speaks, and the main reason is his content. What Hawking has to say is well worth the time that the audience spends listening.

Now you might consider it unnecessary to list valuable content as an essential trait of an excellent scientific presentation. However, many scientific presenters routinely sacrifice content in their presentations by burying key findings in a sea of extraneous details or on busy slides with ornate decorations. For a scientific presentation to excel, the audience has to understand, believe, and remember the content. Simply put, content is king in scientific presentations and must not be sacrificed.

If valuable content is the first trait of an excellent scientific presentation, then communicating that content with passion is the second. Personifying this trait is Hans Rosling, a professor of global health at Sweden's Karolinska Institute. Rosling is a mesmerizing speaker, and perhaps what is most engaging about him is his passion for his work.[5]

Now, not all of us reveal our passion for our subjects with the same exuberance that Hans Rosling shows, and it would be disingenuous if we tried. Moreover, when presenting an idea that cuts against the grain of what audiences believe, even the most charismatic presenter will soften the voice and adopt a quiet, but earnest, delivery. Despite this change in delivery, the sincere passion that the speaker has for the subject is clear.

Although not all of us will reveal our passion with the charisma of a Hans Rosling, all of us can reveal genuine enthusiasm for our work. In fact, we have to, because if we do not show the audience that we care about the subject, then how can we expect our audience to care, especially when the content becomes challenging to understand?

The third essential trait of an excellent scientific presentation is a keen awareness by the presenter of the audience: who they are, what they know about the work, why they are listening, and what preconceptions they have. An exemplar for this trait is Jane Goodall. Whether she is giving a paper in London, speaking to potential donors in Nebraska, teaching school children in Singapore, or negotiating with tribal chiefs in Tanzania, Jane Goodall has an acute sense of to whom she is speaking. Without a keen sense of the audience, even a dynamic speaker with valuable content is prone to miss the mark. Achieving this keen sense of audience is not easy. In fact, most of this book is devoted to achieving this goal.

If we have content that is worth the attention of the audience, if we reveal our passion for that content, and if we have a keen sense of what our audience knows about that content and what about the content will engage them, then we are in position to excel in our presentations. The rest of the details such as organizing our thoughts, choosing the words to say, creating effective visual aids, and delivering are a matter of effort.

When speaking, you should seize upon the advantages of presentations and downplay the disadvantages

Before deciding how to make a scientific presentation, a good first question to ask is, Why not just write a document? Depending on the situation, writing a document or creating a web page might be a better way to deliver the information. Even when we are already committed to make a presentation, understanding the advantages and disadvantages of a presentation in relation to a document is valuable so that we can seize upon the advantages and downplay the disadvantages.

1. Presentations allow speakers the chance to field questions from the audience. In a document, the author imagines what the audience needs and then writes accordingly. For instance, the author selects the concepts to be covered and then imagines what background and depth are needed to convey those concepts. In a presentation, though, the speaker does the same selection beforehand, but can adjust the presentation during the performance to respond to cues from the audience.

Certainly one cue given by the audience would be questions. From the questions posed by the audience, the speaker can essentially revise the scope and depth of the original presentation. A key here is that the speaker allots time for questions. In many cases, particularly in shorter presentations, the audience is best served by delaying questions to the end. However, in other talks, allowing questions to be posed throughout serves the audience better.

2. Presentations allow speakers the chance to read audience expressions. During a presentation, the audience continually sends the speaker non-verbal cues such as facial expressions for agreement, understanding, confusion, boredom, or disagreement. To make use of these cues, a key here is for the speaker to be watching the audience during the talk and to be flexible enough to make needed adjustments. During a presentation to mathematicians, Patrick McMurtry, a fluid mechanics researcher from the University of Utah, noticed from the blank looks of his listeners that they did not understand the term "laminar flow." McMurtry asked to borrow someone's lighter, clicked it on, and gave the audience an example. The smoke just above the flame rose in distinct streamlines. Such a flow was laminar. However, well above the flame, these streamlines of smoke overlapped in random turns and curls. Such a flow was turbulent. Because understanding the difference between laminar flow and turbulent flow was crucial to understanding the work, McMurtry salvaged the presentation with this on-the-spot revision.[6]

3. A presentation's delivery is a means to emphasize key points. In a document, a writer can use repetition, placement, and formatting for emphasis. A presentation, though, not only allows for those strategies in the talk's organization and visual aids, but also allows for strategies from a perspective that documents do not have: delivery. For instance, a speaker can pause before an important point. Also, for effect, a speaker can speak more loudly or reduce the voice to a whisper. Moreover, a speaker can provide additional emphasis by gesturing or moving closer to the audience.

4. Presentations offer more variety for visual aids. So far, the advantages of a presentation have centered on the interaction of the speaker with the audience. A different type of advantage of making a presentation concerns the visuals aids that one can use in a presentation. Essentially, a printed document is limited to an illustration that fits on a page. However, a presentation can incorporate not only the still images of a document, but also the sequential images of a film. Moreover, a presentation can incorporate color into those images more easily and less expensively than a document can. In addition, the presenter can include demonstrations and models, which not only allow the audience to see the work, but sometimes allow the audience to hear, touch, smell, and even taste the work.

5. Presentations ensure that the audience has witnessed the information. A fifth advantage of a presentation is of a legal nature. With some presentations, such as the evacuation procedures for a tall building, the presenter might want to ensure that the audience members have witnessed the information. For such a presentation, the presenter can have the audience sign in when entering the room. This arrangement has advantages over a document, which might lie unopened.

Perhaps a better way to view the advantages of presentations is to imagine a world in which they do not exist. Such was the world of Lise Meitner when she worked at Berlin's chemistry institute in the early part of the twentieth century. Because of rules forbidding women to participate, she was not allowed to attend the chemistry seminars. Meitner, who later helped discover nuclear fission, had such a strong desire to learn chemistry that she sometimes sneaked upstairs into the institute's amphitheater and hid among the tiers of seats to listen.[7] Almost 30 years later, a parallel situation existed at Oxford for Dorothy Crowfoot Hodgkin, who later won a Nobel Prize in Chemistry for discovering the structure of insulin. The chemistry club at Oxford did not permit women, even if they were on the faculty, to attend meetings. Unable to interact with others in this way, Hodgkin had difficulty attracting students until a student organization invited her to speak.[8]

Although presentations have several advantages over documents, they also have several disadvantages, as shown in Table 1-1. Understanding the disadvantages of presentations is as important as recognizing the advantages.

Table 1-1. Advantages and disadvantages of making a presentation.

Advantages	Disadvantages
1. Chance to field questions from audience	1. One chance for speaker to talk; one chance for audience to hear
2. Chance to read expressions of audience	2. Difficult for the audience to look up background information
3. Chance to use delivery to emphasize key points	3. Audience restricted to pace of speaker
4. Ability to incorporate many types of visual aids	4. Success dependent on speaker's ability to deliver
5. Assurance that audience has witnessed the content	5. Difficulty in assembling speaker and audience

1. Presentations offer speakers only one chance to speak correctly and allow audiences only one chance to hear. In a document, you have the opportunity to revise a document. However, in a presentation, you have only one chance to say things correctly. Simply forgetting a word from a sentence in a presentation can trip an audience, especially if that word is important—the word *not*, for example.

Likewise, if the presentation triggers an idea for someone in the audience and that someone contemplates that idea for a few moments during the presentation, then that person misses what the speaker has said during those moments. A document, on the other hand, allows readers the chance to review a passage as many times as needed.

2. Presentations do not allow audiences time to look up background information. If in a presentation the speaker uses an unfamiliar word, such as *remanence*, and does not define the word, then the audience is stuck. If the presentation's format does not allow for questions until the presentation's end, then members of the audience sit frustrated wondering what *remanence* means. With a document, though, the reader has the chance to look up *remanence*, which is the residual magnetic flux density in a substance when the magnetic field strength returns to zero.

3. Presentation audiences are held captive to the pace of the speaker. Unlike the pace of a document, which an audience controls by reading as slowly as is needed for understanding, the pace of a presentation is determined by the speaker. If the presenter goes too quickly for the audience, the audience becomes lost. Likewise, if the presenter goes too slowly for the audience, the audience becomes bored.

4. The success of a presentation depends upon the delivery of the speaker. A poor delivery can make a presentation appear weaker than it actually is. If the speaker is so nervous that he or she cannot communicate the ideas to the audience, the presentation will not succeed. Other aspects of delivery can also bring down a talk. Niels Bohr, for instance, undermined his content with a voice full of hesitant pauses and distracting hisses that made it difficult for audiences to understand him.[9] An exceptional delivery, on the other hand, can have the opposite effect. Linus Pauling, for instance, had the charisma to make a presentation appear stronger than perhaps it actually was.

5. The audiences for a presentation can be difficult to assemble. A final disadvantage of presentations is one of timing: how to gather everyone at a particular time to attend the presentation. Granted, teleconferencing can often overcome this problem, but even with the best connections, the energy during a videoconference does not rival that of a performance in the same room. Video recording is even less effective, because video recording loses one of the main advantages of presentations—namely, the interaction with the audience.

Another issue with timing is the attention span of the audience. Although some people can listen attentively for long periods, many people become tired and restless after only 20 minutes. When the technical subject is complex and deep, the task of communicating that subject solely with a presentation becomes difficult.

So far, this discussion has centered on the effects of presentations upon the audience. What about the effects of presentations on the speaker? Certainly, one positive effect on the speaker is that when fielding questions from different audiences, the speaker can obtain new perspectives and ideas about the work. Those new perspectives often occur when the audiences come from different disciplines. A second positive effect on the speaker occurs during the preparation of a presentation. As with writing a scientific document, preparing a scientific presentation can help solidify one's ideas and even lead to new insights. For instance, Richard P. Feynman claimed to have experienced such moments of discovery.[10]

As this book will explain, the focus and insights that one obtains in preparing a presentation depend greatly on the approach that one adopts. For example, the common approach is for the speaker to list the topics and subtopics of the presentation. A different strategy is the assertion–evidence approach, which calls on the speaker first to specify the assertions, insights, or results that he or she wants the audience to take away from the talk. Then the speaker matches those assertions, insights, and results with the evidence that the speaker has. As this book will show, the assertion–evidence approach, although more time-consuming, leads to presentations that are not only much more persuasive, but also much more focused.

Analyzing presentations from different stylistic perspectives is important to improving your presentations

When critiquing the presentation of a colleague or even yourself, you will make that critique much more valuable by analyzing the talk from different stylistic perspectives: speech, structure, visual aids, and delivery.

Speech, a first perspective of style, is what you say in a presentation. Structure then is a second perspective that encompasses the organization, transitions, depth, and emphasis of those words. A third perspective of style in presentations is visual aids. While visual aids include projected slides, models, writing boards, films, and demonstrations, this book focuses on projected slides, because that is currently the visual aid of choice for most meetings, conferences, and classrooms. Presentation slides receive much emphasis in this text because slides affect not only the audience's comprehension of the content, but also the speaker's preparation and delivery. The final perspective of style is delivery, which is your interaction with the audience and the room.

In presenting these four perspectives, this book anchors its advice with scores of examples gathered from conferences, symposia, and meetings. In essence, this book pursues a similar study to the one that Michael Faraday undertook as a young scientist when he examined the different styles of presenters.[11] As with Faraday's study, this book's study seeks to determine what makes one scientific presentation strong and what makes another weak.

Many of the examples chosen are from famous engineers and scientists. Some of these are considered excellent presenters, while others are not. Certainly, such characterizations are inherently imprecise. For one thing, not everyone is an excellent presenter every single day. In your career, you are likely to have at least a few presentations that are not well received. Also, some individuals, such as Maria Goeppert Mayer, were excellent presenters in front of colleagues and friends, but shy and stiff in front of strangers.[12] Moreover, not everyone is in agreement about who was an excellent presenter and who was not. For example, the opinions about the presentation skills of the engineer Willard Gibbs varied widely.[13] Having a wide variety of opinions about the effectiveness of a presenter is not uncommon–to see such a spread, one simply has to read a set of teaching evaluations from a large course.

Although the circumstances and variety of opinions make it difficult to draw conclusions about the effectiveness of many historical presentations, the effectiveness of other past presentations is clear. For instance, Richard Feynman's lecture series on freshman physics at Caltech received so many glowing reviews and had such a profound effect on so many people that this series was undoubtedly a success.

While analyzing presentations from these four stylistic perspectives is valuable, such discussions can skew the overall effect of a presentation. After all, a presentation that has weak slides might be strong enough in the delivery that the overall effect is positive. Still, if any of these areas is so weak that it distracts the audience from the content of the presentation, then the presentation has not reached its potential.

One perspective of presentations not considered in this book is content. An assumption in this book is that the technical content of the presentation is worthwhile. Otherwise, the logic of the structure, the clarity of the speech and visual aids, and the smoothness of the delivery are moot, because without content the presentation is doomed.

Interestingly, in engineering and science, there exists a deep-seated distrust of a noticeable style, what many refer to as "glitz." Certainly, style without content reduces to entertainment. If you are going to dazzle the audience with only one aspect in a scientific presentation, you should do so with your content (your ideas, insights, findings, and conclusions) rather than with your style (the way that you present that content). However, that is not to say that style is unimportant–quite the contrary. Style is the vehicle for communicating the content. Presentations without attention to style often leave little of value in their wake. Granted, the content has been presented, but not in such a way that the audience understands it or realizes its importance. Strong presentations require both content and style. Content without style goes unnoticed, and style without content has no meaning.

Notes

[1] J. Mehra, *The Beat of a Different Drum* (Clarendon Press, Oxford, 1994), p. 482

[2] A. Kohli, engineer a United Technologies Corporation, Pratt & Whitney, personal communication to author, 4 Dec 2000

[3] R. Pool, Superconductor credits bypass Alabama. Science **241**, 655–657 (1988)

[4] R. Pool, Feud flares over thallium superconductor. Science **247**, 1029 (1990)

[5] H. Rosling, New insights on poverty. Presentation at TED.com, Monterey, Mar 2007

[6] P. McMurtry, Professor of Mechanical Engineering at the University of Utah, personal communication to author, Mar 1988

[7] S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 37

[8] Ibid., p. 236

[9] D.H. Frisch, private communication to Abraham Pais, Reminiscences from the Postwar Years, in *Niels Bohr*: *A Centenary Volume*, ed. by A.P. French, P.J. Kennedy (Harvard University Press, Cambridge, 1985), p. 247

[10]R.P. Feynman, *Surely, You're Joking, Mr. Feynman*! (Norton & Company, New York, 1985), p. 166

[11]M. Faraday, letter to Benjamin Abbott on 11 June 1813, *The Selected Correspondence of Michael Faraday*, ed. by L.P. Williams, R. Fitzgerald, O. Stallybrass (Cambridge University Press, Cambridge, 1971), pp. 60–61

[12]S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 181

[13]M. Rukeyser, *Willard Gibbs* (Doubleday, New York, 1942), p. 320

Chapter 2

Speech: The Words You Say

Desperately eager to reach his students, his sensitivities sharpened by his own past difficulties, Oppenheimer made it a point to pay as much attention to the troubles of his charges as to the intricacies of his subject. His language evolved into an oddly eloquent mixture of erudite phrases and pithy slang, and he learned to exploit the extraordinary talent for elucidating complex technical matters.[1]

–Daniel J. Kelves

Simply put, speech is what you say in a presentation. A speech targeted to the audience is essential for a presentation's success. Consider J. Robert Oppenheimer's early lectures given at California-Berkeley in 1929. Only 25 years old, but already well known for his work on the quantum theory, Oppenheimer began his teaching that first semester with a class full of eager graduate students. Halfway through the semester, though, the number of students registered for his course had dropped to one.[2]

The principal reason that students dropped the course was that Oppenheimer did not target them in his speech. For one thing, Oppenheimer's pace was much too fast for the students. Interestingly, although the students considered the pace to be much too fast, Oppenheimer felt that it was too slow.[3] Another problem with Oppenheimer's speech was that he made "obscure references to the classics of literature and philosophy."[4] The combination of these two problems caused many of the students to complain to the head of the department. However, Oppenheimer was already aware of the problems

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and worked hard to slow his pace, to clarify his ideas, and to make connections between his points. The result was that Oppenheimer's later students found him to be "the most stimulating lecturer they had experienced."[5]

One important element of speech that Oppenheimer failed to achieve in his early lectures was the matching of what was said to the audience, purpose, and occasion. When this match does not occur, one essentially gives the wrong speech. Another important aspect of speech with which many scientists and engineers struggle involves finding the words that communicate the work in an engaging manner. Put another way, a scientific presenter faces the challenge of not only presenting the work in a precise and clear manner, but also presenting the work in a way that maintains the audience's attention. After all, if the audience drifts off, then no communication occurs.

Notes

[1] D.J. Kelves, *The Physicists* (Knopf, New York, 1978), p. 218

[2] P. Goodchild, *J. Robert Oppenheimer* (Houghton Mifflin Company, Boston, 1981), p. 25

[3] N.P. Davis, *Lawrence and Oppenheimer* (Simon & Schuster, New York, 1968), p. 27

[4] D.J. Kelves, *The Physicists* (Knopf, New York, 1978), p. 218

[5] P. Goodchild, *J. Robert Oppenheimer* (Houghton Mifflin Company, Boston, 1981), p. 25

Critical Error 1
Giving the Wrong Speech

Rutherford, though always inspiring, was not a great lecturer—"To 'Er' was Rutherford!" Bohr was much worse. His failing was that he used too many words to express any idea, wandering about as he spoke, often inaudibly.[1]

–Sir Mark Oliphant

On January 27, 1986, because of the low temperatures expected for the next morning's launch of the space shuttle *Challenger*, engineers at Morton Thiokol requested a delay in the launch. From their examinations of previous launches, the engineers believed that the lower the launch temperature, the more likely that explosive gases from the solid booster rockets would escape. In an afternoon meeting, these engineers succeeded in persuading management at Morton Thiokol to request a delay. However, when Morton Thiokol's engineers and management discussed the delay with NASA during a teleconference that evening, they met strong resistance.[2] After spending almost 2 hours in a conference call and reviewing 13 presentation slides faxed from Morton Thiokol, NASA remained unconvinced of the danger. Moreover, NASA's opposition to the delay was so adamant that Morton Thiokol's management rescinded the request.

The next day, 63 seconds into the launch, a solid rocket booster of the space shuttle *Challenger* exploded, killing all seven crew members on board.

One reason that Morton Thiokol's presentation failed to persuade NASA was that the presentation did not target the audience. For instance, in their presentation, the engineers and management at Morton Thiokol did not anticipate the strong bias that NASA had against delaying the launch. NASA had already delayed the launch more than once and felt strong pressure to place *Challenger* into orbit.[3]

Not targeting the audience is one common reason for the failure of many scientific presentations. Another common reason is a failure to understand the purpose of the presentation. Few presentations have the sole purpose of informing. Most scientific presentations, such as the Morton Thiokol presentation, also include the purpose of persuading audiences. Still other presentations, such as the keynote address at a conference or the concluding lecture of a university course, also call for inspiring the audience.

Yet a third reason that many scientific presentations fail is that the speaker has not carefully considered the occasion of the presentation. Occasions vary greatly, from informal meetings to formal symposiums. The occasion affects the expectations that the audience has for the presentation. For instance, an audience for a morning plenary session at a scientific conference has much different expectations from what that same audience has later that day at an after-dinner talk.

In analyzing an audience, you assess what they know, why they are there, and what biases they hold

Morton Thiokol's presentation to NASA provides a clear example of not targeting the audience. Given in Figure 2-1 are the first two presentation slides that Morton Thiokol faxed to NASA. The second slide contains data that supposedly state and support the main assertion of the presentation—namely, that the lower the launch temperature, the more erosion that the O-rings of the solid rocket boosters would incur and thus the more likely that explosive gases from the rocket would escape.

The information on the second slide is not appropriate for someone with a general scientific background. As Edward Tufte points out in his book *Visual Explanations*,[4] absent from this second slide is the assertion that lower temperatures produce more damage. Also, the statistical evidence to support that assertion is buried in too much detail: the confusing names for the previous launches, the unnecessary cataloguing of the types of

Temperature Concern on SRM Joints

27 Jan 1986

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

		Cross Sectional View			Top View		
	SRM No.	Erosion Depth (in.)	Perimeter Affected (deg)	Nominal Dia. (in.)	Length of Max Erosion (in.)	Total Heat Affected Length (in.)	Clocking Location (deg)
61A LH Center Field**	22A	None	None	0.280	None	None	36° - 66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338° - 18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
410 RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
410 LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
STS-2 RH Aft Field	28	0.053	116.0	0.280	--	--	50

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking rotation of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT HEAR OR BEYOND THE PRIMARY O-RING

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

Figure 2-1. Reproduction of first two presentation slides from a set of 13 that were faxed by Morton Thiokol to NASA to request launch delay of the space shuttle *Challenger* (January 27, 1986).[5] One weakness of the first slide is its lack of attempt to establish authority: No name or company logo is given. The second slide is weak because its assertion is not explicitly stated, and because the evidence supporting this implicit assertion is confusing.

erosion, and the unnecessary details about the locations of the damage. Moreover, missing from this slide is key information to support the assertion, specifically, the temperatures of the different launches.

Targeting a specific audience. Targeting a specific audience is critical for communicating one's work. In general, the less technical the audience, the more difficult that targeting is, because the speaker has to anticipate more terms and background information that the audience needs for understanding the work. Richard Feynman understood this point. After receiving his Nobel Prize, he had been invited to Berkeley to give a lecture to an audience that he assumed would be physicists in his specific field. Upon entering the lecture room, though, he was upset to find a huge crowd of people, who were not nearly as technical as the one for which he had prepared.[6]

My father, who served for several years as plant manager of the Pantex Nuclear Weapons Facility, claims that a common failing of many speakers is that they neglect to define their jargon. For instance, speakers will toss out abbreviations such as *HE* (which means *high explosives*) or *NC* and *NG* (the explosives *nitrocelluose* and *nitroglycerin*) without considering whether the audience knows those terms. Note that not all abbreviations are necessarily less familiar to the audience than the terms for which they stand. For instance, *TNT* is more widely known than the term *trinitrotoluene.*

Although an inspiration for many physicists including Lise Meitner and Otto Frisch, Niels Bohr was not adept at communicating to audiences who were not knowledgeable about physics. Why did Bohr struggle to communicate? Part of the problem was language; he often intermixed German and English, neither of which was his native tongue, Danish.[7] Another part was Bohr's passion for being precise. Bohr often focused on the edges of what he knew. According to Einstein, Bohr stated "his opinions like one perpetually groping and never like one who believes himself to be in possession of definite truth."[8]

Bohr's attention to precision in his speech, unfortunately, occurred at the expense of clarity. Notice in the beginning of his Nobel Prize address how his striving for accuracy causes his first sentence to lengthen to the point of being difficult to follow:

> Today, as a consequence of the great honor the Swedish Academy of Sciences has done me in awarding me this year's Nobel Prize for Physics for my work on the structure of the atom, it is my duty to give an account of the results of this work, and I think that I shall be acting in accordance with the traditions of the Nobel Foundation if I give this report in the form of a survey of the development which has taken place in the last few years within the field of physics to which this work belongs.[9]

A single sentence of this length an audience can handle, but when most of the sentences have this kind of wandering, the audience is pressed to stay with the speaker.

The above example shows what *not* to do in targeting an audience. Now the question arises, How do you target a specific audience? When your audience consists of people whom you know well, targeting the audience is straightforward. As you prepare the presentation detail by detail, you continually ask yourself two questions: (1) Will the audience understand these details? and (2) Will the audience be interested in these details?

A more difficult situation arises when you do not know the audience well. Before such a presentation, many good speakers mingle with the audience before the presentation and ask questions: What kind of work do you do? Why did you come today? What do you know about the presentation's topic? This tactic is not only important for targeting the audience, but also effective at alleviating nervousness (see Critical Error 13). When it is not possible to mingle with the audience beforehand, many good speakers try out their presentation on someone who knows or has the same background as the intended audience.

Dan Hartley, a former vice president at Sandia National Laboratories, was adept at targeting an audience. While managing the Combustion Research Facility in Livermore, California, he met with many visitors, including politicians, managers from industry, Department of Energy officials, and visiting scientists from abroad. I saw him give the same tour three times in a single day, but to three different audiences. On these occasions, Hartley tailored the examples, the depth, and the background information for each group of visitors. As he spoke, Hartley constantly watched the expressions of the audiences to gather whether what he was saying registered with them.

For my own presentations, I find it helpful beforehand to imagine myself giving the presentation to the audience. On morning walks, I mentally step through the presentation—imagining the reaction of the audience to each assertion and piece of evidence. In addition, during the presentation, like Hartley, I find that much can be gathered by the response of the audience. If they appear tired, then I work harder to engage them. In such instances, I usually step closer to them, pick up the pace and perhaps the volume, and try to work in direct connections between my content and their work.

After the presentation is also a fruitful time to think about the presentation. Generally, if you present a subject once, you will have to present it a number of times. When reflecting on a presentation, you should think about the questions raised by the audience. Perhaps those questions arose because you needed to explain certain points better in the body of the presentation. You also should consider the comments of the audience: not only what they responded to, but also what they did not appear to notice. For me, a presentation lasts much longer than the time I am on the stage: The planning, delivering, and reflecting usually last for days, sometimes weeks. Sometimes, long after I have given a presentation, an idea will come to me about how I could have reached the audience more effectively.

Targeting multiple audiences. More difficult than targeting a single audience is the task of reaching a multiple audience. Barbara McClintock, who won a Nobel Prize for her work in genetics, had difficulty with this situation. McClintock communicated her work to other geneticists, but struggled to reach people outside her discipline. In fact, no one at Cornell paid much attention to McClintock's thesis work until a postdoctoral student arrived who had worked for the geneticist Thomas Hunt Morgan. This postdoctoral student not only took notice of McClintock's work, but also explained its importance to others at Cornell.[10] The result was that McClintock, still a graduate student, became the leader of a research group of postdocs.

Much later in her career, McClintock still struggled to communicate to a wider audience. In an hour-long presentation at Cold Spring Harbor in 1951, McClintock failed to communicate her work on transposons ("jumping genes") to those outside of genetics. This work, for which she eventually won a Nobel Prize more than a quarter of a century later, was dismissed by the molecular biologists at that presentation. According to Sharon Bertsch McGrayne,[11] McClintock presented the intricacies of her work in a fashion that was just too dense for this audience to digest. Disheartened by the rejection of her work on which she had spent years, McClintock pared back efforts to communicate her work to the outside world. That she received the recognition of the Nobel Prize is a testament to how important the work was.

In many talks such as a job talk at a research laboratory or a university, a mixed audience consists of both specialists in your field and researchers from other fields. The specialists in your field likely understand the problems that you have faced and want to see you, at some point in the talk, demonstrate depth in your specialty. The researchers from other fields have a much different viewpoint. Although these engineers and scientists might understand the general theories upon which you have based your work, they often will not appreciate the significance of your work, unless you show that significance. They also are not knowledgeable about recent work in your field. In your talk, they are hoping to gain insights into your research that connect with their own research. The way you present greatly affects whether this audience will understand and appreciate those insights

In still other talks, the mixed audience will include a third type of audience: government officials or business managers who have little technical background. Such audiences often do not understand the significance of your work, they are not familiar with the recent work of others in your field, and they probably do not know the general theories upon which your work is based. However, because these people may have the largest say in how your work is funded, you want to find a way to connect with them.

So, for a mixed audience, how do you design the presentation such that everyone is satisfied? The answer is not simple. If your goal is to satisfy the entire audience *throughout the entire presentation*, no answer exists. However, if your goal is to satisfy everyone *by the presentation's end*, then an answer is to speak to the different audiences at different times in the presentation.

One strategy, which is depicted in Figure 2-2, is to begin at a shallow depth that orients everyone in the room to the subject. That orientation includes showing (not just telling) the importance of the subject. Then for each division of the presentation's middle, before diving into the new topic, you begin in the shallows where everyone in the room can follow you. During the deeper dives, many members of the nontechnical and general scientific audience will not be able to stay with you, but you should bring them back into the presentation with the beginning of the next topic. At the presentation's end, you should come back to the shallows and then examine the results in a way that everyone understands. With this strategy, while the nontechnical and general scientific audiences may not have followed all of the theoretical derivations or the analysis of the

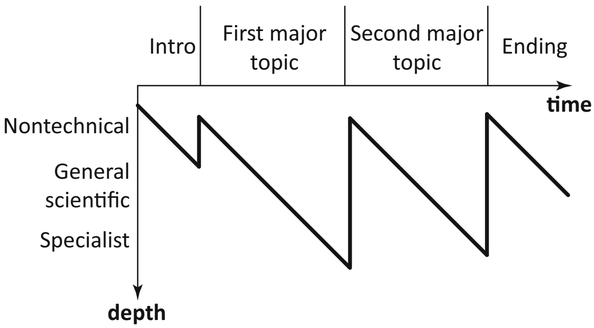

Figure 2-2. Timeline showing presenter reaching multiple audiences by beginning at surface of the topic, diving into a subject, and then surfacing to gather entire audience.

experimental results, everyone would have learned the main points of the presentation.

A fear that many presenters have with this strategy is that they will bore the specialists with the general information. Just because you present information that an audience already understands does not necessarily mean that you bore that audience. For instance, in his lectures to freshmen physics students in the early 1960s, Richard Feynman also drew a number of professors and graduate students who were interested in his presentations about subjects that they already understood. As David L. Goodstein wrote,

> But even when he thought he was explaining things lucidly to freshmen or sophomores, it was not always really they who benefited most from what he was doing. It was more often us, scientists, physicists, professors, who would be the main beneficiaries of his magnificent achievement, which was nothing less than to see all of physics with fresh new eyes.[12]

Dan Inman, a well-known researcher in vibrations, concurs with this assessment. He claims that he does not tire of listening to an explanation of something that he already knows as long as the explanation is done well.[13]

What happens when you have to speak about a subject to an audience that includes an expert who knows more than you do about one of the topics? This situation can be intimidating. Recently, I faced that situation when I had to introduce several principles of multimedia learning while Richard Mayer, the father of multimedia learning, was in the room. In such a case, a good strategy is to mention the expert by name and to admit that this person could explain the topic better than you can. Then you do the best that you can. By showing respect for the expert, you often recruit the expert to your side. If you say something imprecise and the expert corrects you, he or she will more than likely do so in a kind manner.

Targeting the general public. An audience often overlooked by scientists and engineers is the general public. Targeting this audience is important. One reason is that because the audience includes government officials, this audience makes important decisions on energy, health, security, and the environment. Another reason is that the general public contains the next generation of scientists and engineers. Einstein argued for targeting this audience in the following way:

> It is of utmost importance that the general public be given the opportunity to experience—consciously and intelligently—the efforts and results of scientific research. It is not sufficient that each result be taken up, elaborated, and applied by a few specialists in the field. Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual poverty.[14]

Communicating science to the general public not only benefits policy on science, the discipline of science, and the public itself, but it also can benefit the scientist making the presentation. In February 2008, Jill Bolte Taylor gave a talk about strokes to a general public audience at a TED.com conference (TED stands for technology, entertainment, and design).[15] Soon afterwards, her book *My Stroke of Insight*[16] became a *New York Times* bestseller. In addition, that summer, she received an invitation to appear on the Oprah Winfrey show. Moreover, in November of that same year, she was selected as one of *Time* magazine's 100 most influential people in the world. According to Taylor's web-site, all three of these measures of her popularity could be attributed to that 18-minutes talk to the general public.[17]

Because the general public includes such a wide variety of education levels and interests, getting a grasp on this audience is difficult. Rather than trying to engage everyone, I suggest paralleling Mother Teresa's approach for tackling poverty ("If you can't feed a hundred people, feed just one").[18] In this approach, you focus on just one person whom you know well. For instance, think of one member of your family such as a grandparent or sibling who is not a scientist, but who is respected by the other family members. In imagining how a general public audience will respond to your talk, think about what your respected family member would say. That family member will not hesitate to say "I don't get it" if he or she does not understand something or "So what?" if he or she understands a point, but does not appreciate its importance. Having that voice in your ear will hone your wording and strengthen your arguments.

The purposes of presentations are often a blend of informing and persuading—and sometimes inspiring

Scientific presentations have a variety of purposes. In a presentation to instruct employees about how to operate a streak camera, the primary purpose is to inform. In a presentation to NASA requesting a delay of a launch, the primary purpose is to persuade. In the opening address to a conference, the primary purpose is to inspire.

Although these mentioned presentations have clear primary purposes, most presentations carry a mixture of purposes. For instance, in a technical presentation at a conference, you not only want to inform the attendees of your work, but you also want to persuade them about your results and stimulate conversation about your subject area. Understanding the purpose of a presentation is important, because the purpose affects how you craft the speech.

Presentations to inform. For presentations in which the primary purpose is to inform, such as instructions for operating a streak camera, the audience typically does not doubt what you have to say (as long as you have the appropriate credentials). Put another way, this audience does not approach this type of presentation with the same critical scrutiny as they would the presentation of new research results. Rather, the audience simply wants to learn how to use the device. For that reason, your main objective is to deliver the information in as logical and straightforward a fashion as possible with emphasis on warnings and key steps.

For such an occasion, the adage *Tell them what you're going to tell them, tell them, and tell them what you told them* serves. The introduction places the audience in a position to comprehend the instructions, the middle simply delivers the instructions in a logical fashion, and the ending serves to increase comprehension with repetition.

A stellar example of an informative presentation occurred during the rescue of *Apollo 13*.[19] On April 13, 1970, more than halfway on its voyage to the moon, one of the oxygen tanks of

Apollo 13 exploded. Over the next three days, to bring the crew safely back to Earth, NASA had to devise and communicate a series of complex procedures to change the flight path, to adjust and readjust trajectories, and to preserve life on board the damaged ship. Further complicating matters was the condition of the astronauts—they were weary from lack of sleep. The three astronauts, however, were a willing audience. They were not so much interested in the *why* behind each step of the instructions as they were in the *how*.

Presentations to persuade. For presentations in which the primary purpose is to persuade, the challenge increases greatly. For instance, persuasion was the primary purpose of Morton Thiokol's presentation to delay the launch of the space shuttle *Challenger*.

Linus Pauling, who won a Nobel Prize in Chemistry as well as a Nobel Peace Prize, was effective in persuasive presentations. Why was that? This question is difficult to answer. Certainly, Pauling provided much logical evidence (*logos*) for his arguments, but as James Watson asserts about one of Pauling's presentations, Pauling also appealed to emotions (*pathos*) and appealed to his own character (*ethos*):

> Pauling's talk was made with his usual dramatic flair. The words came out as if he had been in show business all his life. A curtain kept his model hidden until near the end of his lecture, when he proudly unveiled his latest creation. Then, with his eyes twinkling, Linus explained the specific characteristics that made his model—the α-helix—uniquely beautiful…. Even if he were to say nonsense, his mesmerized students would never know because of his unquenchable self-confidence.[20]

A much different approach was taken by Maria Goeppert Mayer, who was particularly persuasive in one-on-one presentations. "Charming" is the word many people used to describe her.[21] Living in Chicago, Mayer came up with a shell model for the nucleus just as three Germans were developing a similar model. Rather than trying to beat this group by publishing first, Mayer waited and published her work at the same time. Because this shell model was such a radical departure from current thinking, she felt that two papers, rather than one, would have more influence on the scientific community. Also, rather than competing with the German group, she collaborated with one of them, Hans Jensen, on a book that explained the theory in more detail. Although she wrote most of the book, she was generous in acknowledging his contribution. What could have been a competitive situation became a fruitful collaboration. For their work, both Mayer and Jensen received the Nobel Prize in Physics.

So how is one's speech affected when the purpose is primarily to persuade? Much depends upon the initial bias of the audience toward your idea, a point that is discussed in more detail in Chapter 3. Assuming for the moment that the audience has a neutral stance to your main assertions, you have several variables to consider. For instance, not all assertions are created equal. An assertion such as, *Design A is an effective design*, is much more difficult to marshal evidence for than is the assertion, *Design C is not an effective design*. For the second presentation, all you need to do is to show that Design C does not meet one criterion for the design, while in the first presentation you have to show that Design A meets all the criteria.

Also, not all persuasive presentations call upon you to bring the audience to your position. In some presentations, the purpose is to negotiate a compromise about the situation. Maria Goeppert Mayer's situation was one in which a compromise worked well for both parties.

Presentations to inspire. A third purpose that arises in engineering and science presentations is to inspire an audience. Presentations that call upon you to inspire might be an opening address to a conference, an after-dinner talk, or a speech before a student organization. When the purpose of the talk is primarily to inspire, the speaker may well want to deviate from the standard practice of projecting presentation slides.

An example of such a deviation comes from a presentation delivered by Doug Henson, a manager at Sandia National Laboratories.[22] The presentation occurred at the beginning of a

4-hour forum for recruiting employees to Sandia. The forum was attended by 100 of Sandia's top management. As the opening speaker, Henson had the goal of motivating his audience behind the recruiting effort. Henson chose the following title: "Winning the War for Talent." In the beginning of his presentation, which had the difficult time slot of just after lunch, Henson stood with his back to the audience. Then someone came out and silently outfitted him in military attire: an authentic army jacket from World War II; a leather holster with a pearl-handled revolver; a riding crop and gloves; and a helmet with insignia. At first, the audience was not quite sure what was going on. However, everyone in the room sat up and paid attention. In contrast to the underlying buzz that normally pervaded this audience, there was silence.

After Henson was completely outfitted, a projector came on and beamed a huge U.S. flag on the wall behind him. Then Henson turned and began to speak, but not in the professional manner of a manager at a national laboratory. Rather, Henson spoke in the spirited and dramatic manner of General George S. Patton.

What Henson did was to memorize one of Patton's famous speeches. In giving the speech, though, Henson substituted Sandia's mission to recruit talented employees for Patton's mission to gain a beachhead on Italy's western coast: "You are here because you want to win. You love a winner and will not tolerate losing. I wouldn't give a hoot in hell for someone who lost and laughed, but will stake my career on someone who will fight to win." The audience listened intently to every word. At the conclusion of his speech, Henson came to attention, did a left-face, and marched off stage. Then the next scheduled speaker took the podium and began her portion of the forum, as if nothing unusual had occurred.

Henson received much good feedback for this performance. What normally would have been a sleeper presentation with ten slides and tepid applause became a provocative call for action that the audience still talked about months later. Granted, such a presentation could not be repeated to the same audience, because the power of the presentation lay in the underlying tension of the audience not knowing exactly what the speaker would do. Another point that added to the success of this presentation was that both the chosen speech and persona were appropriate for this audience: managers at a laboratory that does much research for the U.S. Department of Defense.

Multipurpose presentations. As mentioned, most presentations do not have just the single purpose of informing, persuading, or inspiring. A conference presentation, for instance, certainly includes the instructional purpose of informing others about the work, but also has the purpose of persuading audiences to believe the results and the purpose of inspiring the audience to discuss the topic and contribute new ideas.

Another interesting situation in which to analyze the purpose is the teaching of a class of students. In this situation, the primary purpose is to have the students learn the material at hand, and a secondary purpose is to inspire the students to continue studying the subject after they leave the course. Given these two purposes, just telling the students the main points is not always the most effective way to teach. As a teacher, you often want the students to discover the information on their own, because by discovering the material the students are much more likely to own the material.

Given the wide variety of students and course subjects, this book does not even attempt to discuss all the methods for teaching students. However, it is important to understand that for any given subject and audience, several different methods are effective, and at least as many methods are ineffective. Moreover, some unusual methods that would have no place in a business or conference presentation can succeed with the right teacher and audience. For instance, the great mathematics teacher Emmy Noether spoke very quickly, so quickly that the students struggled to keep up. Not only did she speak quickly, but she wiped the blackboard clean almost as soon as she had written upon it. According to one of her students, the algebraist

Saunders MacLane, her method was an exercise of sorts that forced the students to think quickly, which Noether believed was necessary to become a mathematician.[23]

To introduce the first law of thermodynamics to his sophomore students, Philip Schmidt, a mechanical engineering professor at the University of Texas, uses a similar strategy to the one that Doug Henson used in the Patton presentation at Sandia. In his presentation, Schmidt dresses in the formal attire, including top hat, of Nicolas Carnot and speaks to the students as if he were Carnot himself, introducing this law for the first time. For this audience and for this occasion, the strategy succeeds.

Occasion, although often overlooked, can greatly affect the way you present

In addition to considering the presentation's audience and purpose, you should think about the occasion of the presentation. The occasion is defined by several variables. One is the formality of the presentation. Is the presentation at a conference, at a business meeting, or after a dinner in a banquet hall? Each of these presentations is quite different in regard to the formality expected by the audience.

The occasion is also defined by the time limits. In some presentations, such as at conferences, the time limits are fixed because others are waiting to speak. In such situations, if you exceed the limits, you risk upsetting, even angering, your audience.

The occasion is also defined by the time at which the presentation occurs. Are you speaking in mid-morning, when people have much energy, or late in the afternoon, when people are usually tired? This variable might affect how ambitious you are, covering four main points in the mid-morning as opposed to covering just three points in the late afternoon.

Yet another defining variable is the logistics for the presentation. Is it a face-to-face meeting, as it was between the engineers and management at Morton Thiokol on the afternoon before the fateful decision to launch the space shuttle *Challenger*?

Or is it a teleconference, as it was between Morton Thiokol and NASA later that evening? The logistics might affect variables such as how you design your presentation slides. In a teleconference presentation, in which you do not have the opportunity to gauge the audience's expressions and adjust your speech, you should design your presentation slides so that they carry your main assertions and evidence for those assertions.

Still other variables that define the occasion are the location for the presentation and the number of people in attendance. For instance, if the presentation is a dissertation defense, is the presentation before the dissertation committee in a small conference room? Or is the presentation in the Sorbonne before 1,000 spectators, as was the case in 1925 for the dissertation defense of Irène Curie?[24] The number of people in the room could affect decisions such as whether to incorporate humor. With a packed room, because the laughter of the audience appears amplified, the audience is more likely to perceive the humor as successful. If the room is half empty, though, any laughter quickly dissipates.

In summary, occasion dramatically affects the speech. If the occasion is formal and if the time short such as my colleague Melissa Marshall's 3-minute talk at TED Global in 2012, then you probably would choose a speech that stays close to the targeted subject.[25] If the occasion is informal or if there is time to diverge from a "just-the-facts" style, you might weave in different threads to the speech: examples, stories, humor, and personal connections.

Notes

[1] Sir M. Oliphant, Bohr and Rutherford, in *Niels Bohr: A Centenary Volume*, ed. by A.P. French, P.J. Kennedy (Harvard University Press, Cambridge, 1985), p. 68

[2] *Report of the Presidential Commission on the Space Shuttle Challenger Accident*, vol. 1 (United States Government Printing Office, Washington, D.C., 1996), pp. 104–111, 249

[3] Ibid., chap. V.

[4] E.R. Tufte, *Visual Explanations* (Graphics Press, Cheshire, 1997), pp. 44–45

[5] Ibid.

[6] R.P. Feynman, *Surely, You're Joking, Mr. Feynman!* (Norton & Company, New York, 1985), pp. 303–304

[7] O. Frisch, *What Little I Remember* (Cambridge University Press, Cambridge, 1996), p. 92

[8] A. Einstein, letter to B. Becker (24 June 1920); also in Abraham Pais, Einstein on particles, fields, and the quantum theory, in *Some Strangeness in the Proportion: A Centennial Symposium to Celebrate the Achievements of Albert Einstein,* ed. by H. Woolf (Addison-Wesley, New York, 1979), p. 212

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Critical Error 2
Boring Your Audience

If you're giving a presentation and you're not interested, how can your audience be interested? You've got to figure out the story of what you've done and tell it in a way that is interesting and enthusiastic. In other words, you really have to show up for your audience. I would say that selling your science is at least half of the work that you do and how successful you will be.[1]

–Jill Bolte Taylor

Perhaps the most stinging criticism for a presentation is that the talk is boring. Many talks are boring because the speaker projects bulleted list after bulleted list. Soon after the presentation begins, the audience becomes overwhelmed by the sheer number of details. Equally important, because the details are simply listed in a bulleted column, the audience has difficulty seeing connections among those details or appreciating their importance. The result is that the audience does not have an anchor to understand those details or a mnemonic to recall them. The speaker might have said much, but the audience retains little.

The best speakers of science, however, find ways to make their work connect and stay with audiences. The presentations of these speakers are not only understood, but are remembered. So what do these speakers do differently? One strategy for many of these speakers is the use of stories. While stories might appear at first glance to be too informal for a scientific presentation, stories create anticipation for audiences, thereby increasing their attention on your work. In addition, stories provide a frame that makes it easier for audiences to recall the work. Steve Jobs used stories in his presentations. Also using stories are the neuroscientist Jill Bolte Taylor and the ocean explorer Robert Ballard.

A second important strategy is to anchor complex or abstract details in examples and analogies. Einstein and Feynman were particularly adept at incorporating examples and analogies into their talks. Still a third strategy is making a personal connection with the audience. The presentations of Boltzmann and Faraday were distinguished by this strategy. Finally, a fourth strategy to emphasize details and make them memorable is to incorporate humor. Although humor is not for every speaker, it can be an effective way to engage audiences and emphasize key details in your talk. To be effective, the humor should arise naturally from the content and should not offend anyone in the audience.

Stories can be engaging and memorable

As mentioned, stories appear at first glance to be too informal a means to communicate science. After all, stories are typically associated with entertainment, such as in novels and scripts, and presentations are typically associated with informing and persuading, such as in articles and reports. However, the best scientific speakers incorporate stories into their presentations. In a highly regarded talk to the general public about what occurs during a stroke,[2,3] the neuroscientist Jill Bolte Taylor powerfully told the story of her own stroke. In addition, in a widely viewed talk about biomimicry,[4] Janine Benyus deftly incorporated the story of how wastewater engineers realized the potential of biomimicry through nature's design of seashells. Moreover, in the presentations about her Space Shuttle missions, the physicist and astronaut Ellen Ochoa uses the stories of her missions as frames to explain her crews' scientific experiments.[5]

So if stories are too informal for documenting science in journal articles and formal reports, why are they used by so many excellent scientific speakers in presentations? Nancy Duarte, in her book *Resonate*, reconciles this apparent contradiction with her insight that presentations actually fall somewhere in between a document and a story.[6] In other words, while presentations are not stories *per se*, strong presentations blend aspects of stories and documents.

For instance, stories create anticipation for the audience. Put another way, stories allow the audience to experience the natural excitement of the experiment or computation that occurred when the researchers were waiting for the results. The effect of that anticipation is that the audience leans in and listens more intently. In addition to aiding the comprehension of details, stories aid the retention by providing a frame to help the listener recall the sequence of details.[7] Much psychology research on how people remember supports this claim.

As an example of the effective use of stories in a scientific presentation, consider a widely viewed talk by Robert Ballard.[8] In this talk, which argued for more funding to ocean exploration, Robert Ballard incorporated the story of his crew exploring the Great Rift Valley for the first time. Before beginning the story, Ballard set up a hypothesis: Heat sources, undiscovered to this point, had to lie along the mid-ocean ridge. In telling the story, Ballard often broke from the narrative to explain different aspects of science. Still Ballard ordered the details such that tension was maintained. Would Ballard and his crew discover hot springs, as hypothesized? When Ballard released the tension of this thread, the talk reached a peak of excitement. Because of his precise and clear descriptions, Ballard had earned this peak, and he allowed his speech and delivery to reflect that level of energy:

> And so we went along this mountain range in an area along the Galapagos Rift, and *did we find the missing heat*. It was amazing. We found these giant chimneys—huge giant chimneys. We went up to them with our submersible, because we wanted to get a temperature reading. And when we stuck our probe in there, it pegged off the scale. The pilot made this great observation: "That's *hot*."[9]

Although Ballard reached this peak with the resolution of the question about the missing heat, the talk did not conclude at that point. Instead, the talk moved onto another question: Was this deep depth essentially void of life, as most people assumed?

In essence, the talk climbed another peak. However, the audience was prepared for that second climb, because in the build-up to the resolution of the heat question, Ballard foreshadowed this second question:

> Most of our planet does not feel the warmth of the sun. Most of our plant is in eternal darkness. And for that reason, you have no photosynthesis in the deep sea, and in the absence of photosynthesis, you have no plant life and as a result you have very little animal life in the deep sea—or *so we thought*.[10]

Like a good storyteller, Ballard maintained tension throughout the talk. He did so with the raising and answering of questions as depicted in Figure 2-3. The middle of Ballard's talk was a story, but this particular story had multiple peaks of excitement, as Ballard recounted one discovery that led to another that led to another. In other words, the discovery of the missing heat led to the discovery of commercial grade metals (copper, lead, silver, gold), which led to the discovery of new plant and animal life. Ballard created tension and then released tension, and then created a different tension. In essence, the middle of Ballard's talk was a series of stories, one leading to the other.

The takeaway from this example is not that talks should simply be stories, but that stories have a role in scientific

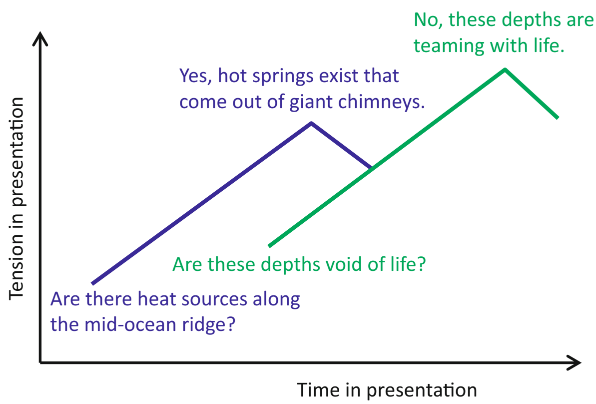

Figure 2-3. Relationship between tension and time in a talk by Robert Ballard.[11] Just as Ballard reaches a peak in tension by answering the question of whether heat sources exist in the mid-ocean ridge (*blue line and text*), he increases the tension of the talk by addressing the question of whether life exists at these depths (*green line and text*).

presentations. As Duarte argues,[12] the best presentations combine the descriptions needed for informing and persuading with the narratives of stories needed to maintain audience interest and to make recall easier. The roles of stories are twofold: (1) to engage the audience members so that they listen to you, and (2) to provide a memorable sequence so that hours later the audience can recall what you said.

In his commencement address to the graduating class of Stanford in 2005,[13] Steve Jobs provides an excellent example for the power of stories. In this address, Jobs tells three stories from his own experience—the first one being a story of connecting the dots, the second being a story of love and loss, and the third being a story of death. Many commencement addresses are tiresome, but Jobs' address was riveting. The three stories not only fascinated the audience, but instructed them as well.

Examples and analogies can help audiences understand unfamiliar concepts

When describing a concept that is unfamiliar to your audience, a powerful strategy is to anchor your description in examples or to explain that concept with analogies. For instance, in describing the features of the mid-ocean ridge, Robert Ballard incorporated a number of examples and analogies:

> The greatest mountain ridge on Earth lies beneath the sea: the mid-ocean ridge. It runs around like the seam on a baseball. This [image on the screen] is on a Mercator projection, but if you were to place it on an equal area projection, you would see that the mid-ocean ridge covers 23 percent of the Earth's total surface area. Almost a quarter of our planet is a single mountain range, and we did not enter it until after Neil Armstrong and Buzz Aldrin went to the Moon.[14]

Examples and analogies serve audiences in a different way from how stories do. Often, presentations fail because the speaker restricts the speech to an abstract or mathematical perspective. While some people can learn from such perspectives, most cannot. To follow the discussion, most people require an image or physical perspective. Examples provide those images or perspectives. Consider the difference between listening to the solution of a second-order differential equation and listening to the solution of a second-order differential equation that represents the flight of a paratrooper dropped from a plane behind enemy lines. In the second presentation, you have something physical to which you can anchor the mathematics. When listening to presentations of mathematical derivations, Richard Feynman would request physical examples for the equations shown. To the surprise of the presenter and everyone else in the room, Feynman would sometimes catch errors in the middle of detailed derivations because while everyone was desperately trying to follow the mathematics, Feynman was working through the physics of the example.[15]

Analogies orient audiences in a different way. For instance, when you simply want to convey the size of something unfamiliar to audiences or the likelihood of an unfamiliar event, analogies are powerful. Otto Frisch liked to use the following example to describe the size of a nucleus: "If an atom were enlarged to the size of a bus, the nucleus would be like the dot on this *i*."[16] Einstein used the analogy of "shooting sparrows in the dark"[17] to describe the likelihood of producing nuclear energy with alpha particles striking nitrogen nuclei. When describing his work with turbine blades in gas turbine engines, the engineer Fred Soechting uses the following analogy: "The amount of power produced by a single gas turbine blade equals that of a Maserati sports car."[18] Such descriptions, when they support the presentation's content, are *keepers*: things that audiences hold onto when they leave the room. Too often, not but two days after attending a conference presentation, I cannot remember anything about the talk: not a result, not an image, not an observation, not even a striking detail. One good test for the success of a presentation is what the audience remembers two days later.

Steve Jobs was a master at making numbers meaningful and memorable. For instance, when introducing the iPod, rather than discussing the device's size in terms of inches or ounces, he said that it "could fit in your pocket."[19] Also, rather than discussing its storage in terms of megabytes, Jobs said that the device could hold 1000 songs. At this point in the presentation, Jobs pulled the device out of his pocket and introduced the device's famous slogan: "1000 songs in your pocket."

Making a personal connection is a way to connect with the emotions of audiences

Another thread that many people successfully weave into speech is a personal connection. Michael Faraday was noted for giving presentations that had a warm and personal atmosphere. At a time when so many others spoke for the sole purpose of impressing audiences with their knowledge, Faraday worked hard to make sure that everyone in the audience understood what he had to say. His eye contact, his humbleness, his passion for having the audience understand him—these served to make connections with his audience.[20]

Jill Bolte Taylor often begins her scientific talks on strokes by discussing how she came to study neuroscience. What motivated her to study the brain was a desire to better understand her brother, who has the brain disorder schizophrenia.[21]

Ludwig Boltzmann, the developer of the statistical treatment of atoms, also made his presentations personal by stating things about himself. Teaching at a time when most professors adopted a formal distance from the students, Boltzmann broke tradition and made personal connections with his audience. According to Lise Meitner,

> Boltzmann had no inhibitions whatsoever about showing his enthusiasm when he spoke, and this naturally carried his listeners along. He was fond of introducing remarks of an entirely personal character into his lectures. I particularly remember how, in describing the kinetic theory of gases, he told us how much difficulty and opposition he had encountered because he had been convinced of the real existence of atoms and how he had been attacked from the philosophical side without always understanding what the philosophers had against him.[22]

Boltzmann's personal style contributed to his ability to inspire. Confirming these abilities was his legacy of pupils: Svante August Arrhenius, Paul Ehrenfest, Fritz Hasenöhrl, Stefan Mayer, Lise Meitner, and Walter Nernst.[23]

Other speakers make the speech of their presentations personal by showing connections between their own work and the work done by members of the audience. Such speakers often refer to those audience members by name during the presentation. This style can be particularly effective if you find yourself having to explain something to an audience that includes an expert who knows much more than you do about a topic in your talk. For instance, Professor Karen Thole from Penn State is primarily an experimentalist, but uses commercial computational codes such as Fluent in her work. When she gives a conference presentation, she usually has prominent computationalists in her audience. Given that, in explaining the principles of her commercial code, she respectfully acknowledges the computationalists who could explain the code better than she can, and then she explains the code as well as she can. Naming those computationalists during the presentation not only serves as a sign of respect, but also recruits them to her side.

In teaching large classes, one of the best ways to make a personal connection is to do the unexpected by learning the names of the students. From 1999 to 2006, Harry Robertshaw and I taught a measurements course sequence to more than 200 mechanical engineering students at Virginia Tech. Despite our best efforts, the first two years that we taught the course, the course evaluations were low. In the third year, we did something unexpected. Using a technique of Professor Wallace Fowler from the University of Texas, we photographed the students at the beginning of the first semester so that we could learn a significant portion of their names. In addition, we surveyed the students to learn what measurements they had done in their summer jobs. Then, whenever possible, we mentioned the experiences of individual students in our lectures. Because of these efforts, presentations that the students assumed were going to be anonymous experiences became personal experiences.

One effect of our efforts was that the students concentrated more during the lectures. That effect we expected, because the students now had to be prepared for us calling upon them by name at any moment. An unexpected result, though, was that the students put much more stock into what we had to say. In other words, our making a personal connection to the audience increased our credibility with that audience.

Humor, when appropriate, can energize an audience

For his series of Messenger Lectures at Cornell, Richard Feynman was introduced as someone who had won the Albert Einstein Award in 1954, who had served on the Manhattan Project during the Second World War, and who played the bongo drums. Feynman began his lecture with the following statement: "It is odd, but on those infrequent occasions when I have been called upon in a formal place to play the bongo drums, the introducer never seems to find it necessary to say that I also do theoretical physics."[24]

In one of his presentations as president of Sandia National Laboratories, C. Paul Robinson began in the following way: "As a small boy I had two dreams, and I was torn between them. At times I wanted to become a scientist, and at other times I just wanted to run away and join the circus. But thanks to the grace of God and a career in the Department of Energy's laboratories, I've been able to fulfill both dreams."[25]

Humor can relax an audience. Humor can also allow an audience to respond to a presentation. In addition, humor can engage an audience and can give an audience a needed rest. However, because attempts at humor are risky, three cautions about humor are worth noting. First, not everyone is suited to make a crowd laugh. Granted, humor comes in various forms: Some people's humor is understated, and other people's humor is dramatic. Although these different ways exist to make people laugh, not everyone's attempt will work. Delivering the full power of a humorous line often requires the appropriate pausing, timing, and emphasis. For that reason, many people who try to be funny in a professional situation, especially before an audience whom they do not know, draw more groans than genuine laughter.

A second caution is that although some books on presentations suggest that the speaker should open each presentation with a humorous remark, the beginning of a talk is probably the most difficult time to make people laugh, especially if those people do not know the speaker. One reason is that humor usually arises from saying something that no one expects, but that contains a grain of truth. The unexpected realization of truth then makes people laugh. However, at the beginning of a presentation in which people do not know the speaker, the audience does not know what to expect of the speaker.

Another reason that opening the presentation with humor is difficult is that the speaker is usually the most nervous then. Moreover, if the remark fails to draw warm laughter, the speaker could easily become even more nervous. Worse yet, a failed attempt at humor at the beginning could cause the audience to feel ill at ease with the speaker, and the beginning of a presentation is when the audience often sizes up the value of the speaker. For these reasons, it is far more effective to wait until the middle of the presentation, when the speaker has developed credibility with the audience and when the remark will truly be unexpected.

In a talk on measuring how fast the limbs of manta shrimp move when feeding,[26] Sheila Patek, a biology professor, had several humorous moments. However, as she recounted, "On the advice of my mentor Steve Nowicki, I never plan humor. For instance, I planned none of the funny things in the talk—they just emerged and followed the mood of the audience."[27] The video of that presentation bears that out. For example, when describing one of the experiments to measure the speed of the feeding strikes, Patek matter-of-factly mentioned that the snail in the experiment had been fastened to a stick because it was easier for the shrimp to strike it. At that remark, many of the 800 people in the auditorium began to laugh. Surprised by the response, Patek smiled and off-handedly said, “I hope that there are no snail rights activists in the audience.” Laughter filled the auditorium, and the presentation rose to a new level of energy and excitement.

A third caution is that humor is risky in a professional situation. What might strike people as funny in a restaurant during an informal lunch could come across as crass in a formal meeting where the audience members are seated with their managers and colleagues. Moreover, if the speaker touches on a controversial subject, humor can irritate an audience. What subjects risk controversy in a professional setting? Certainly, comments about sex are taboo, because some managers and colleagues impose an atmosphere of sexual tension in the workplace. Some people claim that such comments would have been acceptable 30 years ago (the supposed “good old days”), but the truth is that they were not. The same uncomfortable situations existed then; it was just that the discomfort of those situations had not been exposed.

Defining the line of what will make everyone laugh and what will make some people feel uncomfortable is impossible. People react differently to different subjects at different times in their lives. Just remember that in any large professional crowd, someone is probably sensitive to race, gender, religion, or death. So what topics are appropriate? Typically, stories about your own failings are the safest. Dan Inman, a much respected researcher in vibrations, is well known for the humor that he works into his talks. For that reason, he is often asked to give after-dinner talks at conferences. Inman believes that self-effacing humor is best. “I’m considered funny because I’m such an easy target,” he says.[28] Like Sheila Patek, Inman believes that humor should be natural, not planned. Moreover, he feels that humor is not appropriate for every situation. If his first attempt at humor does not elicit laughter, he backs off and plays the situation straight. Finally, Inman notes that a problem with continually using humor is that people try to read funny things into what he says, even when he is serious.

Notes

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[4]J. Benyus, Janine Benyus shares nature's designs, http://www.ted.com/ (TED Talk sponsored by AT&T, Monterey, Feb 2005)

[5]E. Ochoa, NASA Astronaut, The Atlas-3 Mission of Space Shuttle, presentation (University of Wisconsin, Madison, 11 Sept 1996)

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[28]D. Inman, Department Head of Aerospace Engineering, University of Michigan, interview with author (2 Mar 2001)

Chapter 3

Structure: The Strategy You Choose

Whereas Einstein tried to grasp a hidden essence by disregarding anything he thought irrelevant, Bohr insisted that nothing be left out.[1]

– Edward MacKinnon

Recently, more than 200 participants heard a lunch-time speaker at a National Science Foundation conference. Because the conference was for those who had won grants that concerned educating engineers, most of the participants were engineering faculty. Before the guest speaker, who was from an outside agency, took the stage, the energy level in the room was high. Most of the participants were presenting their projects in posters that afternoon, and many conversations at the round tables around the room involved participants sharing results. When the speaker took the stage, those conversations quieted.

From a content perspective, the overall topic of this lunch-time talk was inherently interesting for the audience—a vision for educating the next generation of engineers. Also, from a delivery perspective, the speaker was a good choice: good energy, clear voice, and professional movements. However, from the perspectives of visual aids and structure, the talk was a disaster. The speaker beat down the audience with bulleted list after bulleted list. Worse yet, each bulleted point was animated onto the screen. With 62 slides, most filled with bulleted points, the visual aids repeated almost every detail of that talk. The speaker even included a slide in which he introduced him-

M. Alley, *The Craft of Scientific Presentations*,
DOI 10.1007/978-1-4419-8279-7_3,

self, in eight bullet points that appeared one by one in the hypnotizing cadence of a metronome.

As bad as the visual aids were, the structure of this talk was worse. For one thing, the speaker tried to cover much too large a scope. Rather than focusing on just two or three aspects of this vision for educating the next generation of engineers, the speaker tried to cover every way imaginable. Unfortunately, that large scope resulted in such a shallow depth that every piece of advice was generic. Put another way, the speech was void of stories, personal connections, and examples. The result was that people became bored. Many pulled out their phones to check their email. Those without phones simply lost the hour.

A second structural mistake occurred on slide 23. On that slide, the speaker moved into the talk's third and final section. However, the audience's relief that the final portion of the talk had arrived turned to concern when the speaker announced that in this section he would discuss *ten* ideas for creating the new vision. Now if the ideas had been humorous and rattled off in two lists of five, as talk-show host David Letterman does on the *Late Show*, this section would have been bearable. However, the speaker spent two slides on the first idea—with each slide having a list of bullet points painfully animated one by one onto the screen. Many in the audience slumped in their chairs. One idea down, nine to go. At that point, the desperation experienced by a few attendees overrode their concern about insulting the NSF sponsor. These attendees headed for the exits.

As it turned out, the speaker did not dedicate two slides to each idea. In most cases, he dedicated *more*. By slide 50 of this talk (and bullet point 100 of this section), the trickle of attendees leaving the room had turned to a steady stream. The lunch hour was almost over, the poster session was about to begin, and the conference chair was frantically signaling the speaker that he needed to stop. However, the speaker had not finished his death march through the list of ten ideas.

During that lunch hour, much more information would have been communicated if there had been no speaker, and the participants had simply discussed their projects with each other. For this occasion, a bad scientific presentation was worse than no presentation.

In a scientific presentation, the presenter is a guide leading the audience up the mountain of his or her work to give that audience the view that speaker has attained. In this analogy, depicted in Figure 3-1, an important aspect is the route itself—the entry point at which presenter begins the ascent, the direction and steepness of the trail, and the ending point. Those aspects equate to the organization of the talk.

Two other important aspects in this analogy are the number of changes in direction (sections of the talk) and the presenter's signaling of those changes. When too many changes occur, the audience becomes tired. Also, without proper signals (mapping and transitioning), the audience loses sight of where

Figure 3-1. Analogy for structure in scientific presentation.[2] For this mountain of work, you the presenter serve as a guide choosing the entry point, keeping the audience on that path (depicted with the *dotted line*), and highlighting the important sights.

the speaker is on the trail: at the beginning, in the middle, or toward the end. A final aspect of this analogy is the speaker's emphasis of key details. Without proper emphasis, the audience will miss important vistas.

This chapter focuses on these four aspects and points out four major pitfalls to avoid: trying to do much, leaving the audience behind at the beginning, losing the audience in the middle, and not being persuasive enough.

Organization is the path up the mountain of your work

The traditional way to analyze the organization of a presentation is to divide it into a beginning, middle, and ending. In this division, which is represented by Figure 3-2, the beginning shows the big picture of the presentation and then directs everyone's attention to the particular topic.

The middle discusses the topic in a logical fashion. What is a logical fashion depends on the type of topic. For example, if the topic is a process, such as the evolution of a Hawaiian volcano, a logical strategy would be chronological: first the building stages and then the declining stages. If the topic is an object, such as the Earth, a logical strategy would be spatial: crust, mantle, and core. If the topic is a system, such as a solar

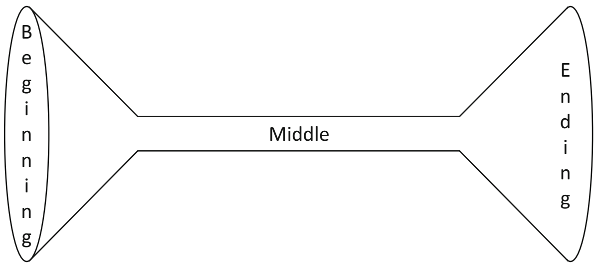


Figure 3-2. Visual depiction of the organization of a scientific presentation. The speaker begins with the big picture, focuses on the work in the middle, and comes back out to the big picture in the ending. In essence, the ending discusses the repercussions of the work on the big picture, which was introduced in the presentation's beginning.

thermal power plant, then a logical strategy might be the flow of energy through the system: radiant energy from the sun that is focused by mirrors and converted to heat in a transfer fluid that flows to a turbine to produce electrical energy.

If the topic can be classified into parts, a logical strategy often is a grouping into parts that are parallel. An example, shown in Figure 3-3, is the classification of methods for reducing the emissions of sulfur dioxide from coal power plants. One way to classify those methods would be into precombustion methods, combustion methods, and postcombustion methods. Note that for each category, the presenter might have

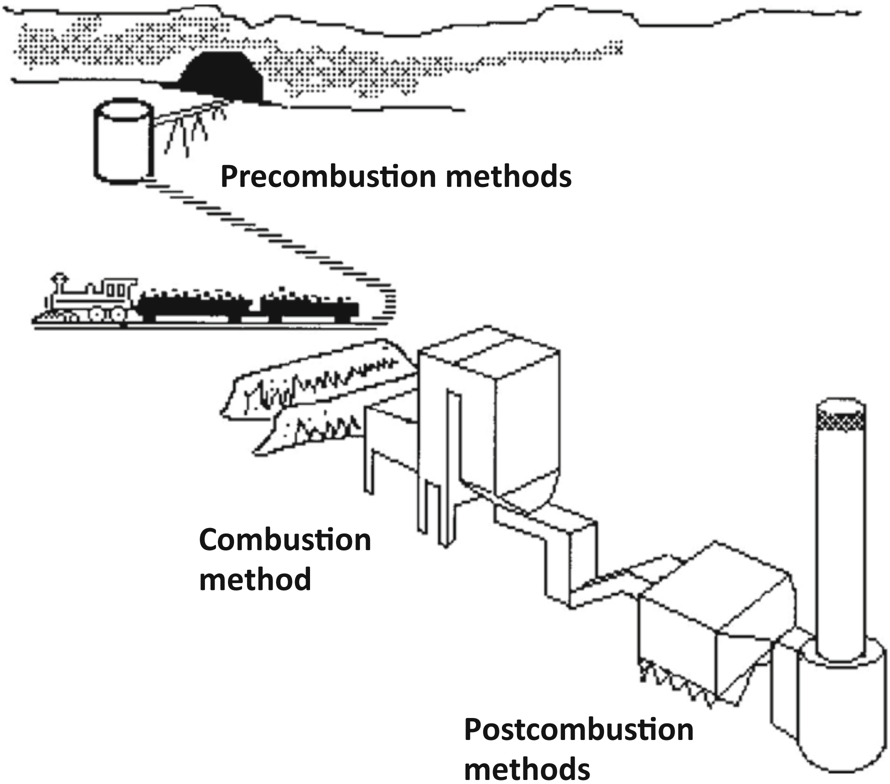


Figure 3-3. Classification of methods to reduce sulfur dioxide emissions from coal power plants.[3] A precombustion method is coal cleaning, a combustion method is an atmospheric fluidized bed, and a postcombustion method is absorption.

subcategories. For instance, two common postcombustion methods are adsorption and absorption.

Audience expectations can impose an organization on the speaker. For instance, in a research presentation, the audience expects that the speaker will identify the hypotheses (or research questions), then discuss how those hypotheses will be tested, and then present and discuss the results of those tests.

In the ending to a presentation, the speaker analyzes the work from an overall perspective. This analysis usually contains a summary of the most important details of the work. In addition, the analysis often contains information that provides closure to the presentation. That closure could be provided by a set of recommendations for the work, a list of questions about the work that still need to be resolved, or an examination of how the work presented in the presentation's middle affects the big picture presented in the beginning.

The failure of a speaker to organize a presentation in a logical manner sounds a death knell on the likelihood that an audience will return to listen to that speaker. For instance, lack of organization was the reason given by Linus Pauling for continually skipping the lectures of the physicist Robert Millikan.[4]

Transitions keep the audience on the trail

In addition to dividing a scientific presentation into a beginning, middle, and ending, the middle is usually broken up into segments so that the speaker can cover what is needed to lead the audience to the vista. To aid the audience, the presenter should limit the number of these divisions. In general, people are able to process lists of twos, threes, and fours.[5] Lists larger than four will tax the listener. Few moments in a scientific presentation are sadder than a presenter announcing that he or she will discuss six, seven, or even eight main points.

During a scientific presentation, the speaker will shift focus and direction in several key places. In such places, shown with arrows in Figure 3-4, the speaker should make clear

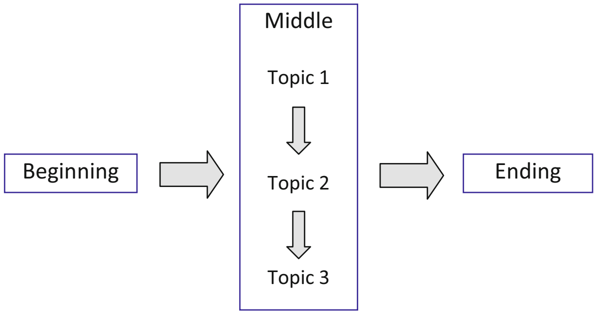


Figure 3-4. Key transition points in a presentation that has three main topics in the middle. Major transitions occur between the beginning and middle and between the middle and ending. Other transitions occur between the main topics of the middle.

transitions, which can occur through the speech, the visual aids, and the delivery. Speakers can signal a transition simply through the wording of what he or she says: "That concludes what I want to say about precombustion methods—now, I would like to discuss methods when the coal is being combusted." Transitions can also occur through a change in visual aids (Chapter 4 presents a number of ways to signal such transitions). Finally, speakers can signal transitions through delivery, such as using a pause.

In a scientific presentation, the first major transition occurs between the introduction and the presentation's middle. If the presentation's middle has three sections, major transitions would then occur between the first and second sections and between the second and third sections. A final major transition would occur between the presentation's middle and the conclusion. This last transition is particularly important for the audience to recognize, because if the audience realizes that the ending is at hand, they will sit up and pay more attention. After all, only a minute or two more of concentration is expected. In a way, the energy level of the audience picks up at this point much as a stable mare's pace picks up once it returns to within sight of the stables.

Making a transition becomes an even greater challenge when the change in topic is accompanied by a change in the speaker. During a group presentation, each new speaker requires the audience to adjust to a new voice, stage presence, and set of movements. While occasional changes in speaker can serve a long presentation by providing variety, too many changes in the speaker in a short presentation can cause confusion.

Emphasis tells the audience when to appreciate the view

The emphasis of details in a scientific presentation can be as important as the organization of details. People typically do not remember everything that they hear—far from it. For that reason, although a presentation might be well organized, the presentation could fail without proper emphasis. In such a case, the details that the audience takes away from a presentation might be the least important ones.

Much about the way you emphasize details in a presentation is similar to the way you emphasize details in an article or report.[6] Repetition, illustration, and placement play important roles in both situations. One key place for emphasis in a presentation is the beginning, when the audience is the least tired and the listening abilities are the sharpest. For that reason, you want to use the beginning of a presentation to say something important: to define the scope of your presentation, to show the audience the importance of the work, or in many cases to simply state the most important result of the talk. As will be discussed later in this chapter, beginning with the most important result succeeds when the talk presents a result that strikes the audience in a positive or neutral way and when the audience understands and appreciates that result. For example, the following opening to a talk would work for a general technical audience: "In this talk, we present a new process to remove 99 % of nitrogen oxides from diesel exhausts."

In the middle of a presentation, you can help maintain a higher level of retention for the audience if the audience sees the logic in the path that you have chosen. As mentioned in the section on organization, that path might be chronological or spatial; it might follow the flow of a variable through a system; or it might break down the presentation topic into parallel divisions. Whatever path you choose, the audience should be able to identify and recall the logical strategy of that path.

While the introduction and middle of a talk certainly provide opportunities for emphasis, the best opportunity for emphasis occurs at the ending. However, for that opportunity to occur, the audience has to know that the ending is upon them. Why is that? As mentioned in the section on transitions, if the audience knows that the ending is near, they will sit up and concentrate, even if they have not understood everything up to that point. You can observe this phenomenon at church, especially in Protestant churches in the South in which the sermons can go awhile. To let the congregation know that the end of the sermon is at hand, the preacher usually gives a clue such as "…as is sung in the hymn of invitation, number 343, 'On a Hill Far Away.'" At that moment, the congregation realizes that the sermon will end in a couple of minutes. In many a sermon at that point, the creaking of pews is distinct as everyone sits up.

Another opportunity for emphasis in the ending occurs with the slide projected during the question period. The slide projected during the question period is often on the screen for a number of minutes. For that reason, the presenter should have valuable information on that slide, especially for those times of the question period when the presenter is handling a tangential question that does not interest most people in the audience. Unfortunately, many engineers and scientists squander this opportunity by projecting something worthless such as a question mark or the word *Questions*. Perhaps the best slide to have projected during this time is the conclusion slide, which should be the most important slide of the presentation, because it summarizes the presentation's main results. By continuing to show your conclusion slide during the question period, you increase the chances that the audience will retain your presentation's most important results.

Notes

[1] E. MacKinnon, Bohr on the foundations of quantum theory, in *Niels Bohr: A Centenary Volume*, ed. by A.P. French, P.J. Kennedy (Harvard University Press, Cambridge, 1985), p. 103

[2] United States Geological Survey, Long's peak in Colorado, photograph (United States Geological Survey, Washington, D.C., 2002)

[3] C.M. Schmidt, Methods to reduce sulfur dioxide emissions from coal-fired utilities, presentation (Mechanical Engineering Department, University of Texas, Austin, 8 Dec 1989)

[4] A. Serafini, *Linus Pauling* (Paragon House, New York, 1989), p. 33

[5] J. Sweller, Implications of cognitive load theory for multimedia learning, in *The Cambridge Handbook of Multimedia Learning*, ed. by R.A. Mayer (Cambridge University Press, New York, 2005), pp. 19–30

[6] M. Alley, *The Craft of Scientific Writing*, 3rd ed (Springer, New York, 1996), pp. 63–71

Critical Error 3
Trying to Cover Too Much

The major weakness that I see [in talks by young researchers] is that they present and organize their talks to parallel the time and effort required for the various aspects of the research. So, if they spent 90 % of their time doing X, they seem to almost inevitably design the presentation so that 90 % of the talk is focused on X—even when the most interesting and significant results are in the other 10 %.[1]

– Andrew Zydney

In our presentation workshops for scientists and engineers that we give around the world, the most commonly asked question about the structure of presentations is, How much depth should the speaker go into? Although the simple answer to the question is, whatever depth the audience needs or desires, determining this depth is not easy. Moreover, in a presentation to multiple audiences, the difficulty in determining this depth increases several fold.

As discussed in Chapter 2, meeting the expectations of your audience in a presentation requires sensitivity and imagination. You have to assess what the audience already knows about the subject and begin your discussion at that level. In addition, you have to account for how much the audience wants to learn, or needs to learn, about the subject.

This sensitivity to what the audience wants, or needs, to learn is often overlooked. As Andrew Zydney, the Department Head of Chemical Engineering at Penn State, points out, many younger researchers place the focus of their presentations on how much work they performed. These researchers approach their talks as if the talks were being judged by the quantity of tasks done. However, research presentations are judged by the quality of new insights communicated. Given that the audience is not interested in every bolt (or perhaps any bolt) that you turned, you have to exclude many of the tasks that you did and focus on what your audience wants or needs. These decisions on what to exclude and include are difficult, which is why the question about depth arises so often.

Depth is interwoven with scope, which consists of the boundaries of the presentation. In other words, how wide of a talk should you take on? In many presentations, such as a progress review, the presentation's scope is already determined. In other presentations, such as a research seminar, the speaker defines the scope. In general, the wider the scope, the more difficult it is to satisfy the audience with the depth. For instance, trying to cover ten ideas was a major problem with the lunch-time talk discussed at the beginning of this chapter.

The relationship of scope and depth can be seen in the dimensions of vessels of equal volumes, as depicted in Figure 3-5. For a presentation with a fixed time (a vessel with a fixed volume), the speaker can convey only so many details. For that reason, the wider the scope is (top vessel), the greater the chance that at least a portion of the scope will initially connect with the

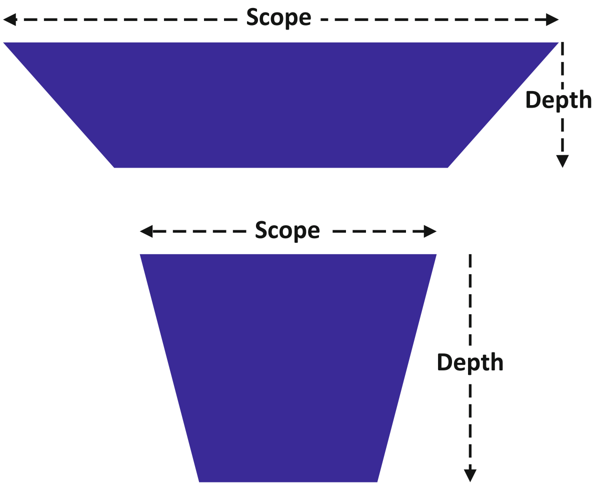


Figure 3-5. Relationship of depth and scope. The broader the scope (*top image*), the greater the likelihood that a portion of the talk will connect with the audience, but the less the depth that the speaker can achieve. Likewise, the narrower the scope, the less chance that the talk will initially connect with the audience, but the more depth that can be achieved.

audience. However, the wider the scope is, the less will be the depth that the speaker can achieve and the less is the chance that the speaker will reach the specific details needed to satisfy the audience. Likewise, the narrower the scope is (bottom vessel), the greater is the depth that the speaker can achieve and the more likely that the speaker will satisfy the interest of the audience. However, with too narrow a scope, the less is the chance that the talk will initially connect with the audience. For these reasons, a balance exists between scope and depth.

Many talks fail because the scope is too broad

A while back, I attended a NASA presentation entitled "Eight Technology Innovations for Space Applications." Although the speaker was knowledgeable, engaging, and deft at explaining concepts, the presentation did not succeed. Granted, the first 20 minutes were interesting. During this time, the speaker discussed high-temperature superconductors, which was the first innovation on the list. Unfortunately, in the remaining 40 minutes, the speaker tried in vain to cover the other seven innovations. Throughout this portion, the speaker furiously flipped through a large set of slides, showing each slide for less than 15 seconds, and then apologizing for how little time he had.

One problem with this NASA presentation was that all the slides were much too detailed for the depth that the speaker was forced to adopt. The effect of showing such detailed slides in such a cursory manner was that the audience had many unanswered questions about each one. In the end, the audience became frustrated because the speech was so shallow and yet the slides were so deep. If the speaker had limited himself to only two or perhaps three innovations, then the presentation might have succeeded.

Establishing the limitations of a talk is a strategy that the best scientific presenters use. The best presenters think about what scope would be large enough to connect with the audience and how much detail on that scope is needed to satisfy the audience. Often, many topics that you could discuss have to be excluded. In addition, explicitly stating what you will exclude is often important. For example, when giving a talk about methods to reduce sulfur dioxide emissions from coal power plants, you might have to limit the talk to methods that occur during and after the coal combustion. Because your audience would wonder about methods before the coal is burned, you should anticipate this question and address it up front: "…Because of time, I will not be able to discuss precombustion methods such as coal switching or coal cleaning, even though these methods could significantly reduce the amount sulfur dioxide emitted."

While a strong presenter imposes limitations to make sure that the audience is not overwhelmed with too many details, an insecure presenter does the opposite. An insecure presenter will cover as much as possible in an attempt to impress the audience. In some cases, the insecure presenter tries to overwhelm the audience so that they are hesitant to ask questions. With such a strategy, some in the audience might be impressed, but most will not.

Just because giving a "broad-scope" or big-picture presentation is challenging does not mean that one should always avoid doing so. For keynote addresses and talks reaching large audiences, a big-picture perspective is often desired. What a big-picture presentation requires, though, is that the speaker finds a way to provide a satisfying depth.

One such strategy is to present memorable stories and examples across the scope of the talk. A problem with many big-picture talks is that too much of the speech lies at an abstract level. However, as Chip and Dan Heath explain in their wonderful book *Made to Stick*,[2] memorable details that stick with audiences share certain qualities. For scientific presentations, one of most important qualities is that the details are concrete. A second key quality for scientific presentations is that the details are simple. Sometimes, the details should share additional qualities such being unexpected or containing emotion. The following example from a successful proposal presentation by William Wilson, a computer scientist from Sandia National Labs, captures these qualities:

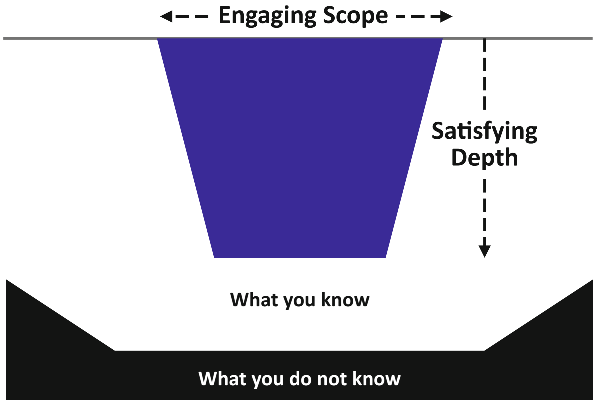
> By the late Middle Ages, cities throughout Europe were building Gothic cathedrals. The only way, however, that architects could test a new design was to build the cathedral, a process that took more than forty years. Unfortunately, many cathedrals caved in during or after construction. What took forty years to test in the Middle Ages could have been done in minutes on a supercomputer.[3]

For presentations in which the scope has become large because of the number of topics, another strategy is to group those topics into two or three memorable categories. For instance, you could group seven methods for reducing sulfur dioxide emissions into precombustion methods, combustion methods, and post-combustion methods. Then instead of trying to cover every method in a rushed manner, you focus on only one example from each category. For instance, you could discuss coal cleaning as one example of a precombustion method. In this strategy, you still cover a large scope at the category level, but you achieve a satisfying depth for one topic within each category.

Many talks fail because the depth is too deep

A second common mistake with the scope and depth of presentations is to go into too much detail about the topic and lose the audience. When you effectively present your work, you do not present everything you know about your work. Rather, as indicated in Figure 3-6, you select those details that allow the audience to understand the work, and you leave out details that the audience does not desire or need. Effectively presenting your work also means that you sort details so that the audience is not faced with a long laundry list that has to be catalogued and synthesized on the spot. Finally, effectively presenting your work means that you provide hierarchy to your details so that the audience knows which details to hang onto and which details to let go in case they are overwhelmed.

Figure 3-6. Ideal selection of scope and depth: a large enough scope that interests the audience and a deep enough depth that satisfies the audience.



One of Niels Bohr's weaknesses as a presenter was that he did not leave out details. Bohr's passion for completeness overshadowed his audience's need for clarity. In his Nobel Prize speech, Bohr's passion for completeness can be seen in the long lengths and complex structures of his sentences:

> The present state of atomic theory is characterized by the fact that we not only believe the existence of atoms to be proved beyond a doubt, but also we even believe that we have an intimate knowledge of the constituents of the individual atoms. I cannot on this occasion give a survey of the scientific developments that have led to this result—I will only recall the discovery of the electron toward the close of the last century, which furnished the direct verification and led to a conclusive formulation of the conception of the atomic nature of electricity which had evolved since the discovery by Faraday of the fundamental laws of electrolysis and Berzelius's electrochemical theory, and its greatest triumph in the electrolytic dissociation theory of Arrhenius.[4]

In the second sentence, Bohr's mentioning of one detail (the discovery of the electron) led him to bring a second detail (electricity) into that same sentence. Still in that same sentence, mentioning electricity led him to bring in yet more details: electrolysis, electrochemical theory, and electrolytic dissociation theory. One problem with the addition of those details was that the audience was not prepared for them, because earlier in the sentence Bohr had promised to recall only "the discovery of the electron."

Contrast that dense opening of Bohr's Nobel speech to the clear opening of the Nobel speech that Christiane Nüsslein-Volhard gave:

> In the life of animals, complex forms alternate with simple ones. An individual develops from a simple one-celled egg that bears no resemblance to the complex structure and pattern displayed in the juvenile or adult form. The process of embryonic development, with its highly ordered increase in complexity accompanied by perfect reproducibility, is controlled by a subset of the animal's genes. Animals have a large number of genes. The exact number is not known for any multicellular organism, nor is it known how many and which are required for the development of complexity, pattern, and shape during embryogenesis. To identify these genes and to understand their functions is a major issue in biological research.[5]

In this opening, Nüsslein-Volhard quickly brings the audience from the general (life of animals) to the specific (identifying genes) without leading the audience on unnecessary side paths.

A second way that speakers drown audiences with details is to present them in lists that are too long. As the psychologist John Sweller states, audiences are able to process lists of twos, threes, and fours.[6] Having lists with six, seven, eight, even nine items is overwhelming for most listeners. The effect is that many in the audience will give up, their eyes will glaze over, and they will daydream about their own work. So what happens if you want to present a list of eight items, such as the eight stages of a Hawaiian volcano? As mentioned, you can break the list into two or three categories[7] that the audience can recall more readily:

Building Stages
- Explosive Submarine Stage
- Lava-Producing Stage
- Collapse Stage
- Cinder-Cone Stage

Declining Stages
- Marine and Steam-Erosion Stage
- Submergence and Fringing-Reef Stage
- Secondary Eruptions and Barrier-Reef Stage
- Atoll and Resubmergence Stage

Yet a third way that speakers drown audiences with details is that speakers fail to provide a hierarchy to details so that the audiences can decide which details to hang onto and which details to leave behind. Not all listeners in a presentation will comprehend and retain the same number of details. For that reason, speakers have to be careful to make sure that the audience knows which details are more valuable. Richard Feynman in his introductory lectures on physics at Caltech recognized this predicament. On the one hand, he wanted to challenge the best listeners by presenting tangential details that would expand their thinking, but on the other hand he did not want to lose those who were struggling to keep up with the main points. What Feynman did was to "write a summary of the essentials on the blackboard"[8] at the beginning of each lecture. For his situation, Feynman adopted a strategy of telling the audience up front what the most important details were, and for this situation, that strategy worked well.

Just as Feynman found a way to emphasize his most important details in his famous lecture series on physics, so should you. So, what are possible strategies? As mentioned earlier in this chapter, one way is repetition: mentioning the detail in the beginning, repeating it in the middle, and then repeating it a second time at the end. Another way is similar to what Feynman did: placing key results and images onto the slides and having less important details mentioned only in the speech. Yet a third way to emphasize information is in the delivery: pausing before an important point; raising the voice or, often more effective, lowering the voice; or stepping closer to the audience so that they sense a difference in the emphasis of the presentation.

Notes

[1] A. Zydney, Department Head of Chemical Engineering, Penn State, email to author (12 Mar 2007)

[2] C. Heath, D. Heath, *Made to Stick* (Random House, New York, 2007)

[3] W.D. Wilson, R. Gallagher, *The Need for Supercomputers in Nuclear Weapon Design*, proposal (Sandia National Laboratories, Livemore, 1985)

[4] N. Bohr, The structure of the atom, in *Nobel Lectures*: *Physics*, *1922–1941* (Elsevier, Amsterdam, 1965), pp. 7–43

[5] C. Nüsslein-Volhard, The identification of genes controlling development in flies and fishes, Nobel Lecture (Stockholm Concert Hall, Stockholm, 1995), http://gos.sbc.edu/n/nv/nv.html. Accessed 8 Dec 1995

[6] J. Sweller, Implications of cognitive load theory for multimedia learning, in *The Cambridge Handbook of Multimedia Learning*, ed. by R.A. Mayer (Cambridge Press, New York, 2005), pp 19–30

[7] F.M. Bullard, *Volcanoes of the Earth*, 2nd ed. (University of Texas Press, Austin, 1976)

[8] J. Metra, *The Beat of a Different Drum* (Clarendon Press, Oxford, 1994), p. 486

Critical Error 4
Losing the Audience from the Start

I think from all I hear [that] I was a very difficult lecturer. I started as a lecturer who made things very difficult. I had some help; I remember [Wolfgang] Pauli's advice, almost certainly in '28. He said, 'When you want to give a seminar or lecture, decide what it is you want to talk about and then find some agreeable subject of contemplation not remotely related to your lecture and then interrupt that from time to time to say a few words.' So you can see how bad it must have been.[1]

– J. Robert Oppenheimer

How many times have you seen a presenter project a title slide and then quickly remove it before you had the chance to fathom what the presentation was really about? Or how many times have you had a presenter overwhelm you with an outline list of presentation topics, more than half of which you were unable to remember not one minute after this mapping slide had been removed? Such are the trademarks of presentations in which the presenter leaves the audience behind at the beginning.

Becoming lost at the beginning of a presentation is frustrating for audiences. When the presentation format does not allow for questions until the end or when the size of the audience inhibits the audience from asking for clarification, becoming lost at the beginning often means that the time spent at that presentation is wasted. For that reason, presenters should make it a goal to make the beginning as clear as possible.

While most attendees of a scientific presentation do not expect to understand everything that the presenter puts forward, they hope to understand at least something for the time invested. Unfortunately, many scientific presenters begin as if the audience has had nothing better to do for the previous week than to read every paper that the presenter has written. Why would a presenter make such an assumption? I suspect that in many cases the answer to this question is fear—fear of being considered simplistic. It takes courage to orient the audience to what you have done, because once you have, the audience is in a position to critique your efforts.

So what makes for a strong beginning of a scientific presentation? Imagine yourself in the audience. A few hours or perhaps days earlier, the presenter's title and summary interested you, but now the specific details seem cloudy. From the time you first read the title and abstract and decided to attend the presentation, events have occurred—at a conference, for instance, other presentations have taken place. As the presenter moves to the front of the room, a hush falls over the crowd, and the following questions come to you:

(1) What exactly is the subject?
(2) Why is this subject important?
(3) What is needed to understand or believe the subject?
(4) In what order will the subject be presented?

A strong beginning to a scientific presentation makes sure that the audience has answers these questions.

In some presentations, the speaker does not have to explicitly address all of these questions at the beginning. For instance, the audiences of some presentations might already know the answers to one or even two of these questions. The point is that by the time the presentation's introduction is over, none of these questions should be on the minds of the audience.

What about the situation in which the levels of the audience varies? Often, with a varied audience, some in the audience will not need to have question 2 or 3 answered. Despite that, others will. More than any part of the presentation, the beginning should target the widest possible audience. Although many in that audience will not comprehend every detail in the presentation's middle, if you have a strong beginning, everyone in the audience should be able to go back to his or her colleagues and summarize in a general way what you have done and why the work was important.

How much time should you spend on the introduction? Much here depends upon how much time you have for the entire talk. In a 50-minute talk, an audience will accept up to 10 minutes on the introduction. In a 15-minute conference presentation, though, you should limit the introduction to no more than 5 minutes. Spending too much time on the introduction makes the audience impatient. According to my colleague Dan Inman, when a speaker tells a long story in the introduction of a conference presentation, many people assume that the speaker does not have much to report.[2]

More important than time, though, is the understanding of the audience. According to the Polish physicist Leopold Infeld, Einstein was adept at introductions. Einstein had a "calmness" that contrasted sharply with the "restlessness" that many presenters showed. These restless presenters mistakenly assumed that the audience was equally familiar with the subject matter and proceeded quickly into the details of the talk.[3] Einstein, on the other hand, patiently prepared the audience for the problems about which he would speak.

The beginning should identify the boundaries of the subject

The first question that an audience has about a technical presentation is, "What is this presentation about?" The answer to this question directs the audience to what they should learn from the presentation. Many speakers, unfortunately, do not give satisfactory answers to this question in their presentations. Perhaps, many of these speakers assume that the audience already knows what the presentation is about from the posted title and abstract.

Such an assumption is dangerous. Even if the audience has already read a title and abstract of the presentation, they very likely have done so hours or even days before. Also, because most people remember only a small fraction of what they read, a review is usually welcomed. Finally, the speaker's abilities to emphasize details through the voice's loudness and cadence provide a useful perspective of those details for the audience.

A common mistake of speakers is to go over the answer to this first question too quickly. How many times have you been to a presentation in which the speaker places the title slide up on the screen and discusses it for only 20 or 30 seconds? That is too short. When you begin to speak, the audience has to adjust to your delivery style: your voice, your movements, facial expressions. Such adjustments take a while, and during that time the speaker has to be careful not to overwhelm the audience with too much information.

If you decide to have a title slide, think hard about what information to include. In a conventional title slide, the speaker includes the title, name of speaker, affiliation of speaker, date, and logos of presenting and sponsoring institutions. Typically, such slides are up for only 20 or 30 seconds, while those items are read in an obligatory fashion:

> My name is _____ and I am working with _____ from the ____________ laboratory, and today we are going to discuss atmospheric mercury depletion in polar regions during arctic spring.

Then the slide switches. The effect of this switch on the audience is unsettling. Think about how you feel at this point. Are you comfortable with this talk? Most likely, not. The train has left the station, but the speaker has not appropriately answered any of your initial four questions about the talk.

A much better strategy is to address at least one of those questions before you change slides. To do that, consider including a key image such as what Katrine Aspmo, an environmental scientist from the Norwegian Institute of Air Research, included in her first conference presentation. Like most speakers, Aspmo introduced who the presenters and sponsors were, and that information is important for establishing credibility (what is needed to believe the subject?). However, in identifying the title to her talk, she referred to an image that she placed on her title slide, shown in Figure 3-7, to orient the audience to her subject:

> Today I will discuss depletion of mercury from the atmosphere in polar regions during arctic spring. In the atmosphere all over the earth, including this room, mercury exists. The concentration is not high, only about 1.5 nanograms per liter, and generally it does not

> cause any problems. However, in the polar regions, and especially during the spring, that concentration of mercury sometimes depletes to zero, as depicted in the inset graph on the slide. The question exists: Where does that mercury go? Many people hold the hypothesis that the gaseous elemental mercury depletes into the surface snow. My talk tests that hypothesis by making simultaneous measurements of the gaseous elemental mercury and the amount of mercury in the surface snow over an extended period in the beautiful Ny-Ålesund region of the Arctic shown in the photograph.[4]

Now compare your comfort level at the switch of the first slide in Aspmo's talk with your comfort level at the same point in the first example talk. In Aspmo's talk, you are much more assured that you will learn something.

This strategy of being patient at the beginning is especially important for younger speakers who do not yet carry credibility with an audience. At the beginning of such a talk, many audience members are wondering whether the young speaker will say anything of value or whether the talk will be a waste of time.

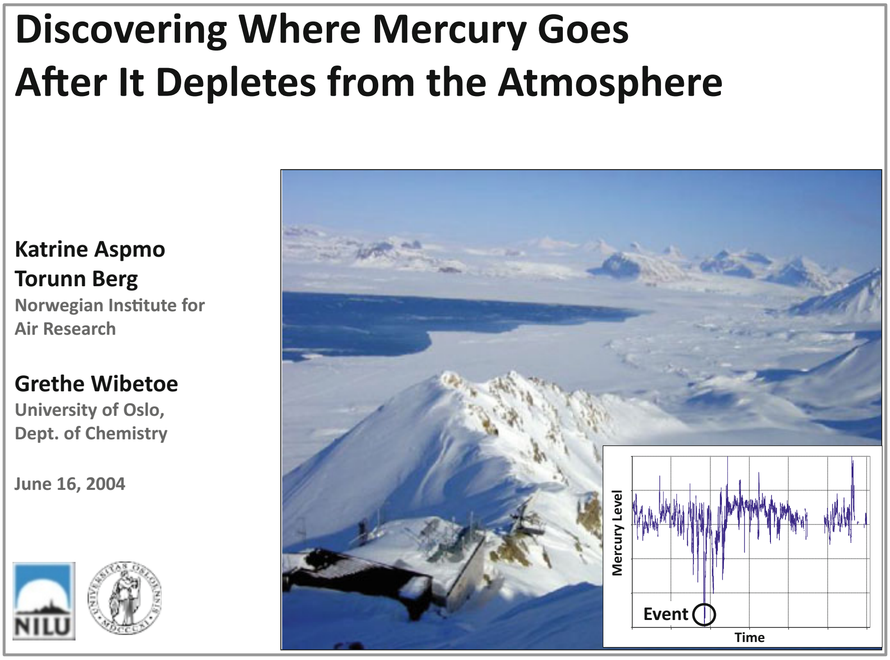


Figure 3-7. Strong example of a title slide.[5] One strength of this slide is the inclusion of images that provide the speaker with an excellent entry point for the subject.

As a young scientist, you should anticipate that assessment and show the audience up front that you will deliver content that is worthy of the audience's investment of time.

The beginning should show the importance

Listening to a presentation is difficult work, so difficult that audiences will give up concentrating if they do not have sufficient reason to do so. Given that, you should not move into the middle of your presentation unless you are sure that your audience understands the importance of your subject. Often, the importance relates to money, safety, health, or the environment. For example, in her talk, Katrina Aspmo went on to mention how scientists have seen increases in mercury levels of arctic wildlife, particularly polar bears. Her research hypothesis (that mercury depletion events lead to increases of mercury in surface snow) then provided a possible source of such increases. Such connections would take but 30 or 40 seconds to make, but would mean much to an audience later in the talk when the slope is steep and energy is needed to stay on the trail.

In other situations, the issue is not so much the importance of the subject, but curiosity about the subject. For example, consider a presentation proposing research to study Jupiter's two largest moons: Ganymede and Callisto. Such research has no direct benefit in terms of saving money, producing energy, protecting the environment, or maintaining health or security. Rather, the main reason for the researcher to study these moons is curiosity—why do these two moons of Jupiter have the same size and density, but dramatically different colors? To give the audience the motivation to stay with the presentation for its duration, the speaker should instill in the audience the same curiosity that he or she has for the work.

In a talk to the general public, Sheila Patek, a biology professor had this type of challenge. At the beginning of her talk, Patek showed a film clip of the feeding strike of a manta shrimp. The strike occurred in an instant. Patek then showed the strike again in slow motion and described the movement of the shrimp's arm: "As you can see, it's a really spectacular extension of the limbs, exploding upward."[6] Then she stated that the question of how fast that arm was moving intrigued her, "because it was moving pretty darn fast in that video."[7] The reaction of the crowd in this presentation revealed that they were clearly now interested as well.

Often, stating the importance of a subject involves grounding the problem in a specific example. Such a grounding helps many in the audience to stay with you through the abstract or mathematical parts of your presentation. Using an example in this way was a favorite technique of Richard Feynman.[8] That technique is often used at Simula Research Laboratory, which pushes the boundaries on computational techniques to simulate processes. Rather than simply discussing the mathematical techniques, such as improvements to the Fast Marching Method to solving Eikonal equations, they typically ground those discussions in a physical problem, such as how to model a deep reservoir of oil.

The beginning should provide needed background and establish credibility

An unspoken fear that many audience members have about attending a scientific presentation is that they will not understand the subject. All too often, audiences find themselves sitting in scientific presentations and having no real idea what is being discussed. Such a situation is frustrating, particularly when the format does not allow the audience to ask a question until the presentation's end. Even if the audience can ask questions, many in the audience will not do so for fear that they will come across as ignorant or out of concern that the question would distract the rest of the audience.

Because different types of audiences often attend scientific presentations, a speaker should be sensitive to the background information that different members of the audience need to understand the presentation. How do you know what background information to provide? This question is not easy to answer. Sometimes, the time limit of the presentation is such that you have few options. In these cases, it is often important to state up front what you are assuming that the audience knows. That way, those who do not have that information can set reasonable expectations for what they will comprehend. In a way, knowing that they will not understand everything in the presentation allows those audience members to relax and perhaps to understand more than they would if they tried to follow every step.

Note that a speaker does not have to give the audience all of the necessary background in the introduction of the presentation. Certainly, background can be provided as the audience needs it during the presentation. Still, the introduction is a wonderful opportunity to clue in the audience to what types of background information will be given later so as to allay any fears by the audience that they will not be able to understand the presentation. Also, some background details, such as the major assumptions of the work, are better placed up front. At times, that kind of background can be so long that it appears to the audience as if it is a separate section of the middle. Moving a background topic from the introduction to a separate section of the talk's middle is an option as long as the middle does not have too many sections and as long as the audience can see the relationship of that background section to the remainder of the talk.

Not all types of background information address what the audience needs to know to *understand* the subject. Some background refers to what the audience needs to know to *believe* the subject. This second type of background then would be details that build your credibility with the audience. Such details often include your institution and your colleagues. These details might also include a review of the literature on which you based your work. Showing that you know the key players in a research area is an excellent way to establish credibility with an audience who does not know you.

The beginning should memorably map the talk

The last of these introductory questions—how the subject will be presented—is more important in a presentation than in a document. Why? Unlike a document, in which the readers can glance ahead to see the headings and subheadings and therefore see what information will occur, the listeners to a presentation have no idea where the presentation is going unless the presenter tells them. In answering this question of how the details will be presented, the presenter reveals in essence the organization of the presentation. When the organization of the talk is clearly and memorably mapped, the audience has a good idea at any point in the presentation about how much has been covered and how much further the presenter has to go. Providing a strong example (Figure 3-8) of this mapping is

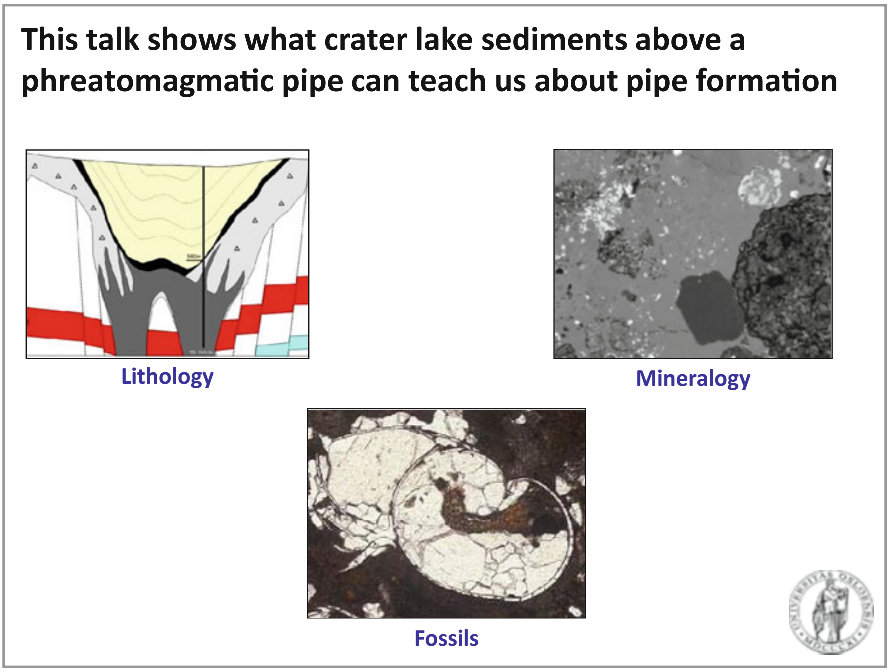


Figure 3-8. Strong example of a mapping slide.[9] One strength of this slide is its use of images to make the mapping memorable. These images are repeated in the corresponding divisions of the presentation. Another strength is that this slide dispenses with unneeded listings such as “Introduction” and “Conclusion,” which every presentation has.

Kirsten Fristad, a geology graduate student from the University of Oslo. Knowing how much more remains in a presentation is important, because listeners have to pace themselves. Listening is hard work, and asking someone to listen, especially to a scientific presentation, without giving a clue as to how much longer the talk will last, is similar to taking that person on a challenging hike without clarifying the course to the destination. Because the person does not know how far he or she is going, the person quickly tires.

Notes

[1]T.S. Kuhn, Interview with J. Robert Oppenheimer (20 Nov 1963), p. 18; *Robert Oppenheimer*: *Letters and Recollections*, ed. by A.K. Smith, C. Weiner (Harvard University Press, Cambridge, 1980), p. 131

[2]D. Inman, Department Head of Aerospace Engineering, University of Michigan, interview with author (13 Feb 2001)

[3]L. Infeld, *Quest: The Evolution of a Scientist* (New York, Doubleday, Doran & Co., 1941), p. 255

[4]Adapted from K. Aspmo, T. Berg, G. Wibetoe, Atmospheric mercury depletion events in polar regions during arctic spring, presentation (University of Oslo, Oslo, 16 June 2004)

[5]Idem.

[6]S. Patek, Measuring the fastest animal on earth (TED Talk sponsored by BMW, Monterey, 2004), www.ted.com/. Delivered Feb 2004

[7]Idem.

[8]R.P. Feynman, *Surely, You're Joking, Mr. Feynman!* (Norton & Company, New York, 1985), pp. 108–109

[9]K. Fristad, H. Svensen, Ø. Hammer, End-Permian Crater Lake Sediments in the Tunguska Basin, Eastern Siberia, presentation (University of Oslo, Oslo, 23 Feb 2009)

Critical Error 5
Losing the Audience on the Trail

> *Divide your talks up into sections, and know roughly how long they take. Know how to get in and out of the sections, but don't be too rehearsed within them. My talks look spontaneous because they are, but within a structure that stops me from wandering off.*[1]
>
> – Brian Cox

In 1860, James Clerk Maxwell, who is considered the father of electrodynamics and one of the greatest physicists of the last two centuries, applied for a chaired professorship at the University of Edinburgh. He did *not* get the job.

Instead, the position went to Peter Guthrie Tait. According to an article in the Edinburgh *Courant*, the reason for Maxwell not getting the position was his lack of skill at speaking.[2] The reasoning of those who made the selection was that whoever taught had to be able to communicate to an audience (the students) that would not know the subject. What made people consider Maxwell a weak speaker? According to one of his students, C.W.F. Everitt,[3] Maxwell prepared lectures that were well organized. He wrote them out in a form that Everitt claimed was "fit for printing."[4] However, soon after beginning to lecture, Maxwell would digress onto a long tangent, filling the blackboard with equations and illustrations, thinking out loud, and surpassing the comprehension of his audience. Maxwell's tangential discussions went on so long that the lecture time would run out, and his original organization would not be presented.

As mentioned in Chapter 1, a major disadvantage of presentations is that the audience does not have the luxury, as they have in a document, to go back and reread a passage. For that reason, an audience can easily become lost. Even when the speaker is careful, the audience can become distracted and fall behind. How many times in a presentation have you started contemplating a connection between the speaker's work and your own work and then snapped back to the presentation, only to discover that the speaker has moved higher up the mountain and that you are unsure what has transpired?

Given the inherent potential for the audience to become lost even when the structure is sound, consider how easy it is for the audience to become lost when the structure is weak. Several instances can arise in a presentation to cause the audience to become lost. One occurs when the presenter gives a presentation that contains gaps in logic, or, figuratively speaking, when the presenter charts a trail over chasms that the audience cannot cross. A second instance occurs when the presenter does not clue in listeners about a major change of direction. Yet a third instance occurs when the presenter exhausts the audience with too many details (too long a trail).

The speaker has to choose a destination that the audience can reach

When describing the presentations of Niels Bohr, Einstein said, "[Bohr] utters his opinions like one perpetually groping and never like one who believes himself to be in possession of definite truth."[5] C.F. von Weizsäcker claimed that Bohr's presentations reflected the great physicist's way of thinking, which Bohr himself had compared to a Riemann surface.

Rather than presenting those subjects with which he was grappling, Einstein chose to present those topics that he felt he understood. That strategy makes sense: If the speaker cannot clearly see the destination, how can he or she expect to lead the audience there? Not surprisingly, Einstein came across to audiences as much more lucid and confident than Bohr did.

This difference between the presentations of Einstein and Bohr raises an interesting question: Should engineers and scientists present only what they know to be stone-cold facts? Or

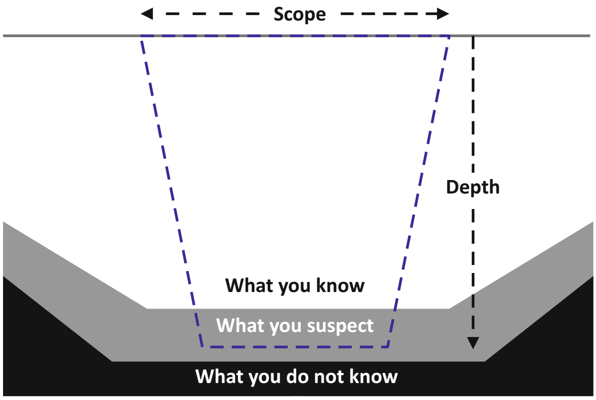


Figure 3-9. Boundaries of a presentation in which the depth goes to a level at which the presenter is not certain whether the results are true.

should they expand the boundaries and present what they strongly suspect to be the case, as depicted in Figure 3-9?

In the latter case, if the charted trail does not actually lead to the destination, as in the claim for cold fusion made by two researchers at a press conference on March 23, 1989, then the presenters could be embarrassed.[6] However, if the ideas prove to be correct, then the presenters stand to receive credit for the bold step. Such was the case for James Watson and Francis Crick when they proposed the double helical structure of DNA. Interestingly, Rosalind Franklin's notebooks from the winter of 1952–1953 reveal that she was very close to finding the structure for DNA.[7] Unlike Watson and Crick, though, she was much more cautious about making jumps.

A scientist who took bold leaps in presentations was Linus Pauling. Pauling's courage (some might say audacity) went well beyond presenting theories that were not fully validated in the laboratory. On several occasions, Pauling presented theories that were, at best, sketchy. In some cases, Pauling was simply wrong, as was the case in his theory that antibodies fastened themselves to antigens by curling up around them.[8] However, many times Pauling was correct or at least close enough that he received credit for the idea. One example was his argument for the chain theory to explain the structure of proteins. That theory went against the cyclol theory, which at that time had a much stronger mathematical basis and was much widely more accepted by the scientific community.

Given the dramatically different outcomes in the examples above, this question of whether to present your suspicions, even strong ones, is difficult to answer. On the one hand, the safe advice is that you should present only what you know for certain. In doing so, you reduce the risk of making an error or embarrassing yourself. On the other hand, one of the advantages of making a presentation is that you can receive feedback from the audience about your work. If you are stuck on a problem, presenting a "straw-man" solution to an audience could trigger a suggestion from the audience that would help you solve the problem. In some situations, you could view presentations as tests for ideas. What is important is that you should make it clear to the audience when you are presenting ideas solidly grounded in theory and experiment and when you presenting your own suspicions of what is true.

Also, much about this question depends upon the audience, the purpose, and the occasion. If you are reporting to an audience in which you cannot afford to stumble, then relying on facts makes sense. For instance, if you are a researcher presenting your work to the organization that funds your studies, it would be wise *not* to take large risks. With a more forgiving audience, though, such as the colleagues with whom you have established credibility, taking a chance would probably have fewer consequences. Another variable is how much risk you are willing to take. Linus Pauling risked much, yet reaped much from his risks.

Some situations, such as a conference presentation, allow you the luxury of defining your scope and limitations for that year's presentation. Unless you are concerned that another researcher will beat you to the result, you can do as Einstein did and stick with what you know. Other situations, however, demand that you present your results even when you do not yet completely understand them. One such example was the situation facing Morton-Thiokol engineers just before the launch of the Space Shuttle Challenger.

However, what should be your strategy in discussing those results with which you are grappling? A tendency for presenters is to downplay such results in a presentation. However, such a strategy runs the risk of having those results not included in important decisions by the audience. Such a strategy also risks having those downplayed results exposed as uncertainties during question periods. After all, during question periods, the audience members typically focus on the portions of the presentation that they did not understand. A strategy that differs from the "downplaying strategy" is to follow the adage at Dow Chemical: *If you can't fix it, feature it.*[9] In other words, if you do not understand a result, then let the audience know up front that you do not understand it. However, make it an emphasis of the presentation that you are seeking an answer to the result in question.

The speaker has to signal changes in direction

Becoming lost on a hike is an uncomfortable experience. The more that you hike, the more tired you become and the less sure you are that you will reach the destination. Although not nearly as unsettling as being lost on a hike, being an audience member lost in a presentation is also disconcerting. You are not sure where you are in the presentation. Are you at the end of the beginning, the beginning of the middle, or the middle of the middle? Because the speaker has not kept you on track, you concentrate more and listen for clues from the speaker. The harder that you listen for clues on where you are, though, the more tired you become. To avoid such frustration by the audience, speakers should be sensitive to keeping the audience on course, especially when the presentation changes direction.

As was shown in Figure 3-4, certain places in a presentation naturally have a shift in direction: from the beginning to the middle, from the first division of the middle to the second division, and so forth. These transitions are important in helping the audience to remain on course. The transitions occur on two different levels. On the first level are the transitions between the beginning and the middle and between the middle and the ending. The transition between the beginning and the middle is important for allowing the audience to assign details to each of the major divisions of the presentation.

As mentioned earlier in the chapter, the shift between the middle and the ending is important for emphasis reasons. Because an audience will sit up and pay more attention during the ending of a presentation, the speaker should make it clear when the ending is upon them. Unfortunately, many inexperienced speakers do not clue in the listeners that the ending is upon them. Rather, these speakers race into port and abruptly ask the audience, “Any questions?” The audience, unprepared for the ending, has lost the opportunity to think about the work from a big-picture perspective and to assess which aspects of the presentation were most important. This mistake diminishes the chances that the audience will catalogue and remember the important details of the presentation.

A second level of transitions occurs between each segment of the middle. Ideally, middles are broken into two, three, or four divisions. For the audience to pace themselves in the middle, the audience has to know where the speaker is: in the first division, in the second division, and so on. For that reason, the speaker should make clear those transitions between each division of the middle.

So how do you make the transitions for those shifts? Several ways exist. The most straightforward occurs in speech. For instance, in moving from the first section of a talk’s middle to the second section, the speaker could state that transition explicitly: “That concludes what I wanted to say about the building stages of Hawaiian volcanoes. Now I will consider the declining stages.” For the transition between the middle and the ending, the speaker can use phrases such as “in summary” or “to conclude this presentation.”

An additional way to make transitions between segments of a presentation is a change in slides. Figure 3-10 shows the mapping slide and three transition slides from a presentation

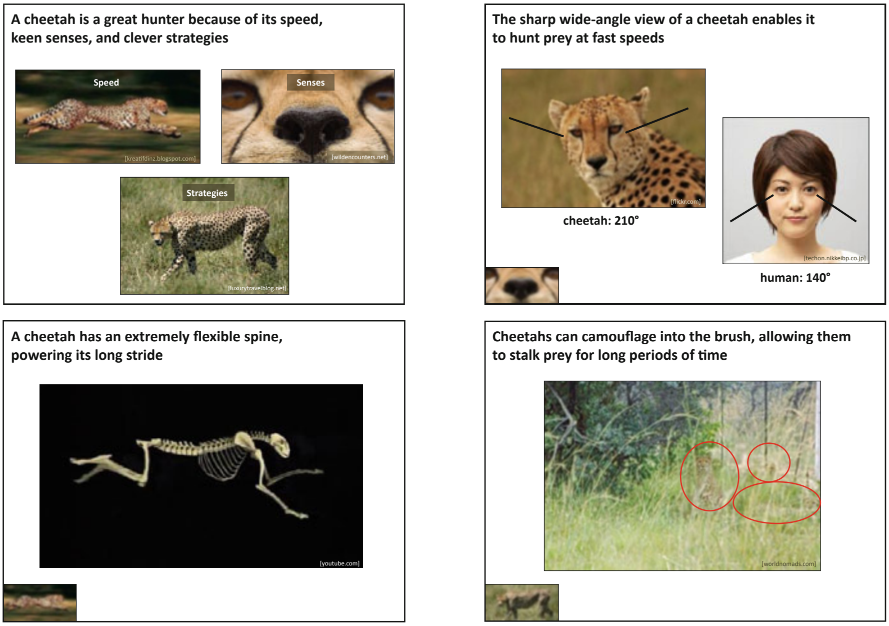


Figure 3-10. Transition slides from a presentation on why the cheetah is such an excellent hunter.[11] The *top* left panel is the mapping slide with key images. The *bottom* left panel is a slide from the first division of the middle. The *top* right panel is a slide from the second division of the middle, and the *bottom* right panel is a slide from the third division of the middle.

on what makes the cheetah such a great hunter. The mapping slide for the presentation includes a key image for each of the three divisions of the presentation's middle. Each image is then repeated as a small icon in the bottom corner on all the slides for that image's corresponding division. Also shown in Figure 3-10 is a slide from each of these three divisions. By showing these icons throughout the presentation's middle, the speaker continually reminds the audience where they are in the middle—in the first division, in the second division, or in the third division.

Delivery also provides excellent ways to signal a transition between sections of a presentation. One signal is a pause. In a presentation, a pause is not initially taken as a sign that the speaker is lost. Rather, the audience assumes that the speaker is collecting his or her thoughts. Moreover, a pause in a presentation, like the white space after a section in a document, allows the audience to collect their thoughts as well. After all, in a successful presentation, everyone is working: the speaker to deliver the details and the audience to sort, synthesize, and analyze those details. Well-placed pauses allow that sorting, synthesis, and analysis to occur.

Other aspects of delivery can signal a transition in a presentation. One signal is the gesture of holding up one, two, or three fingers when mentioning that you are now covering the first, second, or third division of the middle. Another signal is the raising (or lowering) of your voice when beginning a new section. Yet another is moving closer to the audience at each main division of the presentation. A fourth is adopting a certain position, perhaps behind the podium, at start of a new division. In his series of "Messenger Lectures" given at Cornell University,[10] Richard Feynman returned to the podium, paused, and glanced at his notes between each segment of his presentation. These repeated motions of delivery provided a clear signal to the audience of the lecture's divisions.

Notes

[1] B. Cox, Professor of Physics and Astronomy, University of Manchester, email to the author (5 Mar 2009)

[2] I. Tolstoy, *James Clerk Maxwell: A Biography* (University of Chicago Press, Chicago, 1982), p. 98

[3] C.W.F. Everitt, *James Clerk Maxwell: Physicist and Natural Philosopher* (Charles Scribner's Sons, New York, 1974), p. 54

[4] Ibid., p. 54

[5] A. Einstein, letter to B. Becker (24 June 1920); also in Abraham Pais, Einstein on particles, fields, and the quantum theory, in: *Some Strangeness in the Proportion: A Centennial Symposium to Celebrate the Achievements of Albert Einstein,* ed. by H. Woolf (Addison-Wesley, New York, 1979), p. 212

[6] P.N. Saetta, Ask the experts, *Scientific American Online* (2002), http://www.sciam.com/askexpert/physics/physics6.html. Accessed 18 May 2002

[7] A. Klug, Rosalind Franklin and the Discovery of DNA, *Nature* (24 Aug 1968), pp. 808–810, 843–844

[8] A. Serafini, *Linus Pauling: A Man and His Science* (toExcel, San Jose, 1989), pp. 74–75, 101

[9] H. Robertshaw, Professor of Mechanical Engineering, Virginia Tech, Blacksburg, personal communication with author (15 Jan 2002)

[10] R. Feynman, *The Character of Physical Law*, part of the Messenger Lecture Series (Cornell University, Ithaca, 1965)

[11] C. Greenley, B. Milligan, P. Sahd, M. Vulih, The physical characteristics that make the cheetah a great hunter, presentation (Penn State, University Park, 7 Dec 2011)

Critical Error 6
Not Anticipating the Audience's Bias

> *At the end of the presentation, when the speaker asked for questions, Professor Sigmar Wittig rose and said flatly, 'Sir, I have been listening to your talk for the past fifteen minutes, and I don't believe a word that you have said. In two minutes, using the First Law of Thermodynamics, I can prove that everything you have presented is nonsense.' The speaker turned pale. But I turned paler, because the next day I was to give my presentation, the first of my career, and Professor Wittig was sure to be in attendance.*[1]
>
> – Karen Thole

The legend goes that in the 1980s a committee of U.S. scientists was assigned to determine which areas of the country would be finalists for the location of a nuclear waste repository. Most of these places under consideration were rural. After carefully considering the local geography and other criteria, the committee made its selections. Before these selections were to be made public, the Department of Energy requested that these scientists go to the various sites, inform the local residents of the decision for that site, and answer questions that the people had.

At the first location, which was in a western state, the scientists held a meeting in a town hall and adopted the old strategy, *Tell them what you're going to tell them; tell them; tell them what you told them.* The strategy failed miserably. As soon as the scientists announced the decision that this site was a finalist for the nuclear waste repository, the crowd of ranchers and farmers unleashed a firestorm of questions: Why were we chosen? What will happen to our livestock? What will happen to our crops? How safe will it be to drink the water? The scientists tried as best they could to reassure the audience that their decision in no way would affect the ranching and farming that went on in the area. In fact, this place was chosen for that very reason:

The geography of the area was such that the ranching and farming would be able to continue without effect. However, the attempt to pacify the crowd came too late in the presentation. Everyone in the town hall was speaking at once, and many in the crowd had stopped listening to the scientists. The ruckus continued with many in the crowd leaving in disgust and those who remained holding to their position of "not in my back yard." When the meeting finally concluded and the scientists walked out to their rental car, they saw that someone had dropped a load of manure on top of it.

Clearly, these scientists had not accounted for the bias of their audience.

Understanding the bias of the audience helps you decide both the strategy and the energy required for a successful argument. For instance, solidifying support with an audience that already leans toward your position or is neutral toward your position is not nearly as challenging as garnering support from an audience that is antagonistic to the position. As discussed in Critical Error 1, engineers at Morton Thiokol were able to persuade their management that the launch of the space shuttle *Challenger* should be delayed until the temperatures were warmer. However, these same arguments made to NASA later in the day did not succeed. The main reason was that the initial bias of NASA against a delay was much stronger than the initial bias of Morton Thiokol's managers.[2]

Sometimes, the initial bias of an audience is the overriding factor in determining the success of a presentation. Contrast the failed one-on-one presentation of Niels Bohr with Winston Churchill in 1944 with the surprisingly successful one-on-one presentation of Edward Teller with President Reagan in 1982. In Bohr's meeting with Churchill, his purpose was to have Churchill realize the potential nuclear weapons race that Bohr anticipated would follow the Second World War. However, Churchill, who was already defensive about his decision to relinquish intellectual rights to nuclear weapons, ended the meeting after only 20 minutes and asked Bohr to leave.[3] The purpose of Teller's meeting with Reagan was to persuade him to change the United States nuclear weapons policy of mutually assured destruction to a policy of a strategic defense initiative. Given the resistance in the military to such a change and doubts by other scientists such as Hans Bethe as to the potential of the initiative, such a goal seemed out of reach. However, the receptiveness of Reagan and some of his advisors to an alternative to mutually assured destruction proved to be an ally for Teller. The result of that meeting and a later meeting between Teller and one of Reagan's advisors led to the dramatic shift in nuclear weapons policy in March 1983.[4]

An audience is more likely to believe your argument if they know and appreciate the assertions

In his widely acclaimed book *The Uses of Argument*,[5] Stephen Toulmin argues that an audience is much more likely to believe your argument if they know and appreciate your assertions. In a scientific talk, these assertions would be your claims, insights, features, and results. Scientists and engineers would do well to heed this advice. However, when you are putting together a presentation, what exactly does following this advice mean?

Perhaps the most important step in following this advice is for you to recognize exactly what it is that you are asserting. In one of his much publicized talks,[6] Hans Rosling shows a graph of life expectancy of people in different countries versus fertility rates of women in those countries. Here, fertility rate was defined as how many children the women typically bear. Figure 3-11 shows the graph for 1962, which was the first year. In the talk, Rosling showed how this graph changes from 1962 until the present. In other words, Rosling had the data for 1962 be replaced by the data for 1963, which was replaced by the date for 1964, and so forth. In the talk, these updates occurred at a quick pace—about 1 year a second. In addition, during these updates, Rosling excitedly called out detail after detail on

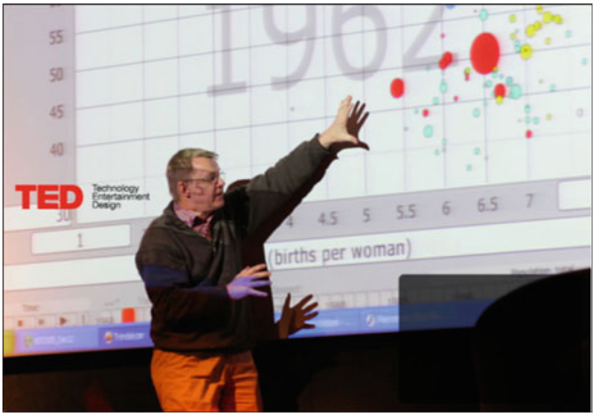


Figure 3-11. Hans Rosling presenting at TED.[9] In the graph, the *y-axis* is life expectancy, and the *x-axis* is fertility rate. Each *bubble* represents a country, with the size of the bubble reflecting the country's population. Each *color* represents a different continent. This graph shows the data for 1962.

what was occurring in different countries: for instance, how China moved, how India moved, and so forth.

What unified all these details and what inevitably made this presentation so powerful was that every detail supported Rosling's main assertion: *Since 1960, most under-developed countries have gone from large families and relatively short lives to small families and relatively long lives*. For Rosling, the assertion or what he calls the "punch line," was where the preparation for the presentation began.[7] In other words, before putting together the presentation, Rosling identified the main assertion or result of the data. Then, once he knew what the main assertion was, he was in a position to decide on the best way to graph the data and present the graph to the audience. In his talk, every detail spoken and shown led the audience to understand the main assertion.

A second important step in having the audience understand and appreciate your assertions is making sure that the audience is in a position to accept the assertion. Put another way, some assertions are so high up the mountain that you cannot with a single graph or set of data expect the audience to reach that point of acceptance. What you have to do instead is create a chain of sub-assertions that allow the audience to move high enough up the mountain that they can accept your main assertion.

For instance, suppose that it is the early 1990s and you are making a proposal presentation to the U.S. Department of Transportation for funds to assess new methods to detect plastic explosives in airline luggage. A key section of your proposal will be to persuade the audience of the following assertion: *New methods are needed to detect plastic explosives in airline luggage*. In the proposal presentation, you have to emphasize this assertion. However, the audience is not yet prepared to accept this assertion. Before the audience will accept this assertion, the audience will have to accept two supporting sub-assertions.

(1) Plastic explosives placed in baggage pose a threat to airline safety.

(2) Current methods for detecting plastic explosives in baggage are ineffective.

If you can persuade the audience of these two sub-assertions, you can bring the audience high enough up the mountain to accept the main assertion. The ascension up this particular mountain is represented in Figure 3-12.

Now to have the audience accept the sub-assertions, you will need evidence. For instance, to have the audience accept the first sub-assertion, you might discuss the tragic example of Pan Am Flight 103 and then present statistics on the number of other aircraft downed in the previous decade by plastic explosives placed in cargo baggage. To have the audience accept the second sub-assertion, you could provide theory showing that a conventional x-ray machine cannot distinguish plastic explosives.

A third step in having your audience understand and appreciate your assertions is to give the audience key pieces of background (what lawyers call *warrants*). For example, suppose that you wanted the audience to accept the following assertion: *An important goal to improve jet engines is to reduce the leading edge vortices on the engine's turbine blades*.

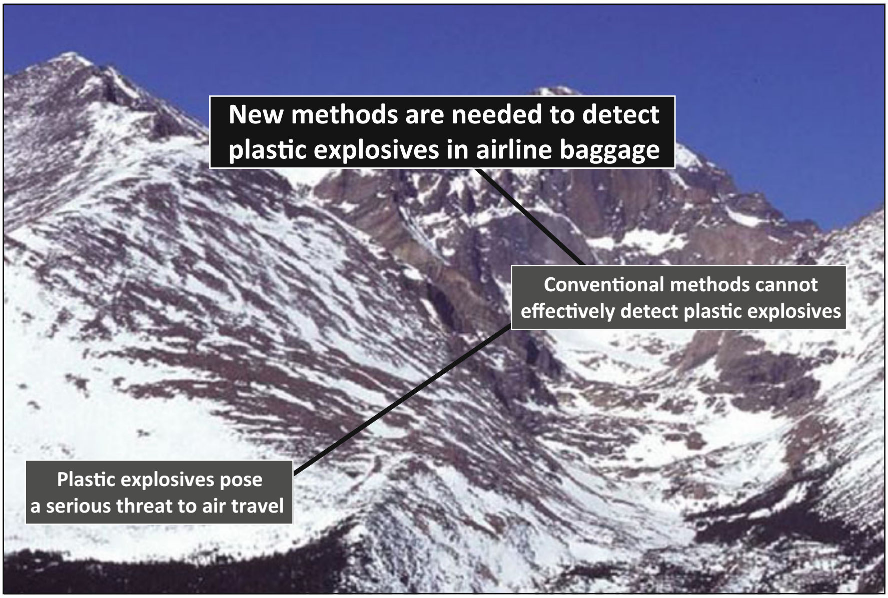


Figure 3-12. Mapping of how sub-assertions can help an audience reach a main assertion in a presentation.

For a general audience to appreciate that assertion, the audience would have to know certain pieces of background information. First, combustion gases that flow over turbine blades are at a temperature significantly higher than the melting temperature of the blades. A second piece of information would be that to prevent the blades from melting, air from the outside is channeled in through holes on the blades to create a protection film from the hot gases. Yet a third piece of background information is that at the leading edge of the blades, vortices from the combustion gases pull away that protective film, exposing the metal to the hot gases. Knowing those three pieces of background information, the audience can appreciate the assertion. The challenge for scientists and engineers is to step away from their work and to look at the assertions as the audience will look at those assertions. Put another way, scientists and engineers have to overcome what the Chip Heath and Dan Heath, in their book *Made to Stick*, call the Curse of Knowledge—that is, when experts "forget what it is like *not* to know what [they] know."[8]

An effective argument provides ample evidence for the assertions

To support your assertions, you can incorporate several different types of evidence. According to Aristotle, this evidence falls into three categories: appeals to logic, appeals to the emotion of the audience, and appeals to your own character. If asked which of these categories exerts the greatest influence on them, most engineers and scientists would name appeals to logic. However, the appeals to character and emotion play much more important roles than most scientists and engineers realize. Moreover, many political decisions about science and engineering are not made by engineers and scientists. Rather, politicians make these decisions, and these individuals often are swayed by appeals to character and emotions. For that reason, you should account for the influence of all three appeals.

Appeals to Logic. Logical evidence includes deductive and inductive reasoning, statistics, referenced findings, examples, and analogies. Not all of these have the same level of strength, as suggested by the ranking in Table 3-1. For instance, deductive reasoning and inductive reasoning are the most powerful, while analogies when used to propel arguments usually follow the axiom as being the "weakest form of argument."

Deductive reasoning often takes the form of a syllogism: Given A and given B, then C follows. A good example of how deductive reasoning influenced a persuasive presentation occurred in the 1980s decision by the United States Congress on where to place a huge particle accelerator, which was named the superconducting supercollider. Because this experiment was to create hundreds of jobs and bring millions of dollars into the local area, more than 43 proposals were submitted for the site. Ellis County, Texas, which won the contract, used deductive reasoning in its arguments.[10] This reasoning followed the premise that the collider site had to meet several criteria, including relatively flat terrain, few freezing days, little seismic activity, and low rainfall. For each of these criteria,

Table 3-1. Different types of logical evidence in descending order of strength.

Type of evidence	**Example**
Deductive reasoning	The site for supercollider must meet 13 criteria. Ellis County is the only place that meets all these criteria. Therefore, Ellis County should be the site of the supercollider.
Inductive reasoning	The gravitational force
Referenced facts	The combustion gases in a gas turbine engine reach temperatures more than 500 °C hotter than the melting temperature of the turbine blades downstream of the combustor[11]
Statistics	Reducing the temperature on a gas turbine blade from 1,140 to 1,090 K increases the blade's life from 560 to 3,900 hours[12]
Examples	Earthquakes can cause many deaths. For example, the 1976 earthquake in Tianjin, China, killed more than 242,000 people.[13]
Analogies	Just as the designs for atomic bombs were reduced from the bulky size in Fat Man to the size of a soccer ball within a decade, so too could designs of neutron bombs, making them extremely dangerous as tools for terrorists[14]

some of which are shown in Figure 3-13a, the presenters of the proposal used referenced facts and the opinions of experts to assign a cut-off value. The establishment of these criteria formed the A-portion of the syllogism. Then with a map of the United States, the presenters used overlays as shown in

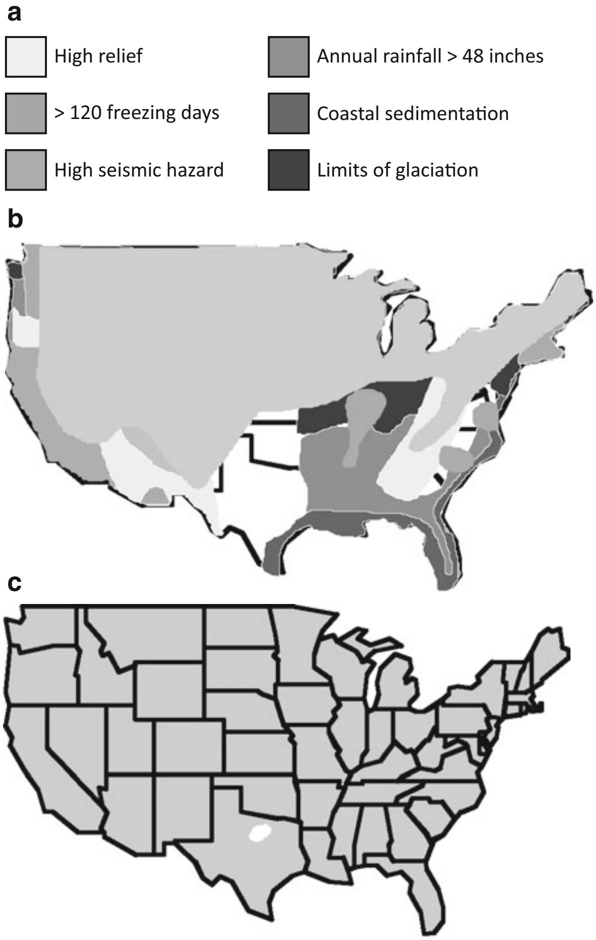


Figure 3-13. Deductive reasoning used by presenters to show that Ellis County, Texas, was the best site for the superconducting supercollider.[16] The reasoning involved first establishing the site criteria, some of which are listed in (**a**). Then, as shown in (**b**), those criteria were applied in overlays to a map of the continental United States. As shown in (**c**), only one area of the country, Ellis County, satisfied all the criteria.

Figure 3-13b to shade those parts of the country that did not meet the stated criteria. This application of the criteria to the map constituted the B-portion of the syllogism. When all the overlays had been placed upon the map, only one small circle in Ellis County, Texas, remained without shading, as shown in

Figure 3-13c. That statement became the C-portion of the syllogism and the main evidence that contributed to the awarding of the contract.

Statistics are a form of logical evidence in which the effectiveness varies widely. At the more persuasive end are experimental data that show definite trends. At the weaker end is the comparison of data that are not comparable. For instance, an often quoted statistic concerns the amount of research funding from the National Institutes of Health (NIH) that has gone to fight the AIDS epidemic. In 1998, for example, NIH distributed $2,400 per patient in research funds to fight AIDS, which was the number-17 killer in the country that year, but spent only $108 per patient to fight heart disease, which was by far the number-one killer in the country that year.[15] The statistic suggests that too much money was being spent on fighting AIDS. That assertion might very well be valid, but the statistic does not account for all variables: how recently AIDS was discovered, how quickly the number of deaths from AIDS had risen, the severity of prognosis for AIDS in terms of life expectancy, or how much progress in fighting AIDS those research dollars had produced.

As with the power of statistics, the power of examples varies dramatically. The power of an example depends upon the assertion that it is to support. For instance, to support the argument that a drug is dangerous, a single example of someone who was harmed by the drug can be powerful. However, to support the argument that a drug is safe, a single example of someone who used the drug with no side effects does not carry much weight.

Although useful for explaining how things work or how large things are, analogies are generally not effective for supporting assertions in an argument. Essentially, analogies show that two dissimilar things, when looked at from one perspective, have a common tie. Given this narrow perspective, a skeptical audience can easily point out differences when those things are compared from other perspectives.

Appeals to emotion. While scientists and engineers agree that appeals to logic are important in an argument, scientists and engineers often underestimate the importance of appeals to emotion, especially when the audience making the decision is nontechnical. For instance, greatly influencing the political decision to stop building nuclear power plants in the 1980s was the appeal to the emotion of fear made by antinuclear groups. Although the nuclear power industry countered with logical evidence such as the statistic that coal plants emit far more radiation than the typical nuclear power plant, the appeal to fear by the antinuclear groups had the larger influence.

Numerous examples exist in which appeals to emotion significantly influenced decisions: protecting the habitat of endangered wildlife, protecting wetlands and coasts from oil spills, and increasing the research funds to fight a disease. As mentioned, an interesting case has been the amount of research funding from the National Institutes of Health (NIH) that has gone to fight the AIDS epidemic. Certainly, the relatively recent discovery of AIDS and its rapid increase in cases account for much of this funding, but also contributing have been the emotional and widely publicized appeals for research funding from AIDS activists.

Appeals to character. An appeal to the character of the speaker can have a deep influence in a persuasive presentation. If a relatively unknown scientist suggests that Vitamin C is the most important vitamin for a long and healthy life, that suggestion does not receive nearly as much attention as when Linus Pauling, a Nobel Prize winner, makes the same suggestion. Likewise, when some relatively unknown engineer expresses concern that the size of a neutron bomb could be reduced to the dimensions of a soccer ball (thus making it an extremely dangerous weapon for terrorists), that statement does not carry nearly as much weight as when it is made by Sam Cohen, the inventor of the neutron bomb.[17]

Even those of us without such credentials can use this type of appeal effectively, such as when we adopt a position that is counter to our background or history. For instance, Walter Mossberg's argument a few years ago against a proposed operating system for Apple's Macintosh computer began with the point that he did not relish taking that position. After all, over the years, he had been a staunch Macintosh supporter and was quoted widely in many of Apple's advertisements. However, he felt that the released operating system demanded too much faith on the part of Macintosh's users.[18]

Character includes your reputation with audiences. Chien-Shiung Wu, the physicist who performed the first experiment showing that nuclear particles violate the law of parity, earned a reputation as a physicist whose work was to be trusted.[19] Such reputations come only after hard work and many tests. When Wu found a result that did not agree with the results of someone else, she did not end her argument by simply showing that her results were correct. She also worked to show why the other results were incorrect.

Character also includes your connection to the audience. As mentioned, Michael Faraday and Ludwig Boltzmann in their talks made personal connections to their audiences. These personal connections were appeals to character that were designed to earn respect. Faraday believed that for a speaker to be effective, the audience must like and trust the speaker.[20] To achieve that respect, Faraday believed that the speaker should first respect the audience. Boltzmann held that same respect for his audience. According to Fritz Hasenöhrl, who was a student of Boltzmann, "[Boltzmann] never exhibited his superiority. Anybody was free to put questions to him and even to criticize him. The conversation took place quietly and the student was treated as a peer. Only later one realized how much he had learned from him."[21]

With an antagonistic audience, building credibility is crucial

In cases in which you desire to win over an audience antagonistic to your position, do not set your expectations too high. As the physicist Max Planck asserted, "An important scientific innovation rarely makes its way by winning over and converting its opponents—it rarely happens that Saul becomes Paul."[22] Although you might have little success winning over your opponents, using one of the following strategies given in this subsection can help you reduce the opposition to your position and perhaps win over those who are neutral on the subject.

One strategy is to define the question up front, but not to give away your results. If those in the audience who are opposed to your results do not know your position, they are much more likely to listen to your arguments. In essence, if your position is unknown to an audience antagonistic to the results, you have much more credibility than if your position is known. Granted, if the initial bias of the audience is strong, you probably will not change their minds by the presentation's end, but you are in a much better position to reduce their vehemence against your position. The reason is that they are much more likely to listen to your arguments.

A second strategy, named the Rogerian strategy for the psychologist Carl Rogers,[23] is to show that you truly understand the opposition's main arguments. In other words, you extend an olive branch to the opposite side by recognizing the strengths of their argument before you begin with a defense of your own. What this olive branch does is to reduce the initial antagonism that the audience has to you and makes them more inclined to listen to your arguments. In essence, this strategy builds your credibility with the audience. Such a strategy works well when the goal is not to win the other side over, but to reach a compromise with the other side.

Notes

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[8]C. Heath, D. Heath, *Made to Stick: Why Some Ideas Survive and Others Die* (Random House, New York, 2007), p. 46

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[11]K.A. Thole, Professor and Department Head, Mechanical and Nuclear Engineering, Pennsylvania State University, private communication to the author (Nov 2001)

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[16]State of Texas, *A Proposed Site for the Superconducting Supercollider* (Texas State Railroad Commission, Amarillo, 1985)

[17]S. Cohen, inventor of the neutron bomb, http://tribune-review.com/ruddy/061597.html, interview with Christopher Ruddy (*Pittsburgh Tribune-Review*, Los Angeles, 15 July 1997)

[18]W.S. Mossberg, Sticking with the Mac will require patience and big leap of faith, *Wall Street Journal* (3 Oct 1998), p. B1

[19]S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 269

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Chapter 4

Visual Aids: Your Supporting Cast

Is there anything so deadening to the soul as a PowerPoint presentation?[1]

–John Schwartz

In the mid-nineteenth century, chalkboards were a novelty. Institutions would boast about having the only chalkboard in a 100-mile radius. At first, audiences were excited just to have a chalkboard as part of the presentation. Over time, though, presenters started using the boards in more sophisticated ways: rulers to make lines, chalk tied to string to make circles, and colored chalk to show features. Some scientists and engineers were admired for the way they used the chalkboard. For instance, Ludwig Boltzmann was considered a master of board work, using one large board for main equations and two smaller boards for intermediate steps.[2] Another master was Richard Feynman. He planned many of his lectures such that the writing for the lecture began in one corner and ended in the opposite one.[3]

Not surprisingly, as audiences saw chalkboards used in these more sophisticated ways, their expectations increased.

Currently in science and engineering, projected slides are the visual aid of choice. At conferences and meetings, slides are the dominant visual aid, with the projector often turned on at the beginning of a session and not turned off until the session's end. Moreover, in classrooms around the world, presentation slides have a prominent role. Not only do teachers project slides to communicate the course material, but students

M. Alley, *The Craft of Scientific Presentations*,
DOI 10.1007/978-1-4419-8279-7_4,

use slides in project presentations to demonstrate what they have learned.

Just as the use of the chalkboard evolved in the nineteenth century, so too is the use of projected slides. Unfortunately, as reflected by the harsh criticism of PowerPoint in the past decade, the evolution to effective slides is moving much too slowly. From *The New Yorker* article "Absolute PowerPoint"[4] to Edward Tufte's "PowerPoint is Evil"[5] to "Research Points the Finger at PowerPoint"[6] in *The Sydney Morning Herald*, the criticism is caustic. One common criticism focuses on the overwhelming number of details on slides. Another common criticism concerns the tiresome drumbeat delivery that bulleted lists produce.[7]

Because slides are used so often in scientific presentations and because that use has received so much harsh criticism, this chapter focuses on this medium. In particular, this chapter discusses specifically how scientists and engineers can design much more effective slides for their presentations. Where appropriate, this chapter also comments on the use of other visual aids: demonstrations, films, models, and writing boards. Posters, which serve a decidedly different type of presentation, are discussed in a number of texts and web-sites.[8,9,10,11]

In designing slides, most speakers do not assess the necessity, purpose, or effect

In discussing how to design slides, one key assumption is that slides are, in fact, appropriate for the presentation. When a presentation has a significant lull in which slides do not contribute to the audience's understanding and retention of the talk, the presenter would do well to blank the screen. That blanking can be easily done by inserting a slide with a black background, pressing the blank button on a remote advancer, or pressing the letter B on the keyboard during a PowerPoint presentation.

Perhaps nothing changes the dynamics of a slide presentation more than a blank screen. Instead of having the screen's shrill light as the center of attention, the focus falls on the speaker who can move to the center of the room and engage the audience. Appropriate occasions to blank the screen would be when the speaker relays a personal story or acknowledges colleagues and sponsors. Steve Jobs often used a blank screen in his talks.[12]

A second key assumption is that the slides projected during the presentation do not, and should not, have as much detail as a handout for the audience to review after the talk. Many presenters lock themselves into projecting way too many words because they feel compelled to have their set of projected slides exactly match the handout that documents the talk. The communication situation of an audience viewing slides *during a presentation* is dramatically different from the situation of the audience reading a handout *after the talk*. In the first situation, the audience member is reading the slides while listening to someone speaking at 120–140 words per minute. If a projected slide has too many words, the audience becomes overwhelmed. In the second situation of reading a handout, the audience member is usually seated in a quiet place and reading at his or her own pace. In this communication situation, the opportunity exists for including many more words.

A final assumption of this discussion is that the slides projected in a talk are for the audience rather than the speaker. Sadly, many scientific presenters project their own speaking notes onto the screen. For the audience, the presentation soon falls into the robotic pattern of the speaker turning to the screen to refer to a bullet point, then facing the audience to say a sentence or two, and then turning back to the screen to refer to the next bullet point. The effect is similar to the hypnotist's watch. Every day, around the world, thousands of scientists and engineers disappoint audiences by giving presentations in this death-by-PowerPoint style.

Your aims should be higher—much higher.

PowerPoint's defaults lead to a topic-subtopic structure, which is ineffective for scientific presentations

In analyzing thousands of presentation slides from scientific conferences, meetings, and classrooms, my research team at Penn State has found that the overwhelming majority of slides are strongly influenced by the defaults of PowerPoint.[13] That finding is not surprising since PowerPoint controls about 95 % of the market share for presentation slideware.[14] The problem with following these defaults, which are shown in Figure 4-1, is that these defaults produce slide designs that stand in direct contrast with what research has found would help audiences understand and remember the content.[15]

PowerPoint was created in 1986 by an entrepreneur, Robert Gaskins, and a computer programmer, Dennis Austin.[16] Three things are important to understand about the history of PowerPoint. First, the program originated at a time when it was difficult to incorporate graphics into software. Second, the defaults were not founded on any research. Third, except for the addition of a small graphics icon in the slide's center and the change of typeface from Times New Roman to Arial type and then to Calibri type, little has changed about this slide master. Granted, Microsoft has added additional slide masters, but the presenter has to maneuver two levels through the program to find those alternatives. Moreover, the two weakest defaults on almost all of these alternative masters are the same as on the main master: (1) the default for the slide's headline, and (2) the default for the large text block in the slide's body.

The first of these two weak defaults calls for a large headline (44 points) to be centered on single line. Because the text size is so large and the block is only one line, this default leads presenters to create headlines that are short—just a few words. According to our research, headlines in scientific presentations are phrases more than 85 % of the time.[17] In other words, most presenters will write a phrase headline such as "Motivation," "Background," "Methods of the Study," or "Temperature vs. Pressure."

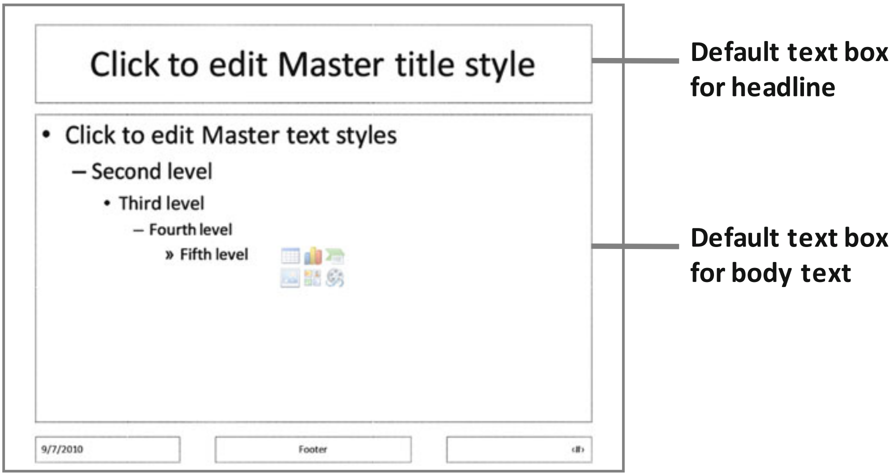


Figure 4-1. Default settings of PowerPoint's slide master for a body slide.

What is wrong with a phrase headline? After all, a phrase typically has fewer words than a sentence, and is it not a problem that PowerPoint slides have too many words? A better question here is whether a phrase headline, as opposed to other types of headlines, leads presenters to write fewer words *overall* on their slides. Put another way, which type of headline leads the speaker to prepare a more focused presentation? A second important question is which type of headline better orients the audience during the presentation, especially when an audience member does not catch the speaker's transition into the slide. For instance, imagine yourself attending a talk about how a fillet design affects the flow around the leading edge of a gas turbine vane. You have followed the talk so far and learned that a vortex at the leading edge is a major problem. However, during the transition to the computational results, you miss what the speaker just said. You are unsure what the main message is now and you look to the screen for help. A typical headline would be a phrase such as "Computational Results." That headline does not provide much help for you. Consider how much more help would have been provided by a well-written sentence headline: "Computational results show that the fillet eliminates the leading edge vortex."

A second weak default in PowerPoint's slide master concerns the way text is incorporated into the body of the slide. PowerPoint's master default calls for text to come in as a bulleted list that automatically fills a large text box. Given this default, it is not surprising that about two-thirds of the slides in science and engineering contain bulleted lists.[18] One problem with this default is that the number of words in these lists is often high, making it difficult for the audience to read all those words and listen to the speaker during the presentation. A second problem is that the positioning of those lists greatly reduces the space available for graphics. Interestingly, even though these bulleted lists are so commonly used, no research exists showing that these lists are an effective way for audience to comprehend and remember details in a scientific presentation. In fact, critics charge that bulleted lists fail to show connections between details,[19] and making connections between details is essential for communicating science and engineering.

In essence, the default settings of PowerPoint encourage presenters to create slides that have a *topic-subtopic structure*. That is, the phrase headline identifies the main topic of the slide, and the bulleted list beneath the headline serves to identify subordinate ideas related to the overall headline phrase. Of the thousands of slides from science and engineering that my team has examined, two-thirds had this topic-subtopic structure. In other words, the slides had a phrase headline supported by one of the following: (1) a bulleted list only, or (2) a bulleted list and a graphic.

In our survey, more than 40 % of all slides had the first case: a phrase headline supported *solely* by a bullet list.[20] Sample slides of this type appear in Figure 4-2. The bottom slide, which is a teaching slide for a key principle in experimental measurements, is representative of the typical number of lines and words for slides in this category. Interestingly, this slide tries to follow to the often-quoted 6-by-6 rule, which calls for no more than 6 lines per slide and no more than 6 words per line. One problem with the slides in Figure 4-2 (or slides that do adhere to the 6-by-6 rule) is that they contain too many words. If the

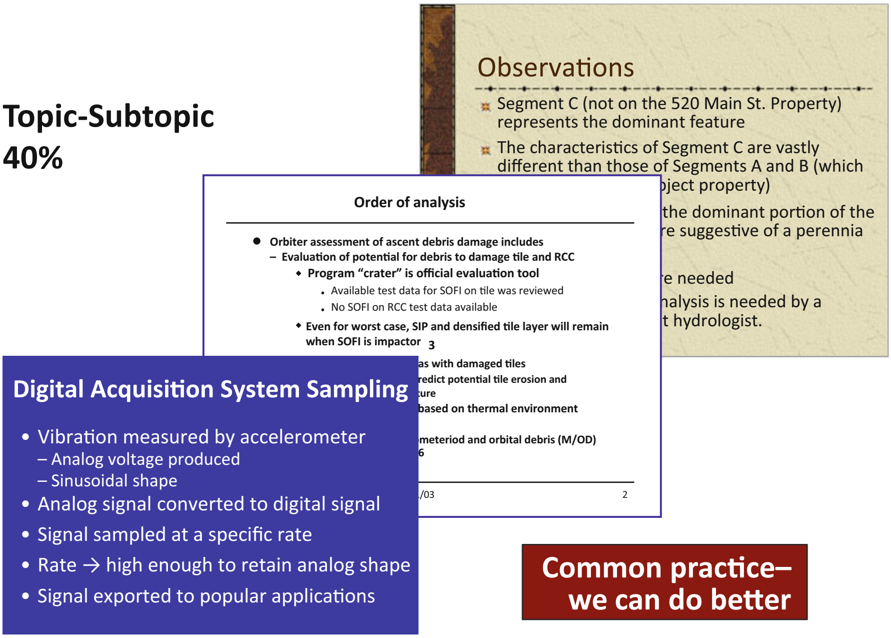


Figure 4-2. Example slides for one type of topic-subtopic structure: a topic-phrase headline supported by bulleted subtopic list. Our research has found that more than 40 % of all slides in science and engineering fall into this category.[24]

slide is projected for 1 minute, which we found to be the common practice for slides in a scientific presentation, most audience members would be hard pressed to read that many words and listen to the presenter, who is saying 120–140 words during that same minute.

According to the respected Australian psychologist John Sweller, if the audience tries to process too many written words and spoken words at the same time, a cognitive overload condition occurs.[21] In this overload condition, Sweller's research has found that the comprehension rate drops very low—even below the comprehension rate of having no slides at all. That research finding is important and should give scientists and engineers a long pause before they begin churning out slides for a presentation. As the physicist and communication expert Jean-luc Doumont puts it, "Bad slides are worse than no slides at all."[22]

According to psychology research done after PowerPoint was created, the same part of the brain that processes spoken words also processes written words.[23] In cases where the speaker projects too many words for the audience member to comprehend, the audience member has three options to avoid being overloaded. First, you listen to the speaker and ignore the text on the screen. Second, you read and tune out the speaker. Or third, you toggle back and forth between reading and listening. For all three options, identifying and comprehending the most important message is a challenge. For instance, the most important takeaway of the bottom slide of Figure 4-2 is not readily apparent: *A digital acquisition system has to sample at a rate fast enough to retain the analog signal's shape*.

Figure 4-3 shows three slides from the second category of this topic-subtopic structure: a topic-phrase headline supported by a bulleted subtopic list *and* a graphic. That graphic could be a photograph, drawing, diagram, graph, film, or table. More than 26 % of the slides we examined had this structure. In Figure 4-3, the bottom slide is representative in the number of lines and words on slides in that category.

Note that the inclusion of relevant graphics on the slides in Figure 4-3 does follow an important principle of psychology. Unlike written text, which is coded in the same part of the brain as spoken text, images are processed in a different part.[26] From your experiences watching film and television, you intuitively know this dual-coding principle. Drawing on this dual-coding principle, Richard Mayer, a widely respected professor of psychology at the University of California at Santa Barbara, has found that audiences learn more effectively from words and relevant pictures than from words alone.[27] The takeaway from this principle, which is called the *principle of multimedia learning*, is that when you project a slide, you want to include relevant visual evidence: photographs, drawings, diagrams, graphs, or films.

Another principle of psychology that affects slide design is that audiences understand and remember more when extraneous information is removed from the presentation.[28] This

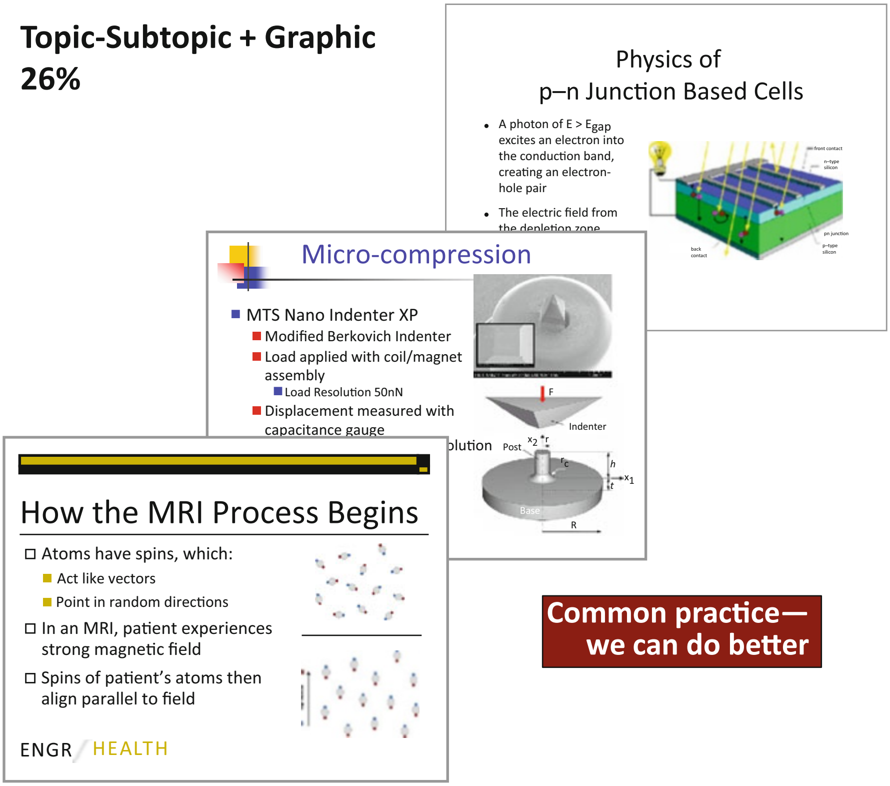


Figure 4-3. Example slides for another type of topic-subtopic structure: a topic-phrase headline supported by a bulleted list and a graphic. Our research has found that more than 26 % of slides in science and engineering fall into this category.[25]

principle, which also arises from Mayer's work, is called the *principle of coherence*. For the design of presentation slides, the takeaway is that you want to rid your slides of details that do not directly connect with the presentation's content. If the information of the slide is extraneous—a phrase or decorative image that does not connect to the spoken message—the audience can become side-tracked. Drawing on transmission theory in optics, Jean-luc Doumont discusses this principle in the following way: Presenters should try to maximize the signal-to-noise ratio of their slides.[29]

Overall, my research team has found a number of disconcerting practices, as listed in Table 4-1, for slides in scientific

Table 4-1. Five disconcerting practices of slides in scientific presentations.

Common practice	Concerns
More than 85 % of slides begin with phrase headlines.	Does a phrase headline orient the audience? Does a phrase headline help the speaker select the best visual evidence?
More than two-thirds of slides contain bulleted lists.	Bulleted lists do not show connections among details.
Only about half of slides contain relevant images.	People learn more deeply from words and relevant images than from words alone.[30]
About 50 % of slides use stock decorative backgrounds.	Such backgrounds waste space (sometimes 25 % of the slide). Such backgrounds increase noise.
Typically, audiences have to read 35 words or more per minute.	With so many written words, the likelihood of cognitive overload is high.[31]

presentations. For anyone who has attended even a few conference presentations, business meetings, or science courses, the frequency of these practices will come as no surprise.

One advantage of creating slides that follow PowerPoint's defaults is that relatively little time or effort is required from the presenter. For many presenters, putting together slides for a talk is simply writing phrase headlines such as "Motivation," "Background," and "Results" for the topics to be covered and then supporting those phrases with speaking points and a few key images. With such low goals, the slides can be created the day before the talk or even the morning of the talk. Now one might assert that 1 or 2 hours is all the time that is needed to be spent on the slides, because in a presentation, slides are simply not that important. However, the design of slides affects the success of a scientific presentation much more than these presenters realize. In particular, the design of slides affects that success of a talk in three important ways: (1) how the speaker prepares the talk, (2) how the speaker delivers the talk, and (3) how much the audience understands and remembers from the talk. This sequence of effects is shown in Figure 4-4.

The next two sections of this chapter compare the way that slides are commonly designed versus one alternative slide structure that is specifically designed to communicate science and engineering content to audiences. This alternative structure, called the assertion-evidence structure, has its roots at Hughes Aircraft in the 1970s and Lawrence Livermore National Laboratory in the 1980s.[32,33] Rather than following the common practice of writing a phrase headline, this assertion-evidence structure calls for a succinct sentence that states the main assertion of the slide. That assertion might be a hypothesis, an assumption, an insight, or a result. Also, rather than supporting that headline with a bulleted list, the assertion-evidence structure calls for relying on visual evidence: photographs, drawings, diagrams, graphs, equations, short tables, or films. In the assertion-evidence structure, bulleted lists do not occur.

Shown in Figure 4-5 is an example assertion-evidence slide. Note that this slide presents the same information as in the bottom slide of Figure 4-2. However, in the assertion-evidence slide, far fewer words are used and the main point

Figure 4-4. Three ways that presentation slides affect the success of a presentation: preparation, delivery, and audience understanding.

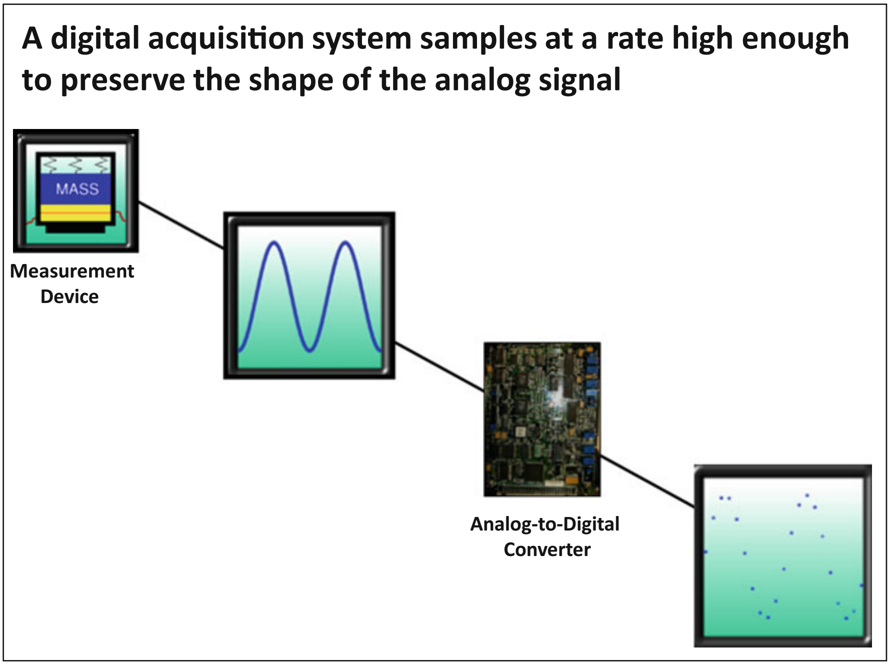


Figure 4-5. Sample assertion-evidence slide.[34] This slide presents the same information as the common-practice slide of Figure 4-2, but does so in a much more memorable way.

of the slide is much clearer. A number of years ago, Professor Harry Robertshaw projected the slide of Figure 4-5 in an engineering measurements course. Five hours later, back in my office, I was able to put together this slide from memory. What came first to me were the four images. Then what came back was the sentence headline. While my memory of the headline was not exactly word for word, it carried the same meaning. Five hours after the talk, I was able to recreate the essence of the slide—what more could a presenter ask from a visual aid in a scientific talk?

This chapter focuses on the assertion-evidence structure for two reasons. First, this structure follows the psychology principles of how people learn. Second, this structure is specifically designed for communicating technical assertions such as found in science and engineering. For other situations such as communicating less technical assertions, other alternative slide structures have arisen.[35,36] Later on, this chapter analyzes these alternatives and offers suggestions for when engineers and scientists might use these other alternatives in their presentation slides.

Assertion-evidence slides lead to much higher comprehension of complex concepts

Does slide design actually affect how much the audience understands and remembers? To answer this question, we performed experiments in which two audiences viewed a presentation with the *same* narrated speech, but with *different* slide designs.[37] One slide design followed the ubiquitous topic-subtopic structure of PowerPoint's defaults, and the other followed the assertion-evidence structure. The presentation explained how magnetic resonance imaging can detect small cancerous tumors. For our two audiences of undergraduate engineers, the process was a good choice because it was both interesting and challenging. Each audience had more than 50 participants, and their prior knowledge of the topic, as self-reported, was both low and not significantly different.

In selecting the number of words and lines for the topic-subtopic slides, we made choices that were slightly better (fewer words and lines) than what is commonly practiced.[38] In determining whether to include an image on a topic-subtopic slide, we followed what is practiced for similar slides in medical school presentations. Finally, in selecting the slide format (typography, layout, and background) for the topic-subtopic slides, we chose a widely distributed format in a nationally known engineering course.[39,40] Example topic-subtopic slides from the common-practice presentation appear in Figure 4-6.

In developing the assertion-evidence slides, we followed our own practices, which have roots with slide designs at Hughes Aircraft and Lawrence Livermore National Lab.[41,42] Over the past 20 years, we have developed guidelines for this

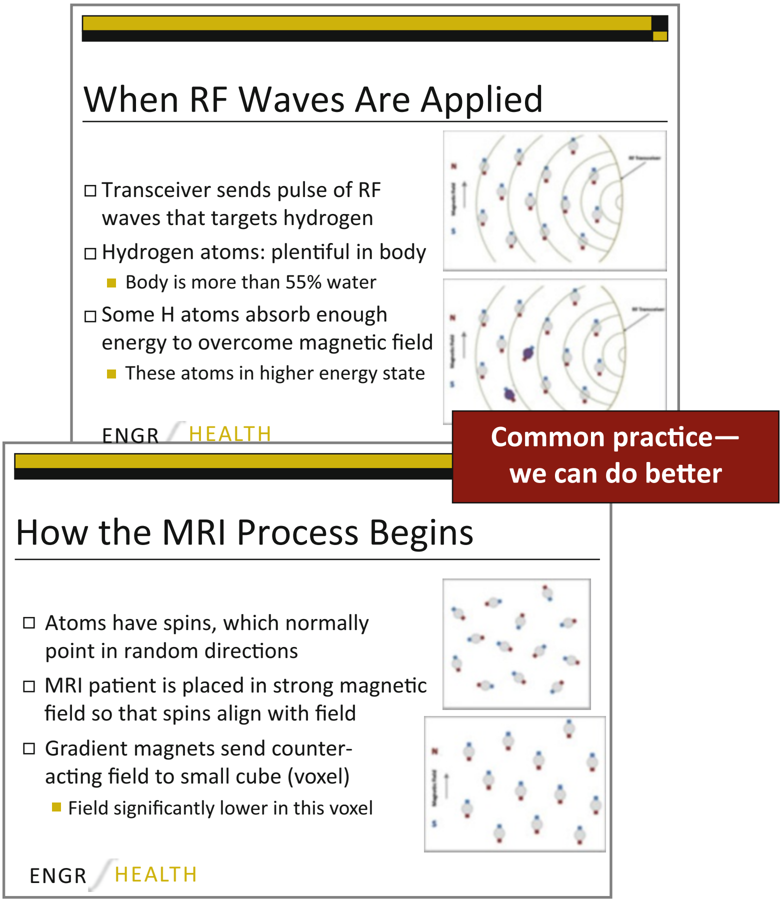


Figure 4-6. Sample slides from the topic-subtopic presentation about the process of magnetic resonance imaging. Audiences viewing these slides scored lower on comprehension and retention of the MRI process than did audiences viewing the assertion-evidence slides.

assertion-evidence structure, which appear later in the book. Example slides from this assertion-evidence presentation appear in Figure 4-7.

In the experiments, the two different audiences viewed their respective presentations and then took a number of tests,

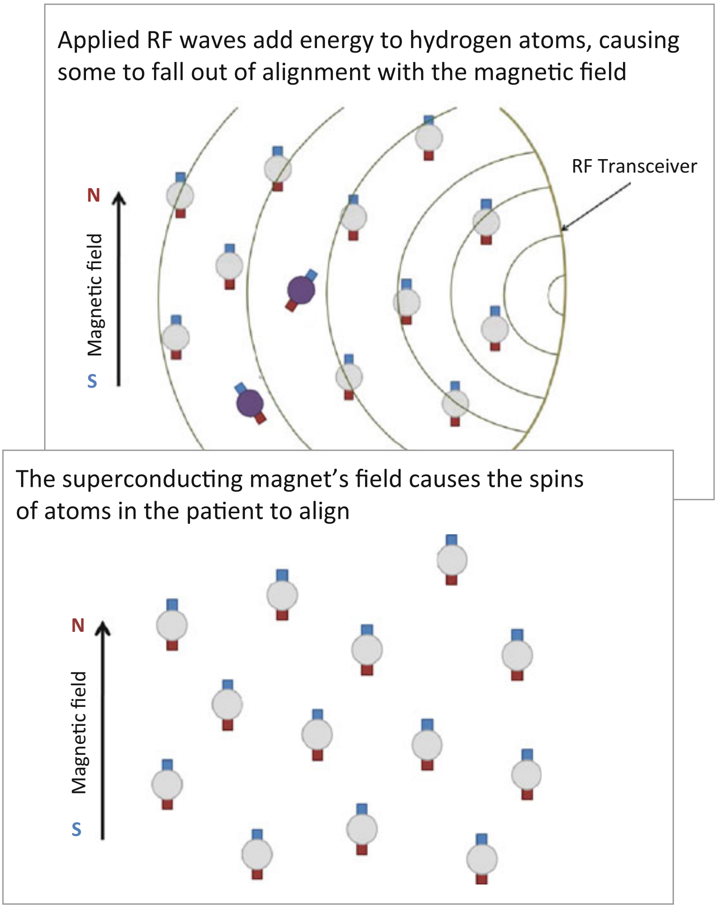


Figure 4-7. Sample slides from assertion-evidence presentation about the process of magnetic resonance imaging.[43] Audiences viewing these slides scored much higher on comprehension and retention of the MRI process than did audiences viewing the topic-subtopic slides. Note that each of these slides had an additional layer of visual evidence that animated in during the discussion of the slide. Shown here are the final layers.

the most important being an essay test that called for explaining the process of magnetic resonance imaging. In all the tests, the audiences viewing the assertion-evidence structure scored significantly higher, indicating that those audiences better understood the MRI process.[44] For instance, in the essay test, the statistical difference in understanding was high ($p < .01$).

What these tests showed is that the assertion-evidence structure was better at emphasizing the most important details of a complex process. That emphasis occurred through those details appearing in the sentence-assertion headline or in the visual evidence. In contrast, in the topic-subtopic structure, the most important information did not stand out as well. One likely reason was that audiences had trouble separating primary details from secondary details in bulleted lists.[45] Another likely reason was that on topic-subtopic slides, the visual evidence that contained important information often had to share space with bulleted lists and therefore received less emphasis.

One big takeaway from these experiments is that slide design *does* make a difference in how much the audience understands and remembers from a scientific presentation. In addition, the assertion-evidence structure, although more time consuming for the presenter to create, was superior in terms of how well the audience comprehended and retained the complex concepts.

Assertion-evidence slides lead to more focused talks and more engaging deliveries

Not only does the design of slides affect the audience, but a slide's design also affects the speaker. That effect occurs in how the speaker both prepares and delivers.

In the delivery of a presentation, the design of slides affects how much the speaker is likely to look at the audience. In the commonly followed topic-subtopic style of slides, about two-thirds of the slides have a bulleted list of speaking notes. With this type of slide, many speakers continually look back at the slide to refer to or, worse yet, to read the next bulleted point. The pattern of looking at the audience and then turning back

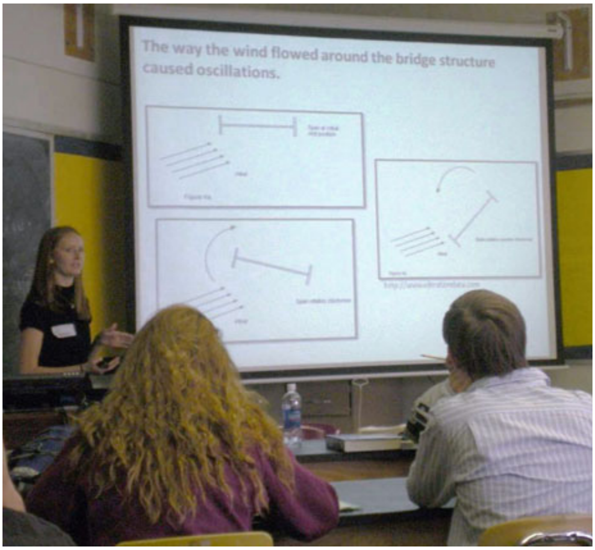


Figure 4-8. Amy Szabo, an Engineering Ambassador at Penn State, presenting an assertion-evidence slide to a high school audience. The purpose of this talk is to show high school science students how engineers use science principles to make a difference in the world.

to look at the slide soon becomes repetitive, and the effect on the audience is similar to the effect of a hypnotist's watch.

In addition, many presenters accentuate that hypnotic effect by animating in the bullets one by one. In fact, the next time you find yourself in such a presentation, look around the room at the audience. You will find that many in the audience will have stopped watching the animations and either are watching the speaker reading the slides or simply not paying attention to the talk.

With assertion-evidence slides, though, most of the words on the slides are in the sentence-assertion headline. Moreover, most speakers preparing for an assertion-evidence presentation will become so familiar with the main assertion of each slide that they will incorporate the essence of those assertions into their natural speech. For that reason, the speaker can maintain more eye contact with the audience, as shown in Figure 4-8. When the speaker does turn to the slide to explain an aspect of the image or the curve of a graph, it is natural for the audience to view the slide as well.

When students from our classes or participants from our workshops adopt the assertion-evidence structure, clear improvement in delivery occurs. The presenters engage the audience more, which occurs because they make more eye contact with the audience. Also, their deliveries are much more natural, which arises because they are fashioning words on the spot to explain images, as opposed to relying on a bulleted list of scripted details. In addition, from the audience's perspective, the presenter appears to be more confident, because in an assertion-evidence talk, the information clearly comes from the speaker. That delivery stands in direct contrast to a topic-subtopic talk, where the speaker appears to have his or her speaking notes projected in bulleted lists on the screen.

While the effect of using the assertion-evidence structure on a speaker's delivery is strong, the effect on a speaker's preparation is even stronger. In essence, creating assertion-evidence slides leads speakers to focus their talks on the most important details. This focus on important details occurs because the sentence-assertion headline compels the speaker to identify the most important takeaway from the slide. Once the speaker has done that, the speaker is in a good position to select only the necessary evidence. Put another way, the sentence assertion headline causes the speaker to converge on more effective evidence, as reflected in the slide shown in Figure 4-9. This slide comes from a lecture by Barbara Bekins on the influence of hydrogeology on 25 years of natural attenuation at a crude oil spill. In contrast, beginning with a phrase headline often has the opposite effect, as depicted in the slide of Figure 4-10.

This difference in focus between the two structures is why assertion-evidence slides have fewer words per slide and, more important, fewer words projected per minute than topic-subtopic slides do.[48] Given that assertion-evidence slides call for more words in the sentence headline than would occur in the phrase headline of a topic-subtopic slide, the headline serves to filter out unneeded words in the slide's body. Our surveys reveal that scientific presentations following the assertion-evidence approach have fewer than 20 words projected per minute, as opposed to 35–40 words per minute for the typical scientific presentation using topic-subtopic slides.

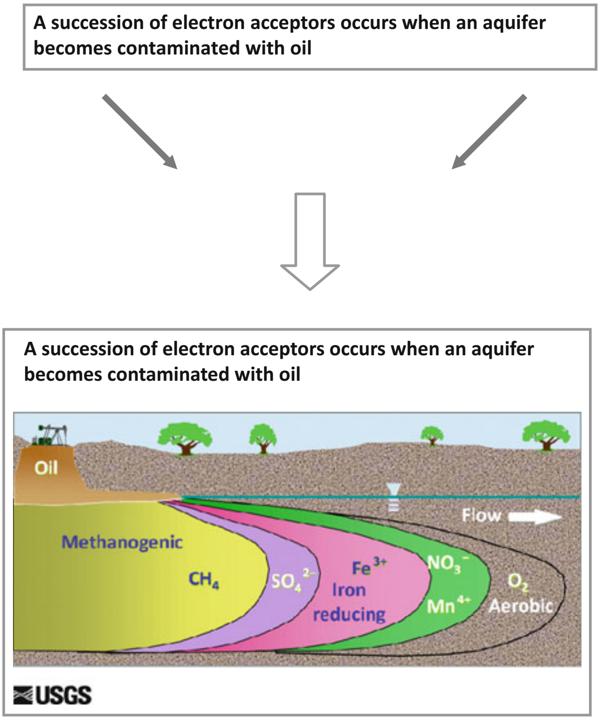
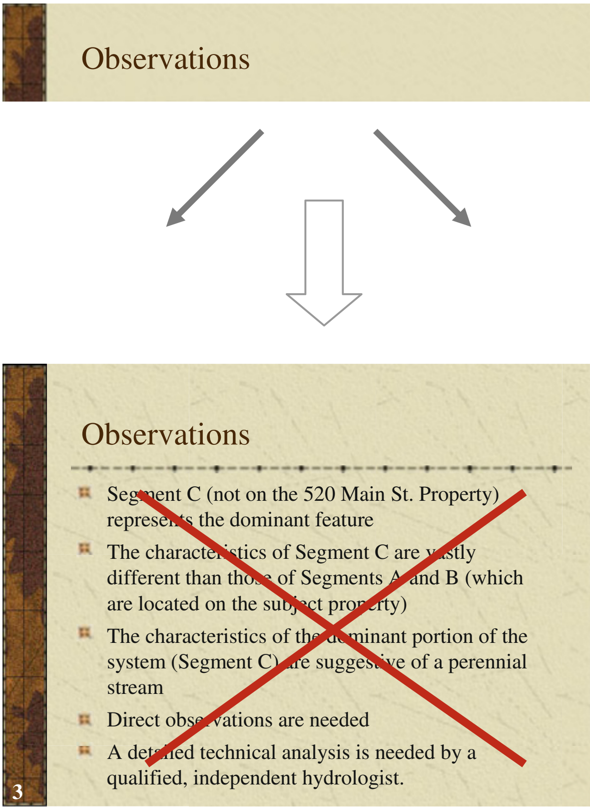


Figure 4-9. Depiction of the effect that a sentence-assertion headline has on focusing the speaker to include only the essential evidence.[46] This focus is why assertion-evidence slides end up with fewer words per slide and, more important, fewer projected words per minute than commonly followed topic-subtopic slides do.[47]

Imagine if assertion-evidence slides were the common practice at scientific conferences and technical meetings. At some research institutions such as Simula Research Laboratory in Norway and certain laboratories at other institutions such as Penn State and Virginia Tech, that has become the case. What engineers, scientists, and managers from those laboratories consistently say is that their presentations are more effective. Audiences understand and remember more of the content. In addition, the level of questions asked by audiences is on a higher plane.

As big a difference as assertion-evidence slides would make in industry and conference presentations, the difference would be even starker in classroom presentations. Teachers would communicate more efficiently to students, and students when presenting their projects would communicate more effectively to their teachers and to other students. Our experiments show that using assertion-evidence slides leads to gains in comprehension of complex concepts that correspond to one and sometimes two letter grades.

Figure 4-10. Example showing that having the typical phrase headline often leads presenters to place too much text in the body. In the preparation of this talk, the presenter should have focused this visual on the essential assertion and folded secondary details into the speech. Better yet, the speaker should have replaced the body text with an image.



Finding a design that is significantly better than what is commonly used is one thing. However, as Everett Rogers describes in *Diffusion of Innovations*,[49] having people adopt that design is quite another. In fact, Traci Nathans-Johnson and Christene Nicometo from the University of Wisconsin have found that when professionals do adopt the assertion-evidence structure, the adoption occurs over a significant period of time and over four distinct stages: interest, doubt, experimentation, and conversion.[50]

Given that the topic-subtopic structure for slides is so weak, the question arises why the adoption of the assertion-evidence alternative is occurring so slowly. One reason, as Cliff Atkinson, the author of *Beyond Bullet Points*,[51] asserts, is that the topic-subtopic structure is entrenched.[52] Not only is the topic-subtopic structure the dominant model projected in scientific presentations, but many institutional and university templates require professionals and students to follow this structure. Another reason that adoption is so slow is that the assertion-evidence structure is so much more challenging.[53] Part of the challenge arises from overcoming the weak defaults of PowerPoint. Also challenging is the effort required to define the key assertions of a presentation. A third challenge is the additional time that it takes to create the visual evidence. Much of the remainder of this chapter discusses strategies for overcoming these challenges.

Given in the Critical Error 7 are the essential steps to achieve the assertion-evidence structure in an individual slide. Then, given in Critical Error 8 are strategies for adapting the assertion-evidence structure to different situations. Critical Error 8 also introduces other alternative slide structures and sequences that can benefit scientific presentations in special circumstances, such as speaking to the general public. Finally, given in Critical Error 9 is a discussion about how to overcome the chaotic forces of Murphy's Law when delivering presentation slides or other visual aids.

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Critical Error 7
Following the Defaults of PowerPoint

> *Bullets do not shown connections. Bullets do not reveal hierarchy. Bullets leave critical assertions unspecified.*[1]
>
> –Gordon Shaw

On a regular basis, managers from the different national laboratories trek to Washington D.C. to present their work and to propose new research. During the early 1980s, many managers, including those from Sandia National Laboratories, where I was working, held a cavalier attitude about making presentation slides for these meetings. In fact, many Sandia managers prided themselves on waiting until the plane ride to begin creating their slides, which they wrote by hand. In effect, these managers considered themselves researchers, not artists, and therefore did not have time to worry about such trivialities as the design of presentation slides.

One year, though, managers from a competing laboratory, Lawrence Livermore National Lab, broke from this tradition and quietly put much effort into the creation of their slides. Their reasoning was that they saw these projected slides as important for the success of their presentations, which in turn were important for the success of their proposals. After much deliberation, Lawrence Livermore came up with a specific structure that they felt could best communicate technical information to a wide audience. One requirement was that the headline be a short sentence headline, left justified and no more than two lines, which stated the main purpose of the slide. A second requirement was that the body of slide contains a supporting image, such as a photograph, drawing, or graph. At that year's meeting, Lawrence Livermore's presentations were very well received—so well received, in fact, that managers from Sandia vowed never to be shown up again.

The slide structure that Lawrence Livermore managers used and that the Sandia managers soon adopted is the foundation for the structure advocated by this book: the assertion-evidence structure. Shown in Figure 4-11 is a sample assertion-evidence slide. The headline states the main assertion of the slide, and the body supports that headline with visual evidence and words only as necessary. This slide comes from a talk given at Ford Motor Company by Scott Fishbone, a mechanical engineering intern from Penn State. In this talk, Scott compared the traditional halogen headlights, currently installed on Ford vehicles, with a new type of headlamp that used xenon. This particular slide presents one takeaway from that presentation—namely, that the xenon headlights are superior to halogen headlamps at illuminating road signs. This slide did not

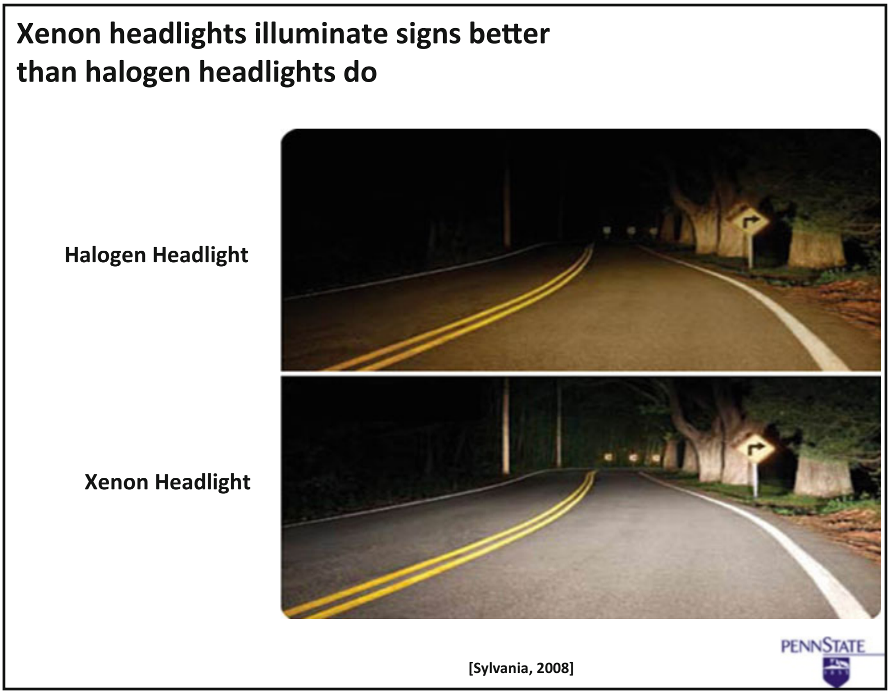


Figure 4-11. Sample assertion-evidence slide from the results portion of a presentation comparing xenon headlights with halogen headlights.[2]

present everything that Fishbone had to say about this takeaway, but the headline conveyed the main message, and the slide's body presented photographic evidence that supported that message. In the words that he said, Fishbone carried the secondary details, such as how Sylvania ran the experiment.

Presented in Table 4-2 and Table 4-3 are stylistic guidelines and format guidelines for the assertion-evidence structure. As mentioned earlier in this chapter, these guidelines carry three assumptions about the use of the slides. First, the slides are, in fact, appropriate for the talk. Second, the slides are designed to serve as a visual aid *during* the talk, rather than as a handout *after* the talk. Finally, the slides are designed foremost to help the audience understand the content rather than to provide speaking notes for the presenter.

Table 4-2. Stylistic guidelines for assertion-evidence slides.

For each slide, craft a succinct sentence headline that states the main assertion (or message)
1. Keep the headline to no more than two lines
2. Left justify the headline for easier reading
3. Capitalize the headline as you would a sentence—note that the period is optional because the sentence is not part of a paragraph
4. If the headline goes more than one line, break the first line such that phrases stay together for easier reading
Support the sentence-assertion headline with visual evidence, using words only where necessary
1. Visual evidence consists of photographs, drawings, diagrams, graphs, films, equations, or short tables
2. In the body of the slide, use words only when necessary
3. Design your slides so that you project no more than 20 words per minute
4. Avoid bulleted lists because bulleted lists do not show connections—if you must have a list, keep the list short and consider presenting that list as a sequence of images or as a short table

Table 4-3. Format guidelines for the assertion-evidence structure.

Select typography that can be read quickly
1. Use a sans serif typeface such as **Calibri**—boldface the type for larger rooms
2. Avoid italics and underline
3. Use 28 point type for the headline, 18–24 point type for the body text, and 12–14 point type for reference listings
4. Avoid setting text in all capital letters, in italics, or with underline
Select colors that serve the audience and situation
1. Choose either dark type against a light background, or light type against a dark background
2. For the background, avoid hot colors such as red, orange, or yellow
3. Avoid backgrounds with decorations
4. Do not allow logos to detract from content
Select a layout that efficiently guides the reader through the slide
1. Keep blocks of text, especially the headlines, to no more than two lines
2. Keep any list or the number of call-outs to two, three, or four items
3. Use animations only when they serve the audience—avoid unprofessional choices for animations such as "flying in"
4. Insert enough blank space *between* the slide's elements that the slide breathes

An assertion-evidence slide calls for a succinct sentence headline that states the slide's main assertion

Perhaps the most challenging part of the assertion-evidence slide structure is crafting the sentence-assertion headline of the slide. While the ubiquitous topic-subtopic structure simply calls on the presenter to identify the topic in a phrase, such as "Background" or "Methods," the assertion-evidence structure demands much more. In essence, for each slide, the speaker has to identify the most important message. This message is often an insight, a feature, or a result.

When properly crafted, the sentence-assertion headlines convey the bare-bones story of the work. For instance, consider the four slide headlines of Figure 4-12. These four sentences provide the skeletal outline for the story of an experiment—it is then up to the speaker to flesh out the story in spoken words. In a strong slide presentation, an important balance exists between what the speaker shows and what the speaker says. With each slide, the speaker adds secondary background details that deepen the understanding. Providing this background also helps the speaker build credibility with the audience and demonstrate ownership of the information. Owning the material is important. For a scientific presentation to succeed, the audience has to believe in the speaker, and a key way to establish that credibility is to show ownership of the information.

For instance, the first headline of Figure 4-12 provides an entry point to the story: *Dogs have a sense of smell that is 10,000 times sharper than a human's*. With this entry point, the presenter can motivate the audience to care about the work. For example,

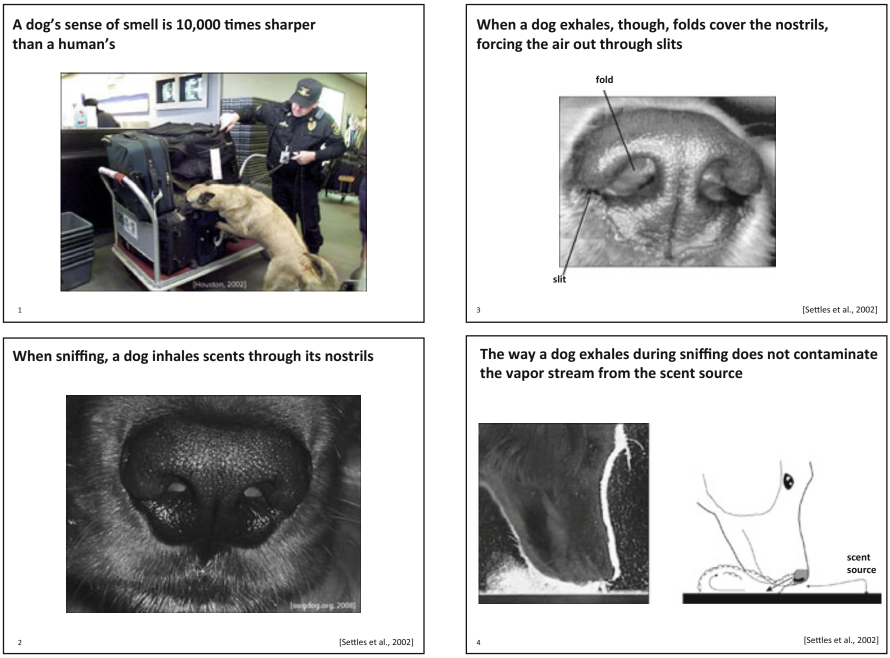


Figure 4-12. Slide sequence revealing how the sentence-headline assertions, when properly crafted, tell the story of the work.[3] Note that type sizes in projected slides are more easy to read than type sizes in this condensed depiction.

the presenter could use the supporting photograph to mention that dogs are used to detect trace examples of explosives at airports, along roadsides, and in government buildings. Not only can dogs detect extremely small traces of such explosives, but dogs when properly trained and handled can do so with high reliability. The speaker could also arouse curiosity as a way to engage the audience about the work. How has a dog's nose evolved to have a sense of smell that is so much more sensitive than a human's? It is not simply that a dog has more olfactory sensors than a human does. Although dogs have 40 times more olfactory sensors than a human, that increased number of sensors does not account for 10,000 fold increase in ability to smell that a dog has.[4] With this question, then, the presenter can easily transition to the focus of this work, which is how the aerodynamics of a dog's nose plays a major role in its ability to detect scents.

The headlines of the second and third slides provide two key insights from what is already known about the front part of the nose during the sniffing process—namely, what happens at the outer part of a nose when a dog inhales and then exhales during a sniff. Again, the speaker has the freedom on these slides to add additional information, such as the sizes of nostrils from different breeds or the frequency at which dogs sniff. Once the speaker has established the two key insights on slides 2 and 3, the speaker is in a position to present slide 4. This slide presents a result from an experiment to test the effects of these two insights on how a dog detects the location of a scent.

If the speaker knows the work, the visual evidence should serve as a sufficient trigger to step through the story. For instance, the image on the left is a Schlieren photograph of the exhalation of a golden retriever's sniff. This particular dog is sniffing peanut butter. Note that on slide 4, the speaker might desire to withhold the drawing on the right until he or she has explained the experiment, which is depicted in the photograph on the left. That withholding is easily done by animating in the drawing on the right after the speaker has finished discussing the photograph.

Finally, depending on the audience and time that the speaker could devote to this story, the speaker could relay more information: how many dogs were tested, what the breeds and genders were, or how Schlieren photography works in general.

In essence, the assertion-evidence approach calls on the speaker to use the visual evidence, as opposed to bulleted lists of words, to trigger what he or she has to say. This approach, which does require the speaker to practice with the slides, leads to a more natural delivery. Rather than the speaker turning to the slide to read the next bullet, the speaker can maintain much more eye contact with the audience. With assertion-evidence slides, you need look at the slides for only two reasons. One would be a quick glance to make sure that the slide has advanced. A second would be to point out details of an image or graph. Such eye contact by the speaker on the image or graph is natural because the audience would be viewing the visual evidence at those times as well.

Sentence headlines help audience and speaker. Earlier, this chapter presented two reasons for writing a sentence headline, as opposed to a phrase headline. One reason was the effect of the headline on the audience. A sentence headlines is much better than a phrase headline at orienting the audience to the purpose of the slide. Having that purpose on the screen becomes important if the audience becomes distracted and misses the speaker's transition into the slide.

A second reason was the effect of the headline on the speaker. Writing the assertion of each slide as the headline makes the speaker's presentation more focused because writing the headline puts the speaker in a better position to see what evidence is needed to support that headline.

My colleague Harry Robertshaw considered this second reason to be the most important. In essence, the sentence-assertion headline forces the presenter to come to grips with what the main purpose of the slide is. This step might seem obvious, but in the presentation slides sent by Morton Thiokol to NASA the night before the fateful launch of the space shuttle *Challenger*, the presenters did not make clear their assertions on their slides and did not provide enough evidence for the assertions that they tried to make in their speech.

Consider the second slide of that presentation again (Figure 4-13, top). If the presenting engineers had simply stated their main assertion "The lower the temperature of the launch, the more erosion the O-rings have experienced" (Figure 4-13, bottom), then the engineers might have reconsidered the evidence that they presented. Perhaps they would have come up with a graph, such as that suggested by Edward Tufte in *Visual Explanations*. This plot, reconstructed in the bottom slide of Figure 4-13, shows an erosion index for the O-rings versus launch temperature for all launches up to that point. As it was, Morton Thiokol had not specified an assertion for their slide (Figure 4-13, top), and the evidence in the slide's body did not show the key relationship for their argument—namely, the relationship between O-ring erosion and launch temperature.

A headline's format affects how easily it is read. In formatting any text block on a slide, you want that text block to be read quickly so that the audience can focus attention back on the speaker. One concern for improving the reading speed of a text block is its size. Clearly, if the size of the text is too small to read, the audience will struggle. Another concern is the size of the text block—one line, two lines, three lines, and so forth. If the text block is too long, many people will not even try to read it.

In selecting the type size of a sentence-assertion headline, you want the headline's type size to be large enough to not only be readable, but to stand out from other text on the slide. Moreover, you want the block of text to be short enough that people will actually read it. At Virginia Tech, my colleague Harry Robertshaw and I ran a large number of focus groups in which the audiences viewed a technical presentation with slides and then reported what text on the slides they actually read. A key finding from these groups was that while almost everyone would read text blocks of one or two lines, more than half the people in the room would not read text blocks that were three lines or longer.[6]

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

	SRM No.	Cross Sectional View: Erosion Depth (in.)	Cross Sectional View: Perimeter Affected (deg)	Cross Sectional View: Nominal Dia (in.)	Top View: Length Of Max Erosion (in.)	Top View: Total Heat Affected Length (in.)	Clocking Location (deg)
61A LH Center Field**	22A	None	None	0.280	None	None	36° - 66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338° - 18°
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
410 RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
41C LH Aft Field*	11A	None	None	0.280	None	None	--
410 LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
STS-2 RH Aft Field	28	0.053	116.0	0.280	--	--	50

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking rotation of leak check port - O deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT HEAR OR BEYOND THE PRIMARY O-RING

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

Weak slide

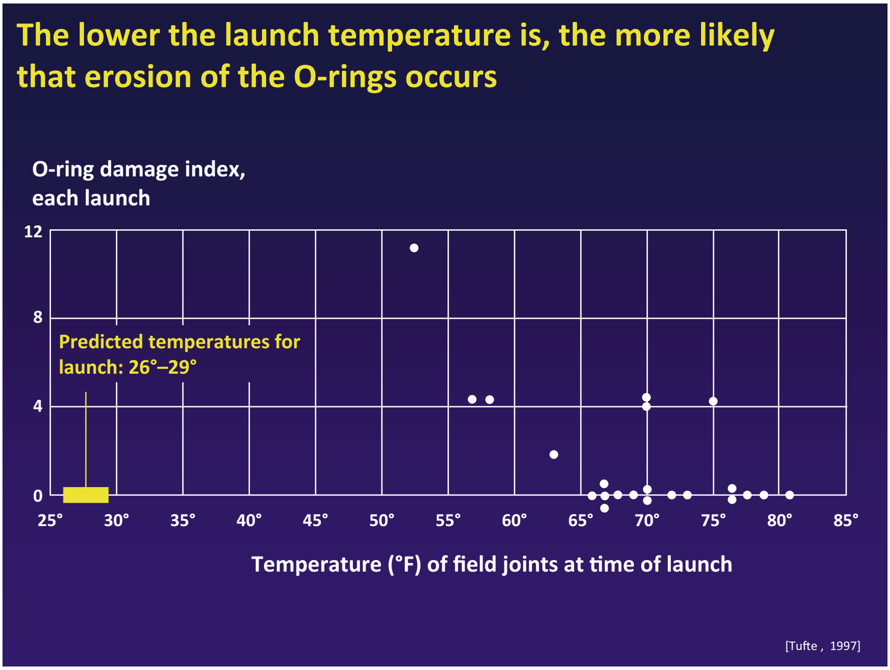


Figure 4-13. Reworking of original slide (*top*) created by Morton-Thiokol to persuade NASA to delay the launch of the space shuttle *Challenger*. If the engineers had selected a sentence-assertion headline such as in the *bottom* slide, they would have been in better position to come up with persuasive visual evidence such as what Edward Tufte created (graph in bottom slide).[5]

Given this finding, headlines should be no more than two lines. For the type size of the headlines, my own research team[7] and other slide designers[8-9] recommend 28 points, which is large enough to stand out on the slide and yet small enough to allow for a meaningful sentence assertion. PowerPoint's default headline size of 44 points is simply too large to write a meaningful sentence assertion in one or two lines. Even though a type size of 28 points allows for more words per line than PowerPoint's default size, you will have to work hard on many assertions to maintain precision and yet be concise enough to meet the two-line limit. To achieve that goal, every word must contribute.[10]

Having the headline's text block be one or two lines is just one way to improve the speed at which the headline is read. For a sentence headline to be read quickly, you should begin the sentence in the slide's upper-left corner. The reason for this choice is that eye tracking studies indicate that Western audiences, when first viewing a piece of multimedia such as web page or a slide during a presentation, look in that upper left corner. Also, to allow for quick reading, you should left justify the headline, as is regularly done by graphic artists with sentence headlines in newspapers and journals. Unfortunately, the defaults in PowerPoint call for a centered headline, which is particularly slow to read when the headline goes more than one line. Moreover, with centered headlines, the headline does not quite begin at the same place each time, which also slows the reading.

A third consideration to allow for quick reading is how you capitalize the sentence. Many graphic artists recommend capitalizing a sentence headline the same as you would a sentence, which means capitalizing only the first word and proper nouns. Using initial capitals, such as what you typically see for titles of books and articles, will not only slow the reading, but will also use up valuable space needed to keep the headline to two lines. In general, a capital letter takes up 35 % more horizontal space than a lowercase letter.[11]

A question that often arises is why there is not a period at the end of these sentences. The reason is that a sentence headline on the assertion-evidence structure is a standalone sentence, as opposed to a sentence that is part of a paragraph. The purpose of a period is to separate sentences from one another, but with a standalone sentence, no other sentences exist to separate. Given that, the period serves no purpose. Often, you will see a billboard follow this style of not punctuating the end of a standalone sentence. However, if you are haunted by the voice of your fifth-grade writing teacher telling you to place a period at the end of every sentence, then place the period there. In this case, all the period adds is a little bit of noise, but if that little bit of noise allows you to sleep at night, add it.

Finally, you should think about where you break the headline. Reading experts tell me where the line of a sentence breaks can greatly affect how fast the audience reads and comprehends that sentence. Certainly, you would want to avoid any orphan, which would be a single word on the second line. However, you also want to keep noun phrases, verb phrases, and prepositional phrases together, if possible. Notice where I broke the longer headlines of Figure 4-12:

> A dog's sense of smell is 10,000 times sharper /than a human's
>
> When a dog exhales, though, folds cover the nostrils, /forcing the air out through slits
>
> The way a dog exhales during sniffing does not contaminate /the vapor stream from the scent source.

Breaking these headlines at these junctures allowed noun, verb, and prepositional phrases to stay together and therefore allowed audiences to read these sentences a little more quickly. Note that with headlines that go the full two lines, you will not have the option about where to break the first line. Also, many people contend that the headline is not aesthetically pleasing if the second line is substantially longer than the first.

An assertion-evidence slide calls for supporting the headline with visual evidence, not bulleted lists

Once you have identified the slide's main assertion in the headline, you want to support that message in the body of the slide. If properly chosen and well designed, visual evidence is the most effective way to support the assertion headline. Visual evidence can be a wide array of things: photographs, drawings, diagrams, films, equations, and small tables. Such visual evidence, unlike bulleted lists, allows the audience to quickly grasp the connections between supporting details.

The visual evidence depends on the headline assertion. What type of visual evidence you select will depend on the assertion in your headline. Some assertions can be supported with images. In such cases, photographs and drawings suffice, such as in the first slide in Figure 4-14 by Brittany Pavelko, a civil engineering student from Penn State. In this slide, the assertion presents background facts for the talk. In turn, the map on the left simply shows where the two crossings occur, and the photographs depict these crossings: the Chesapeake Bay Bridge on the top and the Chesapeake Channel Tunnel on the bottom. From these images, Pavelko provided much information: the possibilities of traffic from nearby cities, the distance between the two crossings, and the number of traffic lanes at each crossing. Because Pavelko spoke to the audience about these details from images, as opposed to a bulleted list, she showed that she owned the information, thereby increasing her credibility with the audience. As mentioned, to establish credibility with audiences, you want to have a balance between what you show and what you say. If everything you say is written on the slides, many in the audience will tune you out and concentrate on reading.

The visual evidence in Figure 4-14 is arranged in a fashion that is not only pleasing to the eye, but is also readily comprehended. One reason is that Pavelko was careful to place blank space between the key elements of the slide: the headline and three images. Note that the headline does not begin in the

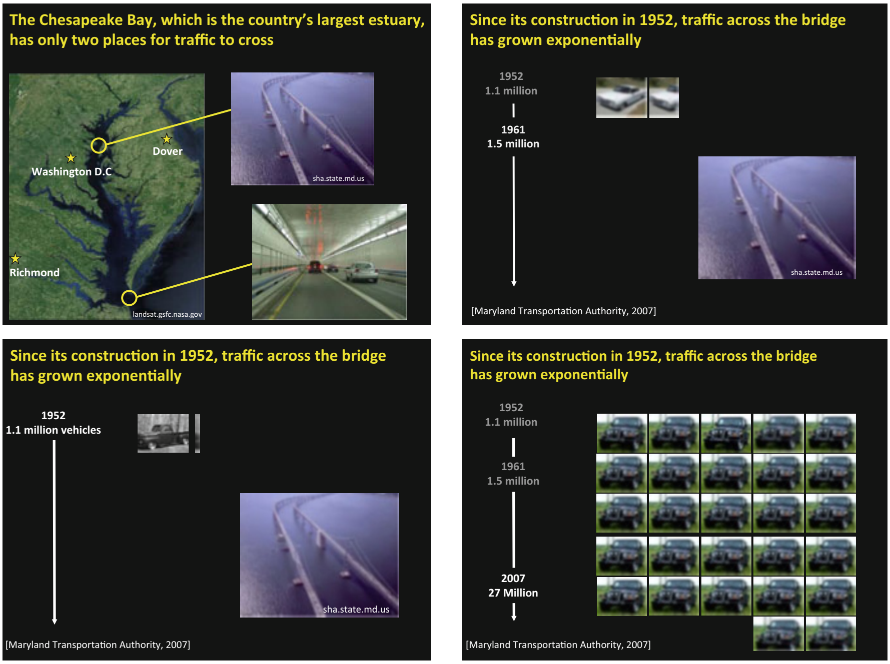


Figure 4-14. Two slides from a talk showing the increase in traffic across the Chesapeake Bay Bridge.[12] In the first slide (*top left*), a drawing and photographs are effective visual evidence. In the second slide (animation sequence occurring over the next three frames), the visual evidence consists of a combination of photographs, a timeline, and a graph. Note that type sizes in the projected slides are much more easily read than type sizes in this condensed version, which focuses on the animation sequence.

default spot for PowerPoint's headlines, which is significantly lower. Instead, Pavelko moved the headline higher so that she had a comfortable space between the headline and the visual evidence below. Blank space between elements in a slide is more valuable than blank space on the edges of a slide.

Also, rather than filling the body of the slide with images, Pavelko sized the images so that they were large enough to view, yet not so large that the body felt crowded. Moreover, she arranged the images so that it was clear in what order to view them. On the left, she placed the map, which she discussed first, and then the two photos she placed on the right, with the top photo closer to the map than the bottom one. For Western audiences, the arrangement of images follows the natural order of viewing those images. The same effect could have been achieved by animation or layering, as will be discussed later. Finally, Pavelko was careful to credit sources for her images—in selecting images, you certainly want to abide by copyright laws.

Other types of assertions require different types of visual evidence. For instance, in the second slide of Figure 4-14 (the animation sequence of the next three frames), Brittany Pavelko argued that the vehicle traffic across the Chesapeake Bay Bridge has increased exponentially since its construction in 1952. For this situation, a combination of types of visual evidence worked well: photographs, timeline, and graph. In this case, animation of visual evidence was also appropriate. In the first layer, the audience views the situation in 1952, in which only 1.1 million vehicles crossed the bridge. Likewise, in the second layer, the audience views the situation 10 years later, in which the annual traffic has increased to 1.5 million vehicles—a noticeable increase, but one that the bridge design could handle. However, the third layer showed the huge increase in annual traffic that had occurred by 2007.

Still other types of assertions require different types of evidence. The slide of Figure 4-15 shows an example of a diagram as visual evidence. In this talk, Are Magnus Bruaset and Jan Olav Langseth from Simula National Laboratory used a diagram to show five steps in the simulation of a plane's flight. The first step of the simulation, in the upper right, calls for defining the partial differential equations for the flight of the plane. In the next step (lower right), those partial differential equations are discretized so that they can be incorporated into computer code, which is the third step (bottom center). The fourth step (lower left) calls for processing the code, and the fifth step (upper left) calls for comparing the results of a simulation with results known from observation. If the simulation does not agree, the computer simulation process begins again with an examination of the partial differential equations.

Although the slide contained several equations and lines of code, the design of the diagram clearly showed the intent

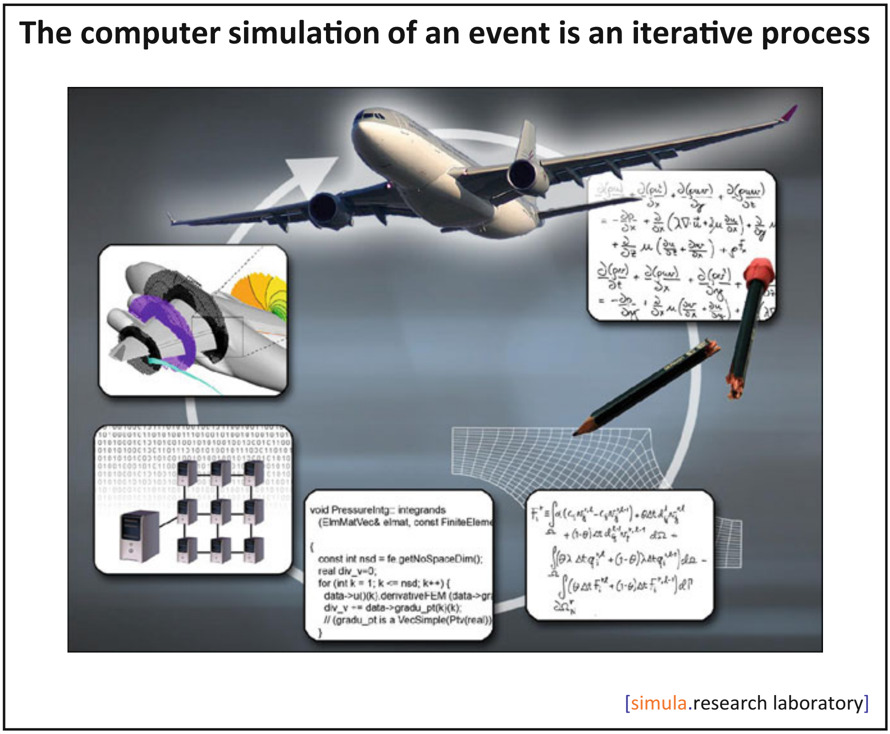


Figure 4-15. Slide that uses a diagram as visual evidence.[13]

was not for the audience to decipher those individual equations or lines of code. Rather, the audience simply had to recognize those blocks as equations or code. Although this diagram has a distinctive professional look, a simpler diagram could be created with a little copying, pasting, and arrangement.

The slide of Figure 4-16 shows an effective incorporation of a line graph. In this presentation, Casey Howsare, an engineering science student from Penn State, wanted to show that reducing the aerodynamic drag on a semi-tractor trailer truck could significantly improve the fuel economy of these vehicles. With this slide, Howsare presented data showing that overcoming aerodynamic drag in a semi-tractor trailer truck requires a large fraction of the engine's power output at typical highway speeds.[14] In presenting this slide, Howsare methodically walked through the graph: what the y-axis is, what the x-axis is, and what each

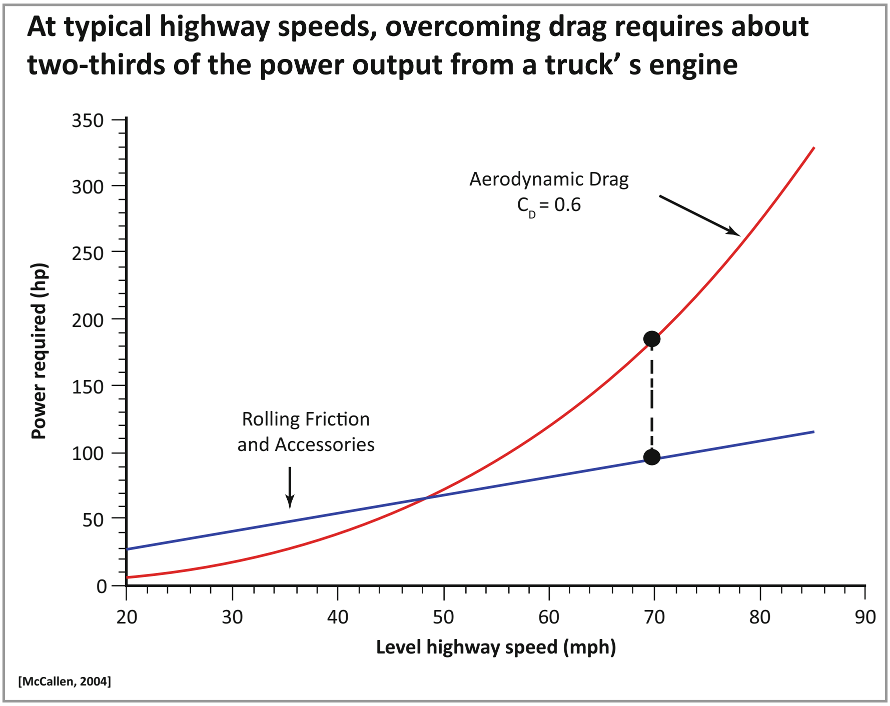


Figure 4-16. Slide from a talk showing how much power that aerodynamic drag draws from the engine of a semi-tractor trailer truck.[15] In this slide, a line graph is an effective form of visual evidence.

curve represents. When he had explained the graph, he then animated in the dash lines, which highlighted the slide's assertion: at typical highway speeds (70 miles per hour), the power required by the truck to overcome drag is twice as high as the power required for other needs.

Shown in Figure 4-17 is a bar graph, this one depicting how much the stream conditions varied between streams being studied in an experiment and the ones used as control. In this slide, Jimmy Webber, a forestry graduate student at Penn State, does a good job of maximizing the valuable information and minimizing the noise. The assertion headline also serves to focus the audience on the key perspective.

In both Figures 4-16 and 4-17, note that no outer box surrounds the graph. In many graph-producing programs, such as

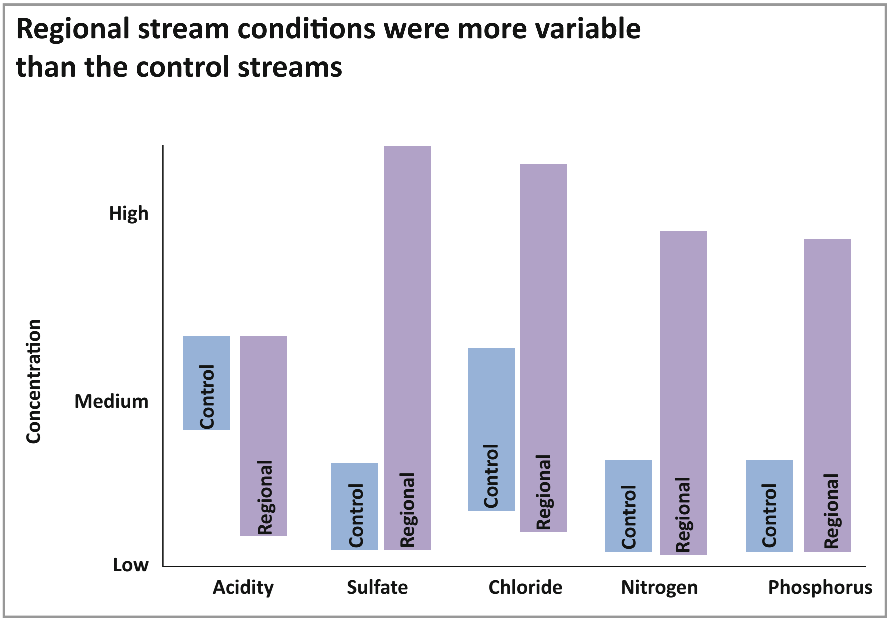


Figure 4-17. Slide from a talk showing conditions from the seasonal streams being studied were more variable than conditions from the streams used as controls in the experiment.[16]

Microsoft Excel, the default calls for an outer box to be placed around the graph, but that box adds only noise to the visual. Just as every word should contribute in a sentence assertion headline, so should every line contribute in the visual evidence. Although borders around a line graph or bar graph do not serve the slide, an outline around a photograph or rectangular drawing often serves to distinguish the borders of the image from the background. For instance, such borders were used effectively in the first three slides of Figure 4-12. Note, though, that because such a border around the line drawing of the fourth slide of Figure 4-12 would have served no purpose, a border was not added.

With graphs and other types of more complicated visual evidence, the speaker should slow down the pace. A common error made by presenters in showing a graph is that they rush through the description of the graph, often neglecting to define the axes or curves. The result is that the audience understands little and believes even less. While the speaker has likely spent much time with the graph, the audience is seeing the graph for the first time. As my colleague Harry Robertshaw would say, for a graph to succeed in a talk, speakers need to allow the audience to have "soak time."

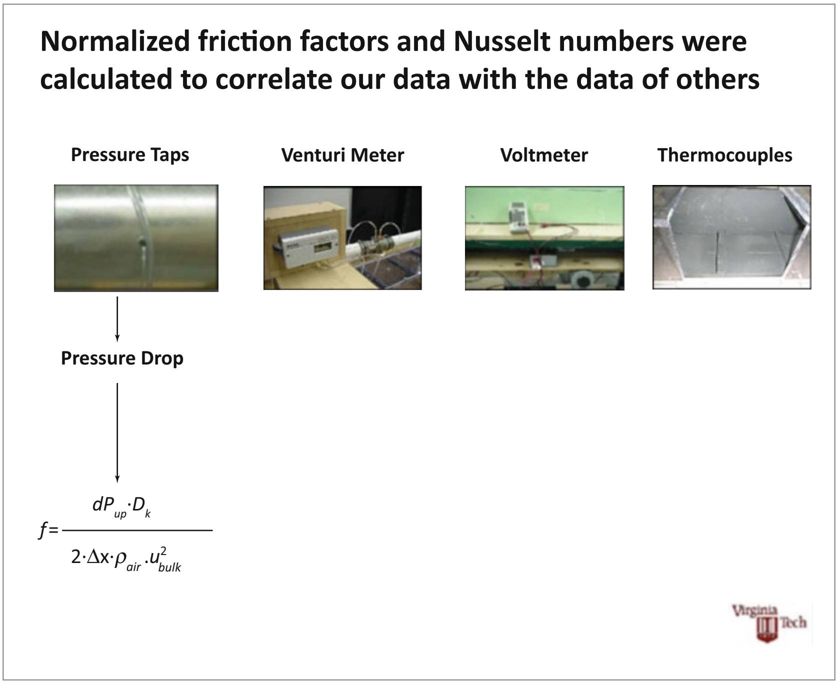
Yet another type of visual evidence available would be an equation. In essence, an equation is a visual arrangement of symbols that shows the connections between the variables that the symbols represent. Figure 4-18 shows the incorporation of equations into visual evidence explaining how the measurements from an experiment are used to calculate the output variables of that experiment.

At this point in the presentation, the team of mechanical engineering students from Virginia Tech had introduced the goal of the experiment: finding the normalized friction factors and Nusselt numbers for flow in a ribbed channel. The team had also explained the wind tunnel experiment for making the needed measurements. What the animated slide in Figure 4-18 shows is the connection between what was measured and what had to be calculated.

Note that if the presenters had shown the connections from all four measurements to the three equations at the beginning of the slide, the slide would have overwhelmed the audience. By viewing each connection one at a time, the audience was in a better position to follow the discussion. Animation is a way to show complicated visual evidence in a piecemeal fashion.

Too much animation, though, is tiresome. For instance, if the first frame of Figure 4-18 just had the sentence-assertion headline, and nothing in the body, that would have been too much animation (and too much bright light reflecting back at the audience). As a presenter, you would like to have some visual evidence present on the slide for the duration of its projection. That way, you take advantage of the audience being able to process relevant images while listening to you speak.

Just as too much animation is annoying, so too is an animation scheme that is unprofessional. *Fly In, Bounce, Swivel, Pulse, Teeter, Spin*—these are just some of the animation schemes available on Microsoft PowerPoint. Not only do these schemes



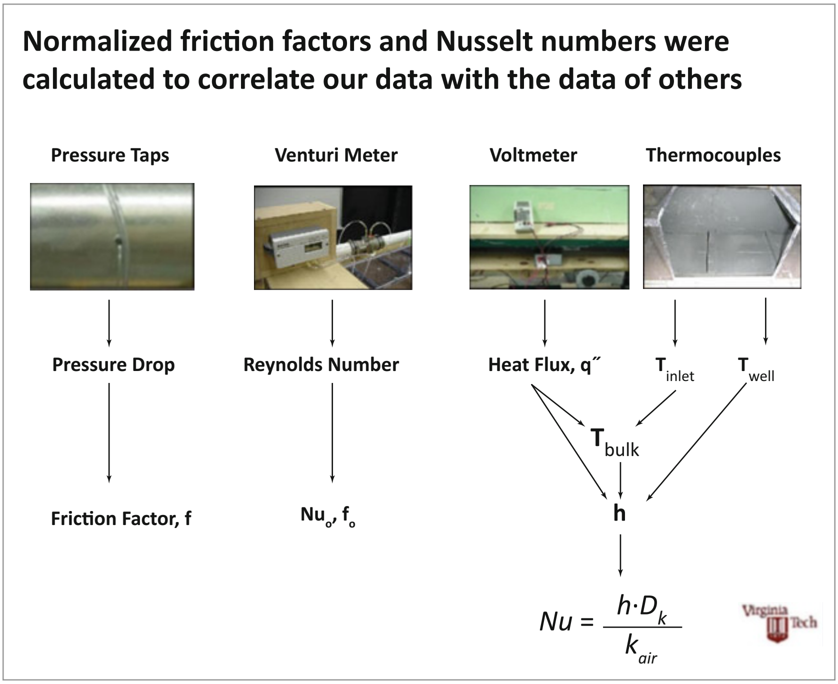


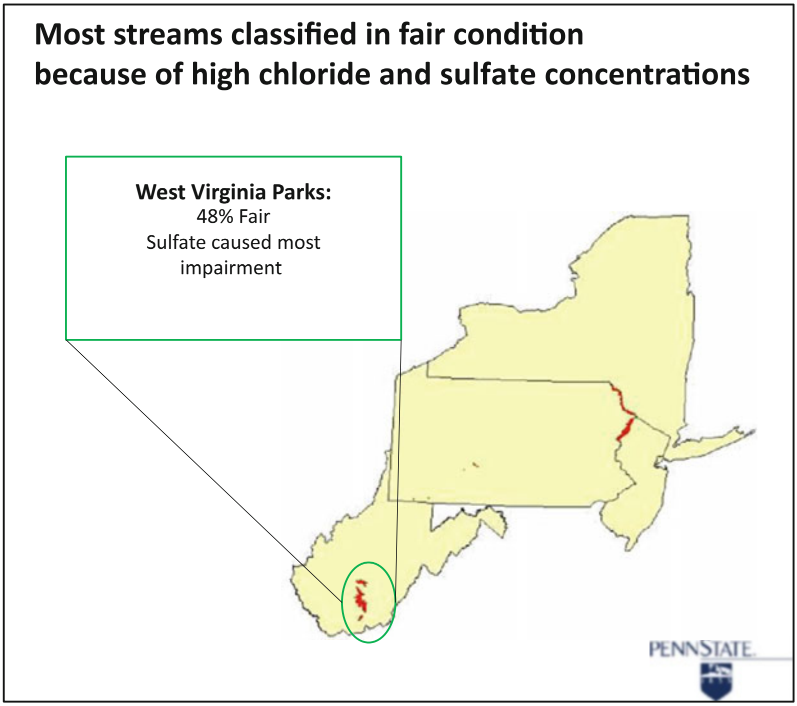
Figure 4-18. Two layers of a slide showing how the measurements in an experiment are used to calculate the output variables of that experiment.[17]

distract and annoy audiences, but they also undercut the professionalism of your talk. I suggest the animation choice *Appear*—it is simple, it looks professional, and it does not annoy people. Unless you are showing actual physical movement in the science, you should avoid those other schemes.

As a last example of types of visual evidence, the slide sequence of Figure 4-19 shows an effective incorporation of a table. In essence, a table is a visual arrangement or words and numbers. Unlike a bulleted list, which is a one-dimensional arrangement, a table allows for multiple connections. In scientific presentations, many tables do not serve the audience, because the tables have too many rows and columns. In such cases, the text is often too small to read. In addition, the large number of table cells makes it difficult for the audience to discern where to look. Even if the presenter highlights one cell with a laser pointer, the large number of other cells can distract. If you remember from Chapter 3, people are able to process two, three, or four items at one time. That rule of thumb is a good one to apply to tables, both for the number of columns and the number of rows.

Even with this rule of thumb, you should consider using animation, such as what occurs in Figure 4-19, to bring in portions of the table. In this figure, the presenter (Jimmy Webber again) has coupled the information of a table with a map. During the presentation of this slide, Webber explains the "columns" of the table one at a time. For instance, when the slide first appears, Webber explains only the information pertaining to streams of the West Virginia Parks. The next animation reveals the table information for the streams of the Delaware River Parks. The actual presentation included layers showing information for the streams of other parks.

Instead of using animation to emphasize details in a table, a speaker could use color to allow rows (or column) to stand out or to fade. One strategy with a table against a white background is to have the numbers (or letters) in the discussed cells be black while having the type in the remaining cells appear as light gray. Another strategy is to use a yellow background behind the discussed cells to make those cells stand out.



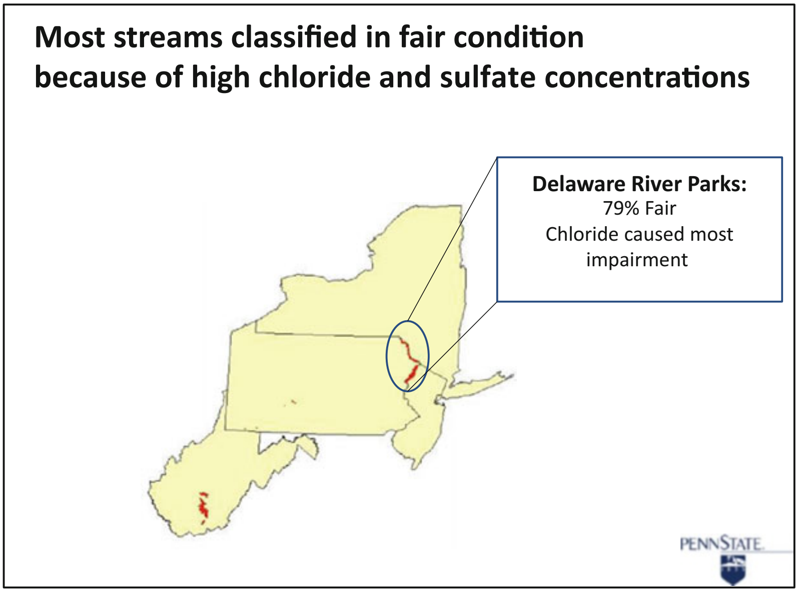


Figure 4-19. Two layers of a slide in which the speaker has found an imaginative way to present tabular information.[18] Anchoring the information to a map makes the locations more memorable and bringing in the information sequentially keeps the audience focused on the information being discussed.

As evidence, a bulleted list is a weak choice. For many presenters, a bulleted list is the first choice for what to place in the body of a slide. As mentioned, our slide survey found that two-thirds of slides in science and engineering contained bulleted lists. What exactly is wrong with a bulleted list?

The main problem is that a bulleted list presents details, but does not show clear connections between those details.[19]

In other words, the ways that details in a bulleted list are actually connected varies—from chronological to spatial to hierarchical to causal or to some combination. When the speaker places the items in a bulleted list, such as the generic A, B, C, D bulleted list shown in slides 1 and 2 of Figure 4-20, the audience has to figure out how those items are connected. However, the speaker could make things much easier on the audience by arranging those details in a visual way that shows their connections. For instance, when the details are connected chronologically, a timeline such as in slide 3 not only conveys more information, but conveys that information more quickly. From the timeline, the audience can quickly discern the separation in time between events. If the details are connected spatially, then arranging call-outs around the image such as in slide 4 is more effective than a separate bullet list as in slide 2. Not only can the audience see where each detail is in relation to the big picture, but also see where each detail is in relation to the other details. If the relationship between the details depends on size, then a pie graph as in slide 5 is more effective, particularly if significant differences exist in the sizes of those details.

Often in science, the relationship between details follows a flow of a variable such as blood, current, oxygen, or information. In such cases, a diagram works well. Slide 6 of Figure 4-20 shows a straight flow: *a* leads to *b*, which leads to *c*, which leads to *d*. In slide 7, another type of flow occurs, this one following a cycle. Finally, slide 8 shows a flow similar to the flow in slide 6, except that feedback occurs between *c* and *a* as well as between *d* and *b*. In this last situation, an audience viewing that same relationship in a bulleted list would be hard-pressed to identify those types of connections.

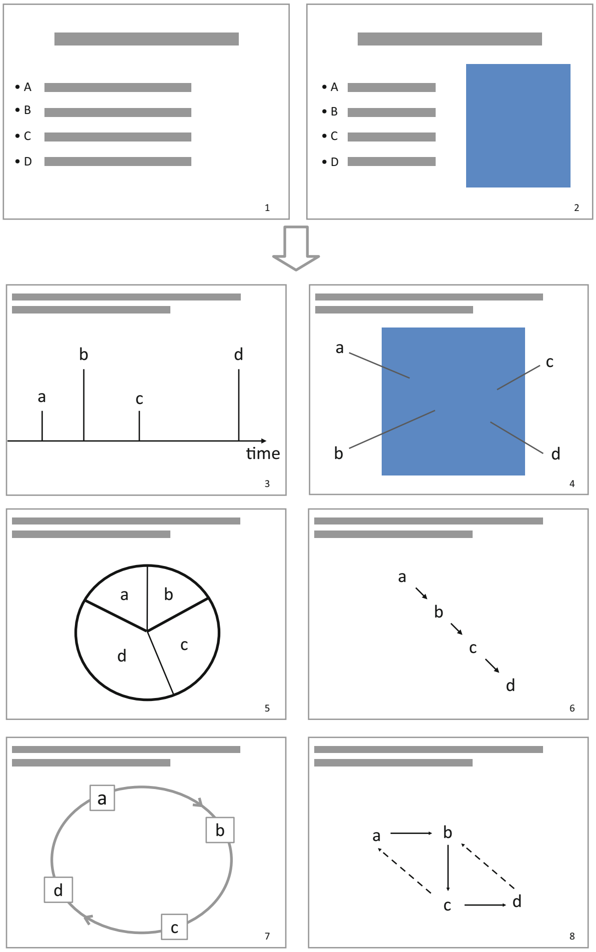


Figure 4-20. Possible strategies for changing bulleted list slides (*top two slides*) to visual evidence slides (*bottom six slides*).

A second problem with bulleted lists is that they lead to too much text on the slides. As has been stated, in a presentation, you need a balance between what you say and what you show. In the 1980s, while visiting one of the national laboratories, the Secretary of Energy attended a presentation given by a department manager. This department manager had worked for weeks on this presentation. He had booked the best conference room at the lab, he had recruited the best artists at the lab to design the slides, and he had practiced the presentation over and over until he could say every word on the slides without even looking at the slides. After the third slide, though, the

Secretary of Energy raised his hand. The department manager stopped and said, "Yes, you have a question?"

"No. I don't have a question," the Secretary of Energy said. "I have a comment. I can read. From now on, don't say anything else. Just put the slides up one at a time, and I'll tell you when to change them."

As you might imagine, the department manager was humiliated. For this department manager, I have sympathy. Given the amount of work that he put into his presentation, he deserved better treatment. Still, a lesson arises from this story: You need to have a balance between what you say and what you show.

If most of the sentences that you say arise from sentences or even phrases that the audience can read, many in the audience will stop listening to you. Such is the situation that often occurs with presentations built on bulleted lists. Figure 4-21 presents a slide from one such presentation, this one given to 200 attendees at a recent NSF grantees conference. Because more than two-thirds of the slides had no images, the slides served little purpose, other than to provide the speaker with a source of sentences for the next 45 seconds. Moreover, in a painful fashion, the speaker animated in each bulleted item one by one. Watching a speaker use slides in this way soon became tiresome for an audience. By the time the speaker projected this slide (slide number 46), the flow of people to the exits had grown from a trickle to a steady stream.

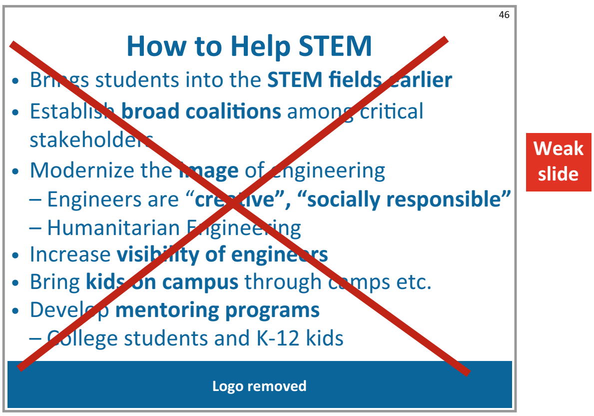


Figure 4-21. Slide number 46 from an exasperating presentation given at an NSF workshop for grantees. Almost every slide had a topic phrase headline supported by bulleted list of subtopics. Worse yet, subtopics were painfully animated in one by one.

When the speaker continually selects visual evidence, as opposed to a bulleted list, the number of words projected during a talk decreases dramatically. Even though the assertion-evidence structure calls on the speaker to invest enough words into the headline to fashion a sentence, the average number of words per slide and words projected per minute for assertion-evidence slides is much less than what typically occurs.[20]

Because bulleted lists can connect details in so many different ways, they are easy to create. The speaker does not have to go through the effort of determining how the details relate to one another. All the speaker has to do is to write the details in a parallel grammatical fashion: noun phrases, participial phrases, and so forth. In essence, a bulleted list captures the ideas of brainstorming and dresses up those ideas in the disguise of a finished presentation. Granted, some of those brainstormed ideas might be blooms, but those blooms are typically surrounded by weeds.

Because bulleted lists are relatively easy to create and because they have the "disguise" of a finished presentation, they have become popular. Simply put, many presenters have been seduced into relying on bulleted lists because of the superficial polish that they exude and the ease with which they can be created.

While bulleted lists make things easy for speakers, they confound audiences. In his service on the Presidential committee to investigate the Space Shuttle *Challenger* disaster, Richard Feynman expressed the frustration that audiences feel in trying to make sense of bulleted lists:

> Then we learned about "bullets"—little black circles in front of phrases that were supposed to summarize things. There was one after another of these little [expletive] bullets in our briefing books and on the slides.[21]

Bulleted lists represent surface thinking, not deep thinking. You should aim higher. Make a bulleted list your last choice, not your first. Richard Feynman did not care much for bullets, and neither should you.

For slides to be effective, the format must rise above PowerPoint's defaults

In addition to crafting the sentence-assertion headline and supporting that headline with visual evidence, a third hurdle to creating effective assertion-evidence slides is to format the slides so that they are readily understood. For those creating slides with PowerPoint, this goal often means rising above PowerPoint's defaults for typography, color, and layout.

Select typography that is quickly read. Typography includes the choice of typeface. Also included is the way that the typeface is set: normal type or boldface, the size of the type, the choice of all capitals or lowercase, and the color.

1. For presentation slides, select a sans serif typestyle. Just because a typeface such as Book Antiqua, Times New Roman, or Garamond is appropriate for the text of reports and papers does not mean that it is appropriate for presentation slides. These three typefaces belong to a class of typestyles known as serif fonts, which have projecting short strokes, such as the little feet on a serif "m." Another category of typestyles is sans serif. These fonts do not have the projecting strokes (consider a sans serif "m"). Two of the more common sans serif fonts are Calibri and Arial.

The most important consideration in choosing a typeface for a presentation slide is not tradition, but reading speed. When a slide is projected, how quickly the audience can read the type is important because the audience is both reading the type and listening to the presenter. In general, when type appears in short text blocks such as on a billboard or presentation slide, sans serif typefaces are read more quickly. That is why most technical artists recommend a sans serif type such as Calibri for presentation slides. Compared with serif typefaces, sans serif typefaces have straighter and less noisy strokes. This cleaner look is especially important for audience members seated on the sides of a screen, because they have to view the type from angles.

Within this category of sans serif typestyles, Calibri (which is the current default typeface on PowerPoint) is a particularly good choice because it is found on most computers. The ubiquity of this typeface is advantageous when you load your presentations onto a meeting room's computer. Calibri is also narrower than Arial, which was default typeface for the 2003 version of PowerPoint. Because Calibri is narrower than Arial, Calibri allows more blank space on the edges of a text block. As will be discussed later in the chapter, blank space is valuable for efficiently guiding the reader through the slide.

Originally, the default typeface of Microsoft's PowerPoint was Times New Roman, a serif typeface that is not read as quickly as sans serif typefaces are. That difference in reading speed is especially noticeable when the quality of the projection or the lighting in the room is not optimal. Such was the case a few years ago when a manager held a 90-minute meeting for 20 engineers. Because the computer projector's bulb had degraded and because the manager had chosen this default typeface, the slides were unreadable. Conversely, using that same projector the next day, another presenter projected readable slides that relied on a sans serif typeface.

2. For presentation slides, use boldface. In addition to advocating a sans serif typeface, many graphic designers also recommend using the bolded version of that typeface, especially if the presentation is to occur in a larger room. Boldfacing the type (**Calibri** or **Arial**) makes the letters more readable from a greater distance.

While boldface is recommended for presentation slides, other options such as *italic* or <u>underline</u> are not. While italic type in small blocks is useful for emphasis in instructional documents, type set in italics is too slow to read in presentation slides, particularly when the slides are viewed from sharper angles on the sides of the screen. Underline is a poor choice because the underlining adds noise (the underscore) that makes recognition of the letters more difficult.

3. Choose an appropriate type size for the room. On presentation slides, the size of the type is important. Type size is measured in points—a point is about 1/72 of an inch. The most important consideration for type size is that everyone in the audience can read the headline and body type.

At a national conference in the 1990s in which presenter after presenter used 12 and even 10 point type on their slides—a size that people sitting in only the first few rows could read—one person in the audience decided that he had had enough. This person moved to the back of the auditorium, stood on a chair, and focused a pair of binoculars onto the screen. Because most of the audience members had long since given up trying to read the tiny lettering on the screen, they soon spotted the man in the back with the binoculars. A wave of laughter passed over the auditorium. The commotion was so loud that the presenter became flustered and turned off the projector. For this presenter, I have little sympathy. Not taking the time to create a slide that the audience can read is inconsiderate.[22]

Shown in Table 4-4 are appropriate sizes for text on an assertion-evidence slide. Also, given in Figure 4-22 is an example slide that demonstrates the use of these type sizes. For the headline of an assertion-evidence slide, 28 points works well and has been the recommended type size for assertion headlines at Lawrence Livermore National Laboratory for more than three decades.[23] Other slide designers recommend that size as well.[24,25] That size is large enough to stand out on the slide, yet small enough that you can write a meaningful sentence assertion in one

Table 4-4. Recommended type sizes for a slide and their corresponding uses

28 points	Headline of slide
24 points	Supporting text for body of slide
20 points	Supporting text for body of slide
18 points	Supporting text for body of slide
14 points	Reference listing (not bold)
12 points	Reference listing, small room (not bold)

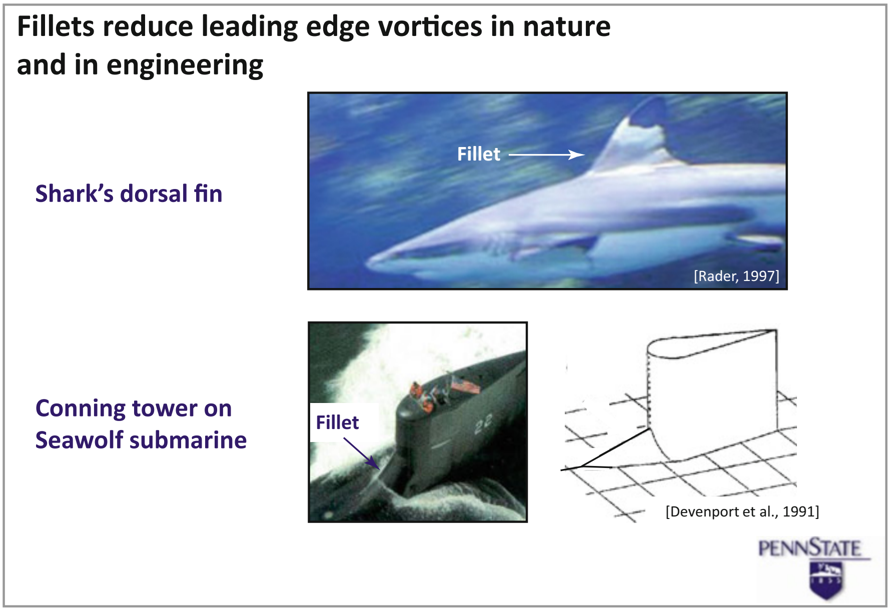


Figure 4-22. Sample slide that shows the recommended type sizes for an assertion-evidence slide.[26] The headline is 28 points, boldfaced; the text in the slide's body ranges from 18 to 24 points, boldfaced; and the reference listings are 14 points, not boldfaced.

or two lines. Unfortunately, PowerPoint's default for headlines is 44 points, which is too large to write a meaningful sentence in one or two lines. This default you will want to challenge.

For text that appears in the body of a slide, a type size between 18 and 24 points works well. If the type is bolded, that size is large enough to be read in the backs of most rooms. The actual size in this 18–24 point range that you choose would depend on the importance of the text block and how much space you have for that text block. As mentioned, you want to keep text blocks to one or two lines.

For reference listings that are typically short and not intended to be the initial focus for the audience, a size of 14 points (or even 12 points for smaller rooms) does the job. Note that a reference listing, which appears on the slide, is much shorter than a reference citation, which appears in the handout or on the slide's notes page. Often the reference listing is nothing more than the author's last name and the year. Also note that with a reference listing, it is not imperative that everyone in the room be able to read the type. However, everyone should be able to see that a reference listing *exists* for the photograph, drawing, or graph that you are using from someone else's work. Not acknowledging another group's contribution during a presentation is at the least an insult to the owners of that contribution and more typically regarded as theft.

Some years back, at a Department of Energy meeting for those with research contracts, a well-known researcher showed a graph that my wife had created. The graph on the slide had no reference listing below. Worse yet, the researcher did not acknowledge that my wife had come up with this trend. Perhaps the presenter had intended to state an acknowledgement of my wife's work, but from the perspective of the Department of Energy, which was the funding agency for researchers in the room, the graph appeared to come from the presenter, not my wife. My wife was upset, but thought it would be out of place for her, a relative newcomer to the field, to bring up this point during this established researcher's presentation. However, another researcher who was familiar with my wife's work challenged the presenter on the source of the graph: "Isn't that graph from Karen Thole's work?" The presenter, embarrassed, admitted it was, and the room buzzed with uncomfortable whispers.

4. Avoid presenting text in all capital letters. Many presenters mistakenly use all capital letters on their slides. These presenters fail to recognize that readers recognize words not only by the letters in the word, but also by the shape of the letters: for instance, the shapes of ascenders such as *b, d,* and *f* and the shapes of descenders such as *g, j,* and *p*. As shown below, using all capital letters dramatically slows the reading because using all capitals prevents readers from recognizing the shapes of words.[27]

> TYPE SET IN ALL CAPITALS IS READ SLOWLY BECAUSE EVERY LETTER MUST BE READ
>
> Type set in lowercase is read more quickly because words can be recognized by their shapes

Another problem with using all capitals is that type set in all capitals takes up much more space (about 35 % more space) than type set in upper and lower case.[28] On a presentation slide, space is valuable, and what space you do not need for type and images, you want to leave blank, to make the slide more inviting to read.

Select colors that serve the audience and situation. At a 30-minute contractors' presentation before 60 engineers and scientists, most of whom had flown to the meeting, an engineer projected a set of computer slides with a dark rust type against a brown background. The audience at first thought that the engineer had begun with a blank brown background upon which he would build a slide. Unfortunately, nothing ever appeared. The engineer proceeded to project another slide with the same blank brown background, and the audience began whispering among themselves. The speaker, sensing the agitation from his audience, turned to look at the screen. Not even he, standing a couple feet from the screen, could read the words. This engineer, who later claimed that he could see the contrast on his computer screen, had neglected to try out the color combination on a projected screen. Even if the engineer could see the contrast on his computer screen, he should have given more thought to the colors that he had chosen.

1. Choose either dark type against a light background, or light type against a dark background. As you might infer from the anecdote about the engineer who used rust letters against a brown background, choosing a color combination with a high contrast is important. Not all color combinations are read with equal speed. The color combination that is read most quickly is black lettering against a yellow background,[29] which is one reason that caution signs use this combination. The next most quickly read combination is black lettering against a white background. One of the slowest-to-read combinations is black lettering against a red background, and even more slowly read is red lettering against a black background. Although dark blue or dark green lettering against a white background is not read as quickly as black against a white or yellow background, these combinations can be read quickly enough to serve a scientific presentation. In the end, what is important is that the contrast be high.

Colors that are neither dark nor light are not appropriate as the main colors for a slide's text or background. Essentially, these colors fall into *no man's land*. As a background color, these are not dark enough to contrast against white type and not light enough to contrast against black type. If you are selecting a color from PowerPoint's palette, you want to stay with dark colors on the edge of the palette, and light colors toward the center.

For shorter presentations such as at a conference, I usually go with a white background. A white background has the advantage of allowing for a seamless incorporation of equations and graphs from other programs, because the backgrounds of elements from those programs are usually white. For longer presentations, though, I prefer a darker background because the darker background is softer for the audience. However, if the projector's bulb is old or if the room allows too much light to fall on the screen, the traditional white background is your best bet.

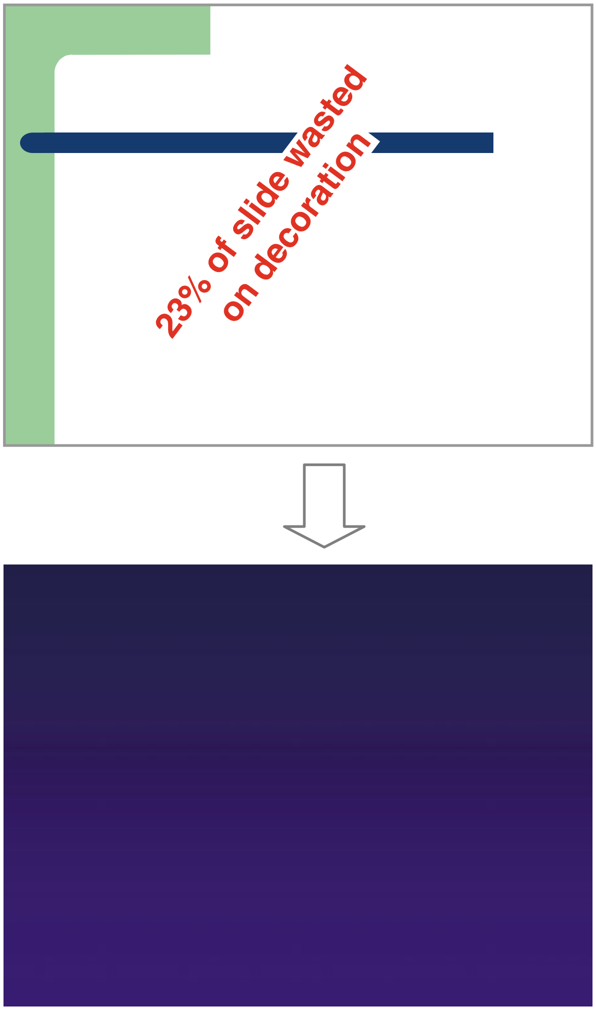
Another consideration for contrast is color blindness, which is the inability by a significant number of people to distinguish different color combinations. The percentage of people with color blindness depends not only on gender, but also on ancestry (Nordic versus Middle Eastern, for example). Still, the color combinations that cause the most problems for these people involve red, green, and brown. Not only should you avoid these combinations for type and background colors, but you should avoid picking more than one of these colors for different curves on a graph.

2. For the background, avoid hot colors such as red, orange, or yellow. Another consideration besides contrast is the effect of the colors on the audience. For Western audiences, blue and green are soothing colors. For that reason, these audiences feel comfortable with either of those colors used as the background of a slide. Orange and red, on the other hand, are hot colors and can unsettle a Western audience. Unless you desire to rile such an audience, avoid such colors as your background color. Even yellow, when used as a background color, agitates. When I first learned that black type against a yellow background was the fastest color combination to read, I tried that combination on my overhead transparencies. That semester the students seemed unusually agitated in class, and their questions were often caustic. When I switched the next semester to a cooler combination (white lettering against a blue background), the classes calmed down noticeably.

For a company that has blue as its identifying color, incorporating blue into the color scheme of its presentation slides is natural. Sandia National Laboratories, for instance, uses blue as an identifying color. For that reason, many presentation slides representing Sandia use blue—either blue lettering on a white background or white lettering on a blue background. Likewise, Lawrence Livermore National Laboratory has green as an identifying color and uses green in a similar fashion. However, in selecting colors for a presentation slide, association with your institution is secondary to the issues of contrast and emotional effect on audience. For instance, Virginia Tech, where I taught for a number of years, has maroon and orange as its representative colors. While these two colors somehow work on the team's football jerseys amid the beautiful autumn leaves of the Appalachian Mountains, neither of these colors work as the color for the background or the type on the slides. For that reason, the main color combination for type and background should be something else.

3. Avoid backgrounds with decorations. Fireballs, starry nights, clouded skies, rippled oceans, wave borders—these stock slide backgrounds from PowerPoint and other programs are noise in scientific presentations. Moreover, many of these

Figure 4-23. Weak choice for slide background. This stock background wastes 23 % of its space on.



stock backgrounds consume much valuable space with decorations that add *zero* content to the presentation. For instance, the decoration on the popular PowerPoint background in Figure 4-23 wastes or makes useless 23 % of the slide. If you want a distinctive background that does not compromise your content, a much better choice is an airbrushed look. The airbrush option in PowerPoint is one of the program's best format features. In such cases, my recommendation is to select two related dark colors, both of which will provide high contrast for a light type.

Another factor in choosing the background color is whether the audience will print out the slides. For instance, students often print out a professor's slides to supplement their notes. In such cases, a white background is preferable to save toner on their printers.

4. Do not allow logos to distract the content. During a presentation, showing the logo of the represented institution at some point is appropriate. Also appropriate is having your logo on any slide that is distributed, either as a print-out or a computer file. However, one common error with logos is making the logo too prominent. The logo of the presenter's institution should be secondary to the content of the presentation.

A second common error with logos is having the logo appear on every projected slide, even when the logo compromises the visual evidence. While having the logo on every slide given as a *handout* is appropriate, logos are needed on only your first and last *projected* slides. After all, it is a safe bet that you will remain with the same institution for the time in between. Even if you decide to keep the logo on projected slides during the middle of the talk, you should not hesitate to remove the logo if crowds your visual evidence. As stated in Chapter 1, in a scientific presentation, content is king and should not be compromised by decor.

Another consideration about logos is where to place them. One of the bottom corners is a good choice. That way, the logos are visible, but not as likely to distract from the content. For some reason, many presenters place their logos in the upper left corner of every single slide. If you remember, the upper left corner is where Western audiences look first when viewing a slide. Put another way, the upper left corner is the most valuable piece of real estate on a slide, which is why the assertion-evidence structure has the assertion headline begin in that space.

Select a layout that guides the reader through the slide. A third consideration in the format of a slide is the layout. Essentially, layout is the way that you arrange the type and graphics.

For a successful slide, you would like to have the arrangement such that the audience comprehends the slide in an efficient manner. The guidelines in this section help you achieve this goal.

1. Avoid text blocks more than two lines. As mentioned, my colleague Harry Robertshaw and I ran a large number of focus groups at Virginia Tech in which we found that while almost everyone would read text blocks of one or two lines, more than half the people in the room would not read text blocks that were three lines or longer.[30] For that reason, keep all text blocks, especially the headline, to one or two lines.

2. Avoid groupings with more than four items. Genesis, Exodus, Leviticus, Numbers, Deuteronomy, First and Second Samuel, First and Second Kings—that grouping continues for another 57 items. While we sometimes spend significant time memorizing long lists such as the books of the Bible, we expect too much of our audiences when we ask them to process large groupings that we display for only a minute or so in our presentations. As mentioned in Critical Error 4, audiences remember groupings of twos, threes, and fours. In a presentation, groupings that have more items are soon forgotten. Those groupings could be the divisions of a talk, the call-outs of a photograph, or the curves on a graph. In truth, many in the audience will not even try to process such large groupings. For instance with a photograph that has seven call-outs, the audience sees the number, perhaps reads the first call-out in the upper left corner, and then turns away. Presenters would do better to place only the three or four most important call-outs on the slide and fold the less important details into the speech.

What if the items have the same relative importance? For instance, what if you are evaluating the seven characteristics of a receiver at a solar energy plant:

Steady-state efficiency
Average efficiency

Startup time
Operation time
Operation during cloud transients
Panel mechanical supports
Tube leaks

Rather than giving your audience all seven characteristics up front, consider placing the characteristics into more memorable groups. One example is as follows:

Efficiency of receiver
Operation cycle of receiver
Mechanical wear on receiver

When you discuss the efficiency of the receiver, you can then mention steady-state efficiency and average efficiency in your speech as characteristics for that category. Likewise, when you introduce mechanical wear on the receiver, you can mention panel mechanical supports and tube leaks in your speech as characteristics for that category. The advantage is that the audience is much more likely to recall the list of three categories than the longer list of seven characteristics.

An exception to excluding a long list is the case in which the presenter does not expect the audience to actually read the list. Rather, the presenter just wants the audience to see that many examples exist. For instance, a presenter might want to show the many negative effects of a drug treatment. In this case, the presenter could use a long list of examples as overwhelming evidence for the assertion that this drug treatment is dangerous. In making that list, consider having the typeface for the more serious effects go from high contrast (black, if white background) to lower contrast (lighter shades of gray) for the less important effects. That way, the audience sees the list more as an image than words to comprehend from top to bottom.

3. Have animation serve rather than irritate the audience. Another way to work in more than four call-outs to an image or four blocks on a diagram is to animate in the additional ones.

When building such a slide, be careful about having too many stages. Unless you are simply trying to overwhelm the audience with the number of items, then limit the number of animations per slide to four. In addition to being sensitive to the amount of building, be sensitive to the way that you bring in items. Avoid PowerPoint's cute functions that bring in the details from all sorts of directions and with all sorts of fanfare. As mentioned, a much less distracting way to bring items on the screen is the choice named *Appear*, which has the item simply and quickly appear on the slide. Although the *Appear* selection is not easy to find in earlier versions of PowerPoint, it is worth the effort. Finally, with regard to building a slide, avoid having any accompanying sounds. These sounds, which range on PowerPoint from clicks to whooshes to brakes screeching, just grate on the audience and have no place in a professional presentation.

4. Insert enough blank space between the slide's elements that the slide breathes. A problem with the layout of many slides is that not enough blank space exists between text blocks and graphics. One negative effect is that the slide feels crowded. A second is that the audience is not sure in what order to view different elements. Yet a third negative effect is that audience views the slide in an inefficient manner—moving from one element to another and then back again.

Much of the fault here lies with PowerPoint's default master, which leaves large gutters at the slide's top and sides, thereby bunching the text blocks and graphics into the middle. Back in the 1980s, when PowerPoint first came out, the large gutters at the top and sides were important because most slides were printed as transparencies, and the gutter was needed to ensure that the various transparency projectors did not cut off portions of text and images. That situation, however, is no longer the case.

Another issue with PowerPoint's default master is that the text sizes for the headline and body text are larger than they need to be, thus reducing the blank space. In the top slide of Figure 4-24, the presenter tried to create an assertion-evidence slide, but began with the defaults of PowerPoint's slide master and did not appreciate the importance of blank space. In the bottom slide, the guidelines for text sizes are followed. Moreover,

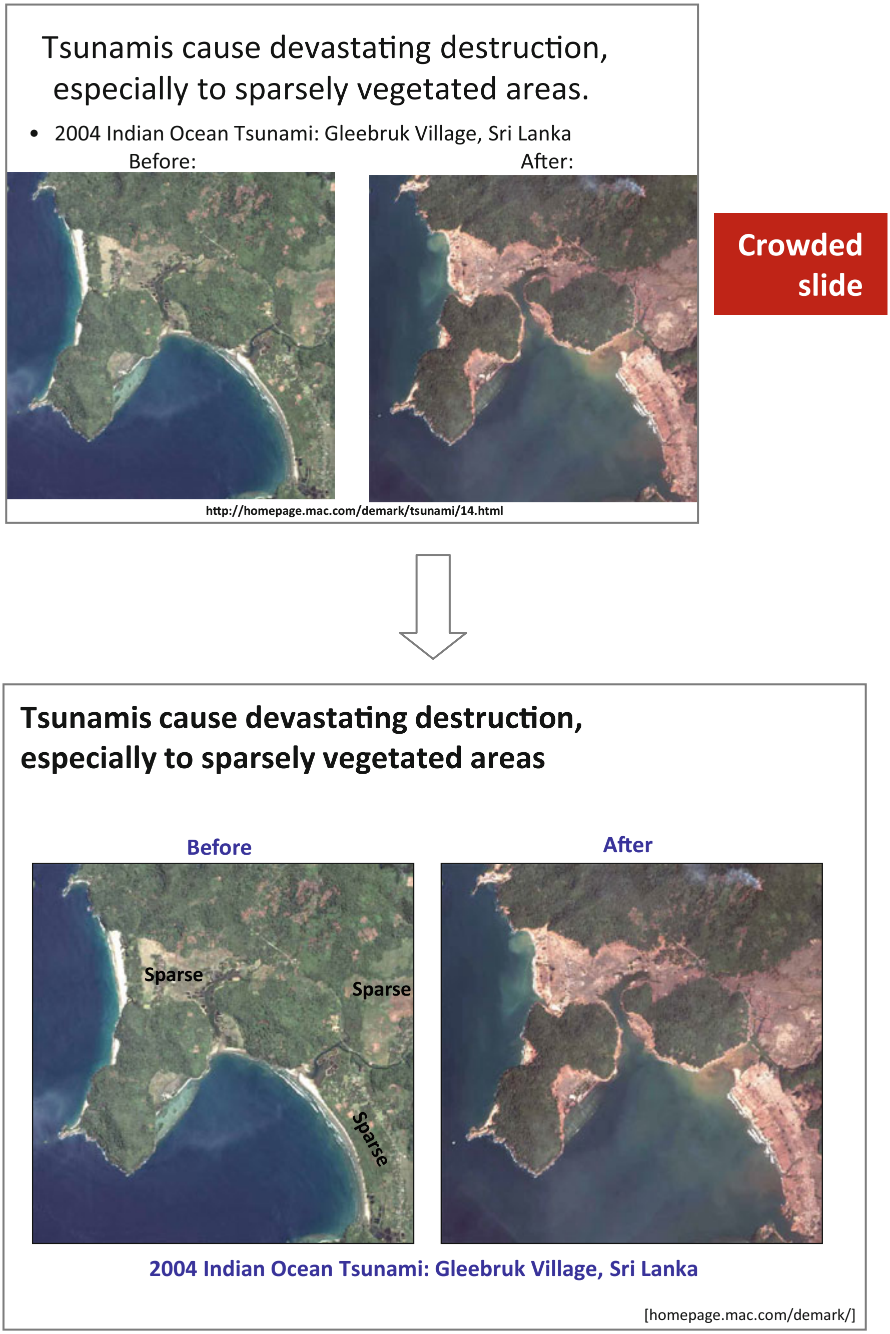


Figure 4-24. Comparison of assertion-evidence slide that follows PowerPoint's defaults for format (*top*) with a slide (*bottom*) that has the same assertion and evidence, but follows the format guidelines in Table 4-3. The *bottom slide* is much easier for the audience to navigate.

the positioning of the assertion headline is higher so that more space exists between elements. Finally, images are sized so that the slide breathes. The result is a slide that the audience can easily navigate.

This chapter has challenged several defaults of Microsoft's PowerPoint. The overall message here is not that you should avoid programs such as Microsoft's PowerPoint. The message is that you should assess the defaults of such programs to determine whether those defaults serve your audiences, purposes, and occasions. In those cases where the program's defaults do not serve the presentations, then you should be proactive and change them.

Notes

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[2] S. Fishbone, Comparison of xenon headlights with halogen headlights for use on automobiles, class presentation of talk originally given at Ford Motor Company (College of Engineering, Pennsylvania State University, University Park, Apr 2008)

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[6] M. Alley, H. Robertshaw, Rethinking the design of presentation slides: the importance of writing sentence headlines, in *2004 International Mechanical Engineering Conference and Exposition*, paper 61827 (ASME, Anaheim, Nov 2004)

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[10] M. Alley, *The Craft of Scientific Writing* (Springer, New York, 1996), chap. 8

[11] Adobe Systems Incorporated, Type is to read, poster (Adobe Systems, San Jose, 1988)

[12] B. Pavelko, Traffic congestion on the Chesapeake Bay Bridge, class presentation (College of Engineering, Pennsylvania State University, University Park, Mar 2009)

[13] A.M. Bruaset, J.O. Langseth, Computational simulations at Simula Research Laboratory, presentation (Simula Research Laboratory, Oslo, 2005)

[14] R. McCallen, F. Browand, J. Ross, *The Aerodynamics of Heavy Vehicles: Trucks, Buses, and Trains* (Springer, Berlin, 2004)

[15] C. Howsare, Reducing aerodynamic drag on Class-8 Semi-Tractor Trailer Trucks, class presentation (College of Engineering, Pennsylvania State University, University Park, Apr 2010)

[16] J Webber, Water quality of streams in National Parks of the Mid-Atlantic USA: a chemical and biological assessment, thesis presentation (Penn State School of Forest Resources, University Park, 31 Mar 2012

[17] J. Cook, J. Hurley, R. McNulty, Z. Reuter, C. Smith, Recommendation of rib configuration for the internal cooling of gas turbine blades, class presentation (Mechanical Engineering Department, Virginia Tech, Blacksburg, 2004)

[18] J. Webber, Water quality of streams in National Parks of the Mid-Atlantic USA: a chemical and biological assessment, thesis presentation (Penn State School of Forest Resources, University Park, 31 Mar 2012)

[19] G. Shaw, R. Brown, P. Bromiley, Strategic stories: how 3 M is rewriting business planning, *Harvard Business Review* (May 1988), pp. 41–50

[20] M. Alley, S. Zappe, J. Garner, Projected words per minute: a window into the potential effectiveness of presentation slides, in *2010 ASEE Annual Conference and Exposition* (ASEE, Louisville, June 2010)

[21] R.P. Feynman, *What Do You Care What Other People Think?* (Norton, New York, 1988), pp. 126–127

[22] P. McMurtry, Professor of Mechanical Engineering, University of Utah, interview with author (2002)

[23] L. Gottlieb, Presentation Designer at Lawrence Livermore National Laboratory, correspondence with author (2002)

[24]C. Atkinson, *Beyond Bullet Points: Using Microsoft PowerPoint to Create Presentations That Inform, Motivate, and Inspire* (Microsoft Press, Redmond, 2005)

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[28]Ibid

[29]Ibid

[30]M. Alley, H. Robertshaw, Rethinking the design of presentation slides: the importance of writing sentence headlines, in *2004 International Mechanical Engineering Conference and Exposition,* paper 61827 (ASME, Anaheim, Nov 2004)

Critical Error 8
Following the Common Practices of PowerPoint Talks

People are not listening to us, because they are spending so much time trying to understand these incredibly complex slides.[1]

–Louis Caldera Secretary of the Army

The way that we as engineers and scientists design presentation slides is naturally evolving. When a presenter comes up with a new slide design that succeeds in a talk, those of us in the audience consider adoption. However, this natural evolution of effective slide designs in engineering and science has been painfully slow. One reason, as slide designer Cliff Atkinson asserts, is that PowerPoints's defaults "are deeply entrenched."[2]

As mentioned, PowerPoint commands a 95 % share of the market for presentation slideware.[3] Also, many of PowerPoint's weak defaults that Robert Gaskins and Dennis Austin chose in 1987 still persist today. In addition, many weak practices have grown out of those defaults and have become so common that younger engineers and scientists might not realize that alternatives exist. Moreover, many of these weak practices have become integrated into company and laboratory slide templates, making it difficult for individuals in these companies or laboratories to break the mold.[4]

Worse yet, following the defaults of PowerPoint, especially the creation of bulleted lists, is easy. Bulleted lists are not only simple to create, but they also give the appearance of significant thought. Even though bulleted lists do not reveal much hierarchy or connection of details to audiences, they are seductive to presenters.

For change to occur in science and engineering, individual scientists, engineers, and technical managers have to step back and critically assess the common practices of PowerPoint talks. This critical assessment means challenging the ineffective common practices that PowerPoint's defaults have spawned. In addition, this assessment calls for analyzing when alternative slide structures such as the assertion-evidence approach are effective and when they, too, should be challenged.

So far, this book has advocated an assertion-evidence approach to slides, and for the lion's share of slides in scientific presentations, the assertion-evidence approach is an effective choice. Unlike the defaults of PowerPoint, the assertion-evidence structure is grounded in research principles for how people learn. Sometimes, though, scientific presentations target special audiences, carry special purposes, or occur on special occasions. For these situations, other alternative slide structures that are also grounded in principles for how people learn are effective.

For instance, the TED slide structure, which Garr Reynolds[5] and Nancy Duarte[6] have championed, is effective for communicating to the general public. While assertion-evidence and TED represent the two effective structures of a slide, four interesting variations exist to sequence such slides: an evidence-assertion order, *pecha kucha*, the Lessig approach, and Prezi. This chapter briefly discusses these alternatives.

Title slides should orient, outline slides should map, and concluding slides should emphasize

Certain slides in a talk serve not only to provide content, but also to show organization. Three such slides are the title slide, outline slide, and conclusion slide. Certainly, not every slide presentation needs these three slides. In fact, the shorter the presentation, the less important each one becomes. For instance, beginning with a blank (black) slide and placing the focus squarely on the speaker is often effective for the beginning of a talk, especially when the audience already has a concrete image of the talk's topic. In addition, talks given at research conferences often do not need an outline slide, because the audience already knows that the speaker will introduce the hypothesis, discuss the methods for testing that hypothesis, and then discuss the results of those tests. However, in longer talks, these organizational slides have important roles that the commonly practiced approaches to these types of slides do not fulfill.

Title slides should orient. As poor a starting place as PowerPoint's default master is for a body slide of a scientific presentation, PowerPoint's default master for a title slide might be worse. This master, shown in Figure 4-25, leads many presenters into showing only the title and their names and institutions. What typically occurs then is rather than having the beginning of the talk be an engaging entry point, it becomes a hurried obligation—*here is my title and here is my name and the names of my collaborators*. In such a presentation, when this first slide changes to the second, uneasiness arises in the audience, because the scene has changed and yet the audience is not oriented. What is this talk about? Why should I care about this talk? Anyone who has attended a scientific conference has seen slides such as the two in Figure 4-26 and experienced this discomfort.

Figure 4-25. PowerPoint's default master for title slide—this default is weak because it leads presenters to create title slides without relevant images, which are important for orienting audiences in scientific talks.

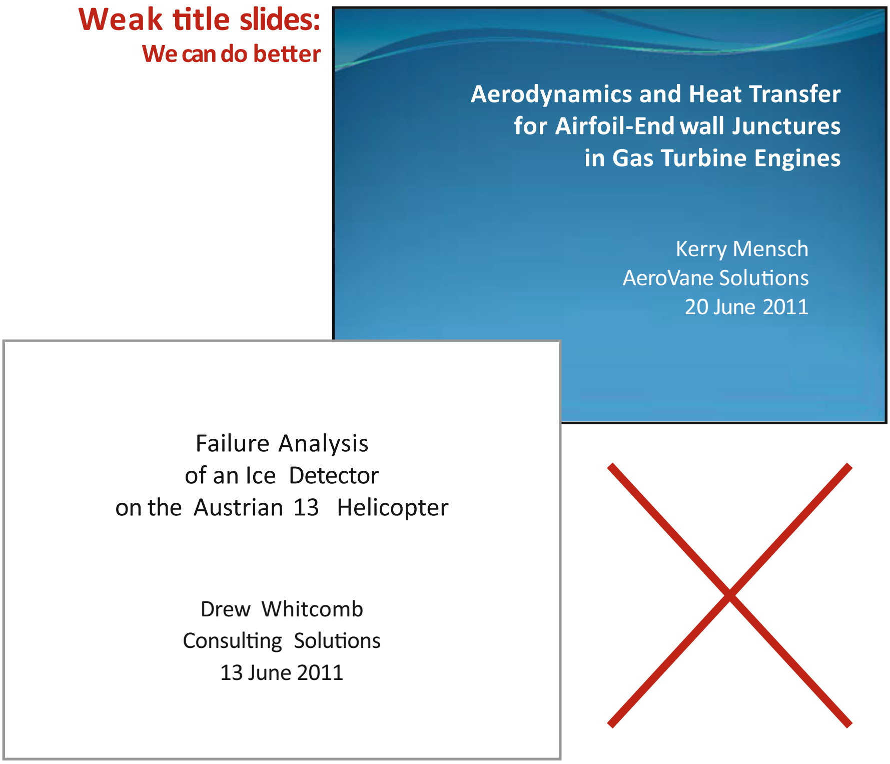


Figure 4-26. Weak title slides, typical of what occurs in scientific presentations. We can do better—much better.

As mentioned in Chapter 3, the beginning of a scientific presentation should orient the audience. For example, Figure 4-27 presents the title slide that Manning Stelzer, a Sikorsky Helicopter engineer, used to introduce his work on analyzing what caused the failure of the ice detector on Austrian 13 helicopter.[7] Having these images allowed Stelzer to select an effective entry point for this talk. For one type of audience, he might begin with the scope of the work and use the images to explain the title. With a different audience, he might begin with the importance of the work and discuss the case in which the ice detector failed on a helicopter mission. For yet another audience, he might begin with historical information about the Austrian 13 helicopter. These two images allow Stelzer to engage different audiences in much

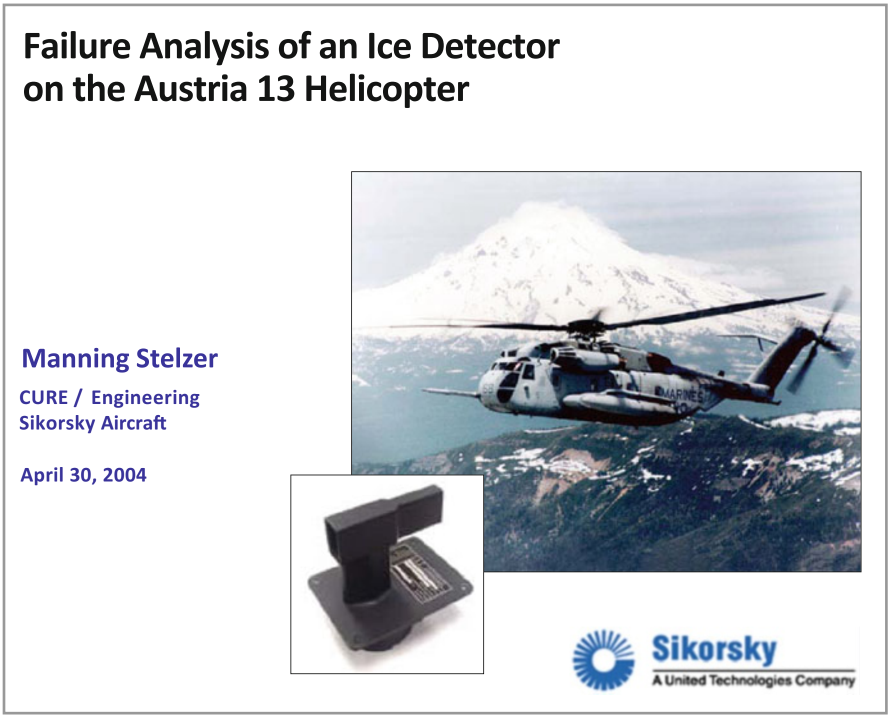


Figure 4-27. Strong example of a title slide.[10] The images are important to help the orient audience.

more powerful ways than a slide with only words would have done.

With some images, the opportunity exists to have the images bleed the page. Such a look can be powerful, as in the title slide of Figure 4-28. In this talk, Steve Lynch, a graduate student in mechanical engineering, wanted to explain the fluid dynamical effects of having different configurations for the junction of a vane and endwall in a gas turbine engine. One of those different configurations followed the fillet shape that nature creates when snow piles against a tree. Lynch chose that shape as his entry point for the talk. Because the background of this photograph allowed enough contrast for the title and presenter information, Lynch was able to bleed the image off the slide. This bleeding is a technique often used by slide designers Garr Reynolds in *Presentation Zen*[8] and Nancy Duarte in *Slide:ology*.[9]

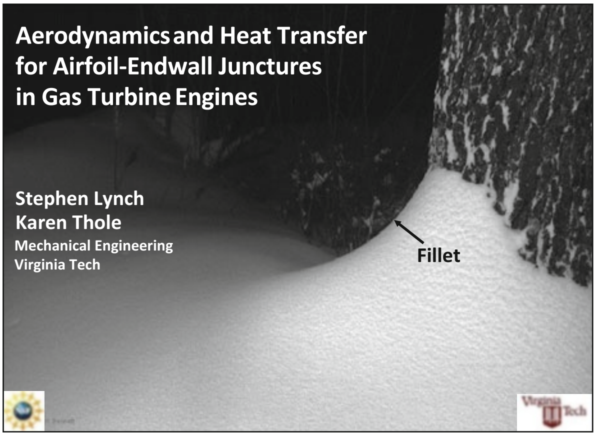


Figure 4-28. Strong example of a title slide in which the image bleeds the slide.[11]

Still another option with the title slide is to use a sentence assertion title. Since the 1980s, Larry Gottlieb of Lawrence Livermore National Laboratory has advocated that approach. For talks where presenting the main result up front is appropriate, a sentence-assertion title stating that main result can be effective. For instance, Figure 4-29 shows a title slide created by Kirin Shi, a research engineer at Shanghai Jiao Tong University. The title of Shi's slide states the main takeaway of the talk. In such cases, the title slide often ends up looking much like the conclusion slide.

Outline slides should memorably map. Another weak common practice in scientific presentation occurs with slides that presenters use to map their talks. As mentioned in Chapter 3, letting the audience know the outline or map of the talk helps the audience pace themselves. If the audience does not know how far along they are in a talk, they become restless and easily lose concentration. Not all talks require a visual aid for mapping. As mentioned, for shorter talks, the mapping can be handled with spoken words. Also, if the outline is one that the audience expects, such as for a research talk (hypothesis, methods, and then results), a slide simply stating that expected sequence is not needed. For cases, though, in which the divisions are not expected or in which the talk is so long that the audience could

Figure 4-29. Title slide in which the title is a sentence assertion stating the talk's main takeaway.[12]

become lost, a mapping slide can be valuable. However, for such a slide to be effective, the mapping has to be done in a memorable fashion. Inexplicably, most scientific talks rely on a bullet list to make the list of items memorable. Is there any way to make a list less memorable than to place it in a bulleted list? Shown in Figure 4-30 are two typical mapping slides that follow this common, but ineffective, strategy.

One problem with the two lists in Figure 4-30 is that they are too long. As you recall from Chapter 3, audiences are comfortable processing lists of two, three, or four items. Closer examination of the two lists in Figure 4-30 reveals that many of the items are unnecessary. Because every talk has an introduction and conclusion, listing those items serves no purpose. In addition, because the occasion for the talk generally establishes when acknowledgments will be made or questions will be posed, listing those items is not needed. Moreover, in many presentations, the speaker can cover background information before the mapping slide is shown, thereby eliminating the need to show that division. Finally, the specific methods placed in the secondary lists in the bottom slide in Figure 4-30 are not needed at this point in the presentation. All the audience needs to know is the order of the methods: methods before combustion, methods during combustion, and methods after combustion.

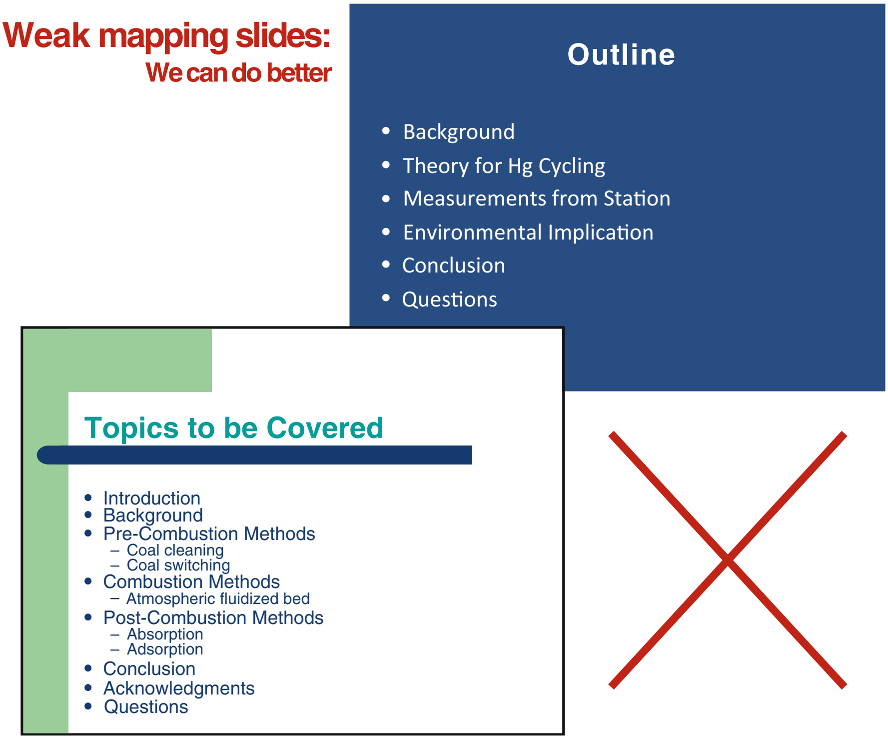


Figure 4-30. Weak mapping slides, typical of what occurs in scientific presentations. We can do better—much better.

All these cuts would greatly increase the chance of the audience to recall the mapping. Still, we can do better. Shown in Figure 4-31 is a mapping slide that follows the assertion-evidence approach. This slide, created by Cynthia Schmidt, a mechanical engineering student from the University of Texas, supported a talk that evaluated different methods for reducing sulfur dioxide emissions from coal-fired power plants.[13] Rather than have separate slides for the mapping and the background of this talk, Schmidt created a single slide that did both. In her slide depicting how coal is mined and transported to a plant to be combusted, Schmidt incorporated the three divisions of her talk: pre-combustion methods, combustion methods, and post-combustion methods. Not only did I remember this list for the duration of this talk, but I recalled it 2 weeks later while summarizing this talk for a colleague. Moreover, 6 years later, I

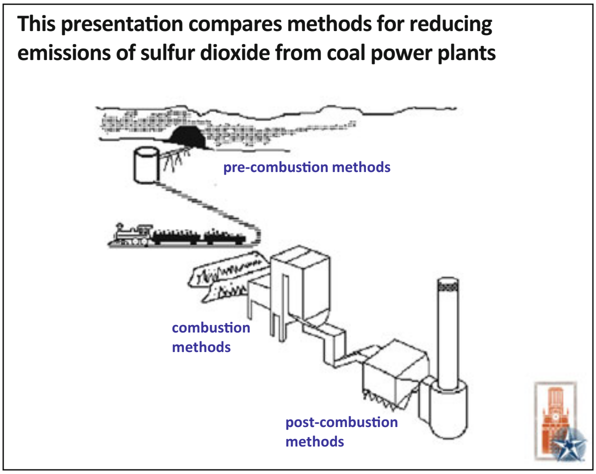


Figure 4-31. Mapping slide that follows assertion-evidence structure. Here, the three outlined topics are integrated into an image that provides background information for the talk.[14]

was able to recreate from scratch this mapping slide. That is a memorable mapping of a presentation.

Now, the contents of most talks do not allow for such a wonderful integration of the talk's topics into a single image. In most cases, the presenter simply has a list of separate, but parallel, topics. How can we increase the recall of that list? Psychology research provides an answer. As Alan Paivio found in a large set of experiments in the 1980s,[15] an audience is twice as likely to recall a topic if that topic is anchored with a representative image. According to Paivio, the combination of the verbal word and the representative image allows the brain to process or code the detail in two ways.

Shown in Figure 4-32 is a mapping slide[16] that uses this dual-coding principle of Paivio to present the three main topics of the talk. Note that each image from the mapping slide appeared in the first slide of each division of the talk. For instance, the chemical equation shown in the top left image appeared on the first slide of the theory section for atmospheric mercury depletion, the station image appeared on the first slide of measurements section, and the polar bear image appeared on the first slide of the environmental section. Note that in that third section of the talk, the polar bear image was not decoration because that section specifically discussed observations of increased levels of mercury in polar bears.

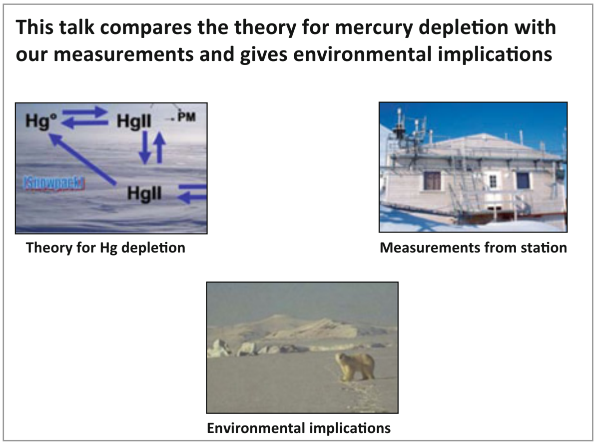


Figure 4-32. Mapping slide that follows the assertion-evidence structure. Here, the three main divisions of the talk are anchored not with bullets but with images representative of those divisions.[17]

Some PowerPoint templates are specifically designed to achieve the goal of letting the audience know where they are in a talk. Typically, these templates will set aside a portion of every slide from the middle sections to list all the topics of the talk. While the intention here is good, the efficiency is not. Many of these templates will use 10 %, 20 %, or more of the slide's space for this mapping. Moreover, much of the space occupied occurs in the most valuable space of the slide—along the top or along the left side. In the end, most of these templates use too much valuable space on every slide for a task that an effective mapping slide and thoughtful transitions in speech could accomplish.

In a long talk in which each section has several slides, the presenter could repeat an icon image from the mapping slide in a bottom corner of each slide from the corresponding division of the talk's middle, as occurs in Figure 4-33. While that icon certainly would take up space on the slide, the space is at the bottom and less than 5 % of each slide. In fact, the icon image could simply replace the logo that many presenters place on each slide. As mentioned earlier, having the institution's logo on the first slide and the last slide is sufficient for slides projected in a presentation.

For the icon of the slide in Figure 4-33, note that some presenters would have chosen clip art to represent the talk's division for the mathematical model. Clip art, while accepted on slides in the 1980s, is out of place today. Essentially, clip art strikes many audience members as unprofessional and undercuts the seriousness of the topic. Instead of choosing clip art, Are Magnus

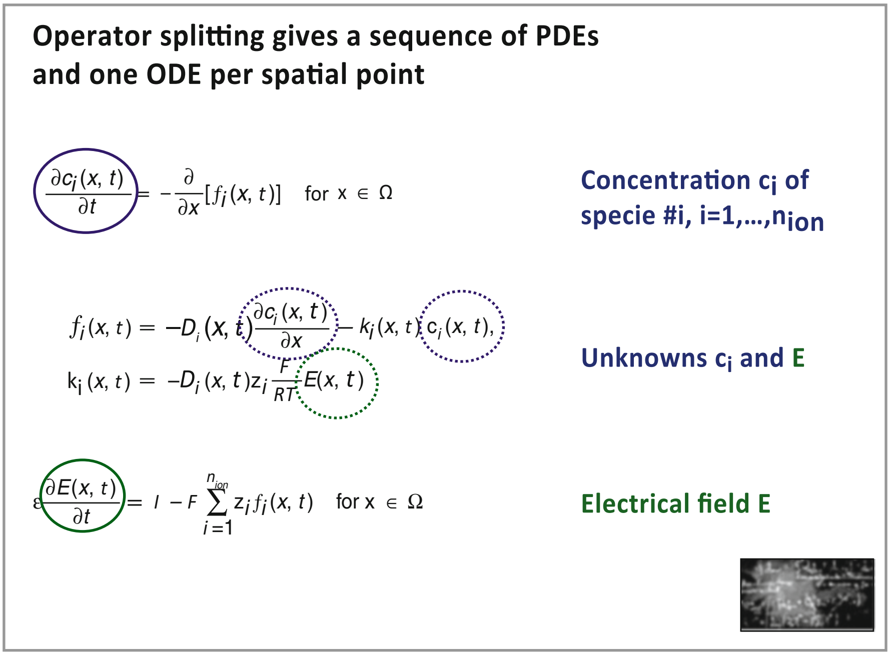


Figure 4-33. Body slide from a longer talk in which corresponding icons from each division of the mapping slide appeared in the *bottom right corner*.[18] This slide occurred in the talk's second division: mathematical models.

Bruaset photographed the blackboard that he and his colleague used to arrive at their model. The black and white photograph carries a much more professional tone than clip art would.

Final slides should emphasize the main takeaway. Because speakers field questions at the end, the final slide projected in a presentation is often displayed the longest. Inexplicably, many presenters choose to display a worthless slide such as shown in Figure 4-34. Both of these slides are zeroes. Actually, these slides are less than zero because a blank screen would be less distracting. Note that using a slide to say "Thank you" is a waste of lumens. If you want to thank the audience in a *meaningful* way, look them in the eyes and say "Thank you." In general, words on slides are much less effective than voice and corresponding facial expression at conveying a presenter's emotion. In addition, when you call for questions, the audience knows that the presentation is in the question period. They do not need an entire slide to tell them that.

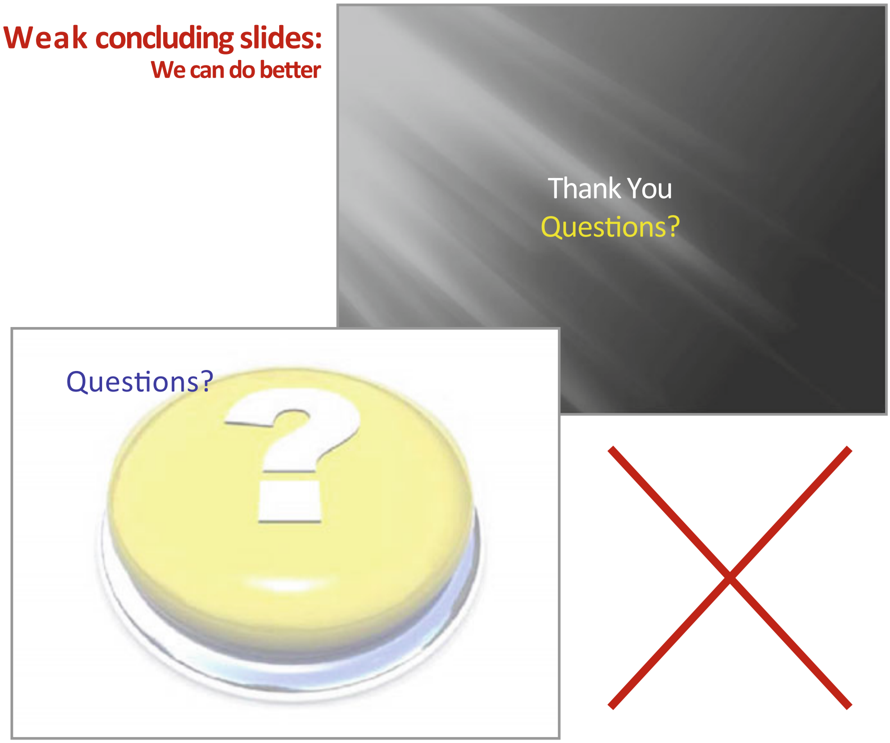


Figure 4-34. Weak final slides, typical of what occurs in scientific presentations. We can do better—much better.

Rather than projecting an empty slide at the end of a presentation, consider projecting a slide that summarizes the most important takeaway of the talk. That way, you emphasize what is most important in the talk and you project content that the audience can use to fashion questions. Figure 4-35 presents an example of such a slide. With this slide, Omar Comacho, a graduate student in material science at Penn State, summarized not only the main assertion of this talk, but also the supporting sub-assertions.[19] While this slide has more words than typically occur in an assertion-evidence slide, the slide was projected not only for Comacho's conclusion, but also for the question period. For that reason, the audience had a longer time to process those words. Moreover, the image and all three assertions on the slide had been stated earlier in the talk.

With such a conclusion slide, the presenter can animate in the word *Questions* when he or she is ready for questions. While placing the word *Questions* on the conclusion slide is not necessary (that transition could be handled by speech), it does give the presenter a sequence to help smooth the transition to the question period. Too often, the presenter abruptly ends and calls for questions, and then an uncomfortable silence envelopes the room as the audience thinks of questions to ask. When a talk ends and the presenter asks for questions, the presenter wants hands to go up. Otherwise, it appears that no one understood or cared about the talk.

So what is a good sequence for the presenter to attempt? With a slide such as in Figure 4-35, the audience knows from the "In closing" or "In summary" phrase at the beginning of the headline that the end of the talk is near. That way, the audience is clued into thinking about questions as soon as the slide appears. A second part of the sequence involves the speaker concluding the talk with a strong sentence and a pause for applause. If applause does not occur, the speaker can simply thank the audience, which will signal the audience to clap. When the clapping begins to subside, the speaker can then animate in the word *Questions* and say something to the effect "And now at this time, I will be glad to handle any questions."

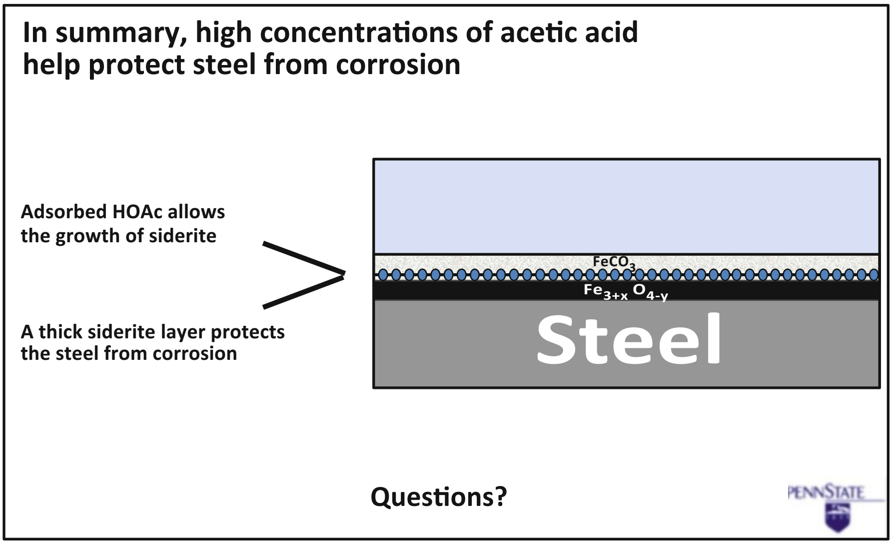


Figure 4-35. Strong example of a concluding slide.[20]

This sequence provides enough clues and delays for the audience to prepare their questions. If the talk was understood and it generated interest, hands will go up.

The TED slide structure is effective for communicating to the general public

As mentioned, the organization TED (Technology-Entertainment-Design) hosts many excellent scientific presentations that target the general public. The slides for these scientific presentations have a particular style: few words (if any) and powerful images that often fill the screen. These slides follow the approach in the books *Presentation Zen* by Garr Reynolds and *Slide:ology* by Nancy Duarte.[21,22] In fact, Duarte often serves as a consultant to TED.

In both of these approaches, the first step is for the speaker to write out each message or takeaway of the talk on a separate sticky note and then arrange those notes into an effective order. If a message warrants a scene, then the presenter creates a slide that best supports the message. Sometimes, the presenter explicitly states the message on the slide—in such cases, the slide essentially assumes an assertion-evidence structure. Other times, the speaker does not state the message on the slide. When the message is not explicitly stated, the speaker carries that role of emphasizing that message to the audience, while the slide carries supporting visual evidence. Nonetheless, before the presentation, the speaker has identified the message for each slide. Similar to what happens in an assertion-evidence talk, this act of defining the message for each TED slide helps the speaker focus the talk.

Shown in Figure 4-36 are two slides from a TED.com talk that follow this style. This talk, given by Professor Alison Carr-Chellman from Penn State, discusses the use of video games to re-engage boys in learning.[23] In this part of the talk, Carr-Chellman argues that boys are not as engaged as girls in learning. Both slides explicitly and artistically state the message and provide

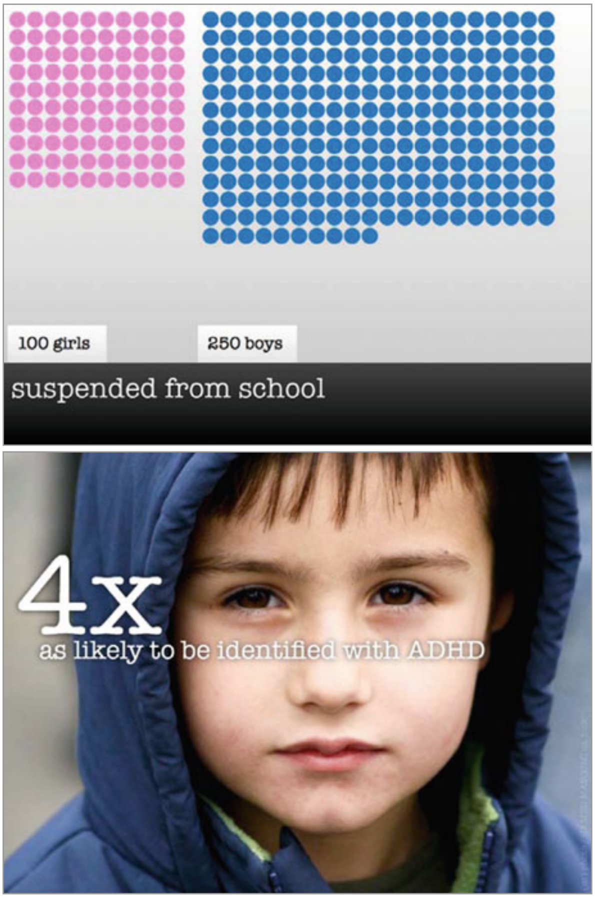


Figure 4-36. Example of two slides that follow the TED-slide style.[27] In each of these two examples, the message explicitly appears on the slide.

powerful visual evidence, but the types of evidence are quite different. In the top slide, the visual evidence is essentially a graph that makes a logical appeal, while the bottom slide uses a photo that makes an emotional appeal. Both slides use arrangement and positioning in a strategic fashion. For instance, in the bottom slide, much thought went into the cropping of the photograph so that the eyes were on the same level as the statistic. Moreover, the statistic was positioned at a special point—about one-third from the top and the left—for emphasis.

As mentioned, not all slides in the TED-style approach have the message explicitly stated. Figure 4-37 shows another slide from this presentation, this one simply a photo. The con-

Figure 4-37. Example slide that follows the TED-slide style.[28] For this slide, the full onus of communicating the slide's message falls on the speaker.

cerned expression of the graduate, the careful cropping of the photo, and the photo filling the screen—all of these worked together to support Carr-Chellman's main assertion during this segment: "Even in their college education, a problem still exists for males." While this photo was projected on the screen, Carr-Chellman not only stated the assertion, but stated other supporting evidence—for example, the statistic that 60 % of all baccalaureate degrees in the United States were now going to women. She also stated the concern by employers that if the trends of fewer males graduating from college continued, not enough employees would be available in certain fields to do the work. For this presentation, Carr-Chellman both had to determine what her assertion would be at this point and practice enough that she could state and support that assertion with her speech. Because she was looking at the audience, as opposed to a bullet list on the screen, this moment of the talk was effective, and the photo provided a powerful backdrop.

For this presentation, Carr-Chellman had a graphics artist, Tara Tallman, help design the slides. Although the presentation lasted less than 13 minutes, Tallman logged in more than 20 hours preparing those slides. Still, this presentation was worth the time invested by both Carr-Chellman and Tallman. The presentation was viewed by more than 500 people on the day it was given. Moreover, within 4 months of the TED.com site adding the talk, the talk was viewed more than 200,000 times.[24]

As apparent from the discussion above, one disadvantage of TED-style slides is that the amount of time to create those slides is typically high, even higher than the time needed for assertion-evidence slides. Another disadvantage lies in the artistic ability needed for choosing, cropping, and positioning images and for sizing, arranging, and positioning text. At first glance, the slides might appear to be simple, but much has gone into achieving that appearance. In *Presentation Zen*,[25] Reynolds explores the idea of simplicity from different perspectives: increasing the signal-to-noise ratio, eliminating unneeded text and lines, and effectively using empty space. In his analysis, Reynolds makes parallels to Japanese principles of design: naturalness and elegance. In *Slide:ology*,[26] Duarte follows a similar approach. She calls on presenters to "practice design, not decoration." Duarte does not seek to create slides, as much as she seeks to create "scenes."

Even if you do not possess the time or artistic ability to pursue fully the TED-style approach, you can incorporate many of the strategies into an assertion-evidence approach. For instance, you can arrange certain photographs to bleed the page on assertion-evidence slides. Shown in Figure 4-38 is a revision of two earlier assertion-evidence slides to include this design strategy. The mentioned texts of Garr Reynolds and Nancy Duarte present many other design strategies.[29,30]

An evidence-assertion order, *pecha kucha*, the Lessig style, and Prezi can be effective at sequencing slides

The assertion-evidence structure and the TED-style are certainly two successful ways to structure a slide, and typically those slides (or what Nancy Duarte calls "scenes") are sequenced in a linear way with each scene remaining projected for 1–2 minutes. However, four interesting variations exist on the

Figure 4-38. Slide sequence that follows the assertion-evidence approach, but incorporates principles of the TED slide style.[31]

sequencing of those scenes: an evidence-assertion order, *pecha kucha*, the Lessig method, and Prezi.

An evidence-assertion sequence is effective for teaching, conveying complex assertions, and swaying skeptics. When the purpose of the presentation is to teach or when the assertion to be presented is complex or controversial, the presentation is often better served by presenting the evidence first and then giving the assertion.

For instance, as a teacher, you want your students to discover principles rather than just be told those principles. When students discover a principle by piecing together the supporting knowledge, the principle is much more likely to stick. In a classroom, one way to set up this discovery is to show the evidence and have the students arrive at the assertion. Figure 4-39 shows a slide sequence for that purpose. In the top slide, the students first see the evidence of population pyramids for two different countries. The question headline prompts the students to figure out which of those two shapes would lead to faster population growth. After leading a student discussion on this question, the teacher could animate in the answer (bottom slide).

Another situation to select an evidence-assertion approach is with a slide in which the assertion is too complex to show at the beginning of the scene. For instance, with a less technical audience, delaying the assertion of Figure 4-40 allowed Jason

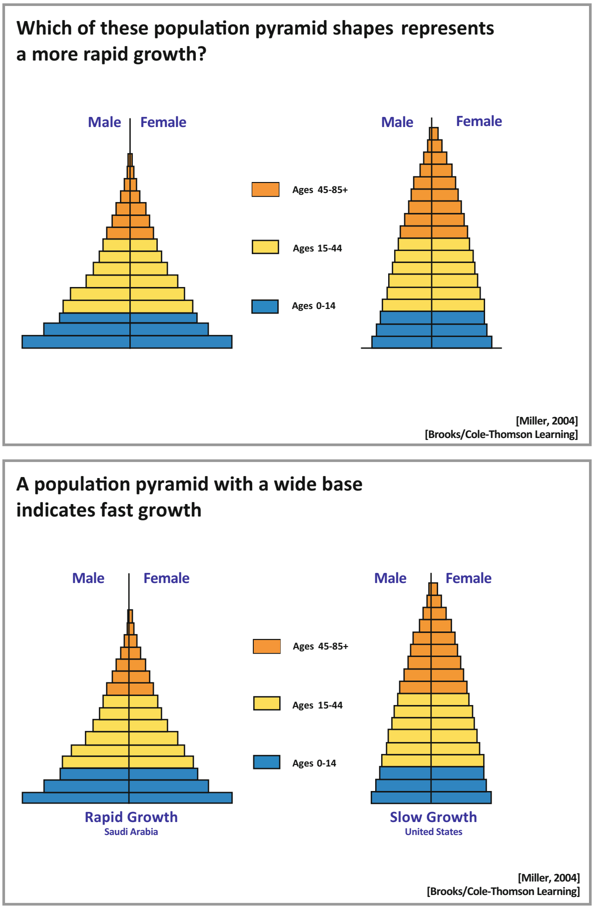


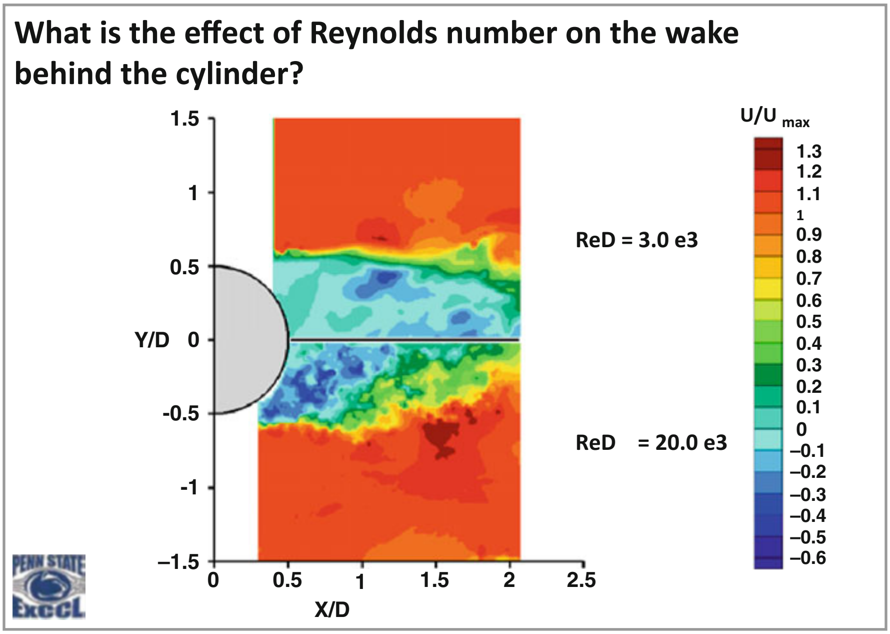
Figure 4-39. Example of an evidence-assertion sequence for teaching.[33] In this sequence, the teacher uses the *top slide* to elicit responses from the students before showing the *bottom slide.*

Ostanek, a graduate student in mechanical engineering at Penn State, time to introduce the graph, which shows the velocity profile behind a cylinder with different Reynolds numbers.[32] Here, the cylinder represents a pin fin placed in an internal channel of a gas turbine blade. The area on the bottom half of the graph is for a Reynolds number that is more than six times greater than the Reynolds number for the top half. Once Ostanek oriented the audience to the visual evidence, he animated in the assertion. After that animation, Ostanek continued showing this slide as he explained the assertion in more depth. Leaving the slide up after the animation is a wise strategy so that the assertion receives proper "soak time."

In addition to helping explain complex assertions, an evidence–assertion strategy can help persuade audiences about a controversial assertion. For any of the assertion–evidence slides shown so far, if the assertion were controversial, the presenter might want to delay showing the assertion until he or she has explained the evidence. While this strategy certainly does not guarantee that you will win over those initially biased against your assertion, the strategy will allow you the opportunity to convey your evidence before the naysayers in your audience begin focusing on how they will rebut your assertion.

Note that just because you might show visual evidence before you reveal an assertion does not mean that you should likewise show an assertion before revealing visual evidence. At least a portion of the visual evidence should be visible when the slide appears. Otherwise, the presenter has not taken advantage of the principle that an audience can process an image while listening to or reading text. Moreover, if the slide background is white, showing just the headline assertion leaves more than 80 % of the screen reflecting a shrill white glare to the audience.

The *pecha kucha* sequencing style is a quick way to raise the level of presentations. In Japan, a style of sequencing slides has arisen that compels presenters to create more effective slides without much instruction. This sequencing style, called *pecha kucha*



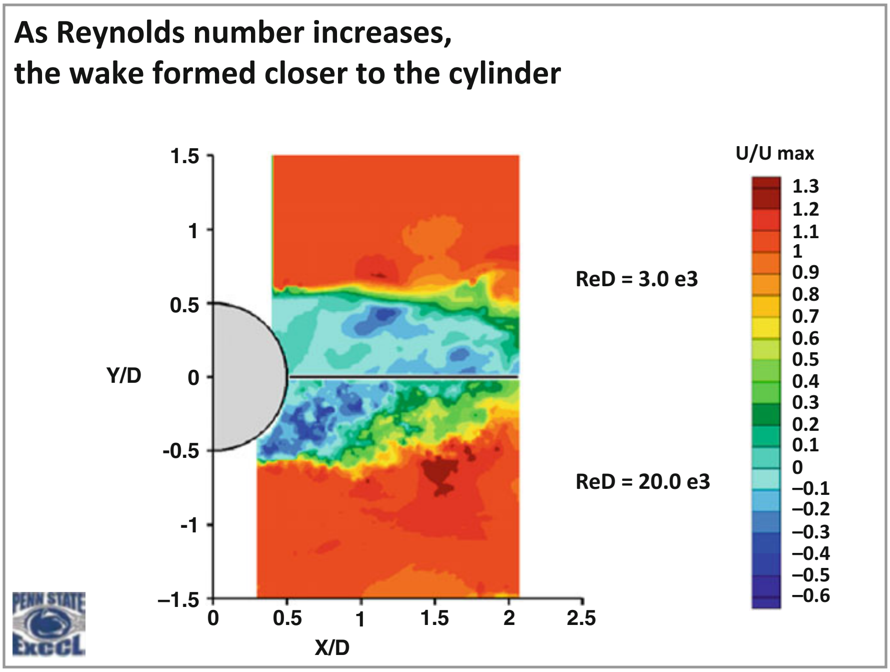


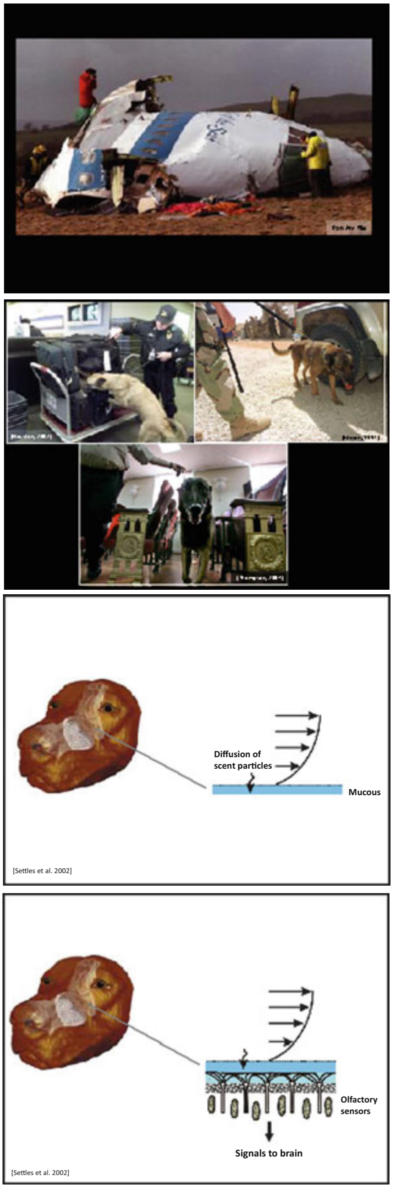
Figure 4-40. Example of an evidence-assertion sequence for a scientific present.[34] In this sequence, the presenter explains the visual evidence enough that the audience can see how that evidence leads to the assertion.

(which translates to "chit-chat"), is the basis for entertainment at nightclubs in which people make slide presentations. In this sequencing style, the presenter projects 20 slides with each slide showing for only 20 seconds. Because the slides are projected for such a short period of time (about two sentences worth of speaking), presenters quickly realize that bullet-ridden slides do not work. For that reason, presenters adopt a more visual-based slide structure.

While this sequencing style is not ideal for scientific presentations, *pecha kucha* leads to much better presentations than would occur if presenters simply followed the common practices of PowerPoint. Moreover, the training time for the presenters is minimal. In essence, the training comes down to one guideline: 20 slides with 20 seconds per slide. For those who do not have the time to teach sophisticated strategies such as assertion-evidence, *pecha kucha* is an easy way to raise the level of presentations of an organization. For that reason, some managers and professors have begun requiring their staff and students to follow it. Shown in Figure 4-41 is an opening sequence from a *pecha kucha* presentation on the reliability of dogs to detect explosives at airports, military check points, and government buildings. Shown to the right of each slide is the key assertion for each slide that the presenter would want to convey in speech.

While *pecha kucha* certainly is a quick way for a manager to improve the presentations of an organization, this sequencing style has its drawbacks. First, the sequence requires significant preparation time on the part of the presenter. Much of that time is well spent—deciding upon the assertion of each slide or scene and then crafting visual evidence to support that assertion. Still, substantial time is required for the presenter to keep his or her speech for each slide to 20 seconds, or about two sentences. In *pecha kucha*, the slides advance automatically, and the speaker has to keep up.

A second drawback of *pecha kucha* is that not all slides or scenes fit into a 20-second window. Some scenes such as a graph require more time to explain. Often that hurdle can be handled by allowing an animation of a detail to increase the soak time of the scene (see slides 3 and 4 of Figure 4-41). Still, the ideal situation would be to have a flexible time window for each scene, but then many presenters would then revert back to the bullet-ridden, death-by-PowerPoint slides. In the end, what *pecha kucha* does



On December 22, 1988, PanAm Flight 103 was downed by an explosive hidden in a suitcase.

This talk discusses how dogs, when properly trained and handled, can reliably detect explosives in airports, military check points, and government buildings.

As humans do, dogs take in scent molecules through the nostrils, and these molecules deposit on the mucous.

The scent molecules diffuse through the mucous to olfactory sensors that send signals to the brain.

Figure 4-41. Example slide sequence from a talk following *pecha kucha*. Given on the *left* is the slide or scene that is projected for 20 seconds, and on the *right* is the key message that the speaker needs to convey during that scene.

with one single guideline is to increase the evolutionary process for creating strong slides. Either the presenter quickly adapts to slides that are image-based or that presenter's talk falls short of the visual-based talks of the others in the group.

The Lessig sequencing style is well-suited for situations to entertain. Professor Lawrence Lessig, an economist from Stanford who was dissatisfied with the common practice approach of PowerPoint, developed a unique approach to sequencing slides. In his approach, Lessig flashes short phrases and images on the screen as he speaks. In the Lessig style, the sequences occur more rapidly than the *pecha kucha* sequences. In fact, these Lessig scenes usually last only a second or so. Moreover, Lessig sizes, colors, and positions the flashing phrases to reflect their meaning. Essentially, Lessig creates simple TED-style scenes, but sequences them very quickly in synch with his speech.

Others have adopted versions of this approach. For instance, an excellent example of this type of talk is a conference keynote address,[35] given by Dick Hardt, the CEO of Sxip Identity. Shown in Figure 4-42 is a sequence of slides from that talk. Given on the right side are the words that Hardt said as these slides flashed on the screen.

The pace of this talk is fast, and the tone is witty and deceptively light. What first appears to be a light talk about the identity of the speaker soon becomes a sophisticated discussion about the meaning of identity on the World Wide Web. For this 15 minute talk, the number of slides in this talk is huge. For just these five sentences, the number is 10. For the entire talk, it was more than 300. Even though each slide is relatively easy to create, much time is needed to create such a huge number of slides. In addition, even more time is required to prepare the delivery of such a presentation. You not only have to know almost exactly what you will say, but you need to say those lines in synch with the slides. Ron Galloway, who is the creator of the documentary *What Wal-Mart Works*[36] and *Rebooting Healthcare*,[37] gives many keynotes each year about these two

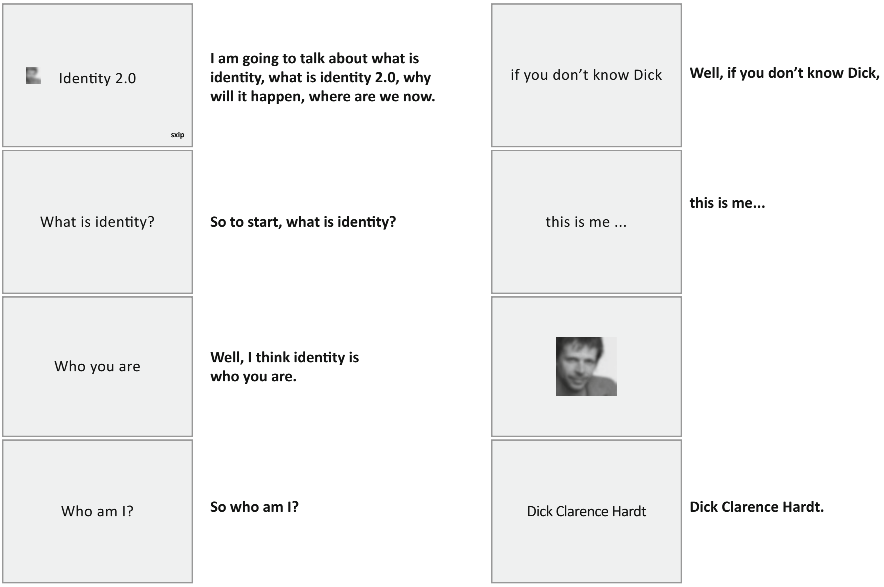


Figure 4-42. Example slide sequence from a talk following the Lessig style. In most slides from this short sequence, the words spoken occur in synch with what appears on the screen. In other slides, the slides are simply images that support what is being said.

topics in this Lessig style. In his preparation for these talks, Galloway says that he has to continually practice to keep sequences fresh in his mind and to maintain the timing.[38]

The large investment in time is definitely a constraint of this sequencing style. For that reason, one should reserve this style for talks or portions of talks that you will give on multiple occasions. Another constraint is the light-hearted tone that audiences perceive with this style. For that reason, the style works best with keynotes and after-dinner talks in which the audience is more open to the incorporation of wit.

An interesting aspect of this Lessig style is that although the number of projected words per minute for this style is high, even higher than the common practice, cognitive overload does not pose the problem that it does with common practice slides.[39] Why? One reason might be that only very few words appear on the screen at any one time. In essence, this style leads the audience to read short groups of words as is advocated in strategies for speed reading. Moreover, the presenter aids the audience with that task because the presenter has created the groupings that speed reading demands. As my research colleague Joanna Garner contends, another reason that cognitive overload does not appear to occur could be that there is an almost perfect synchronicity between visual attention and auditory attention.[40] In other words, the audience is seeing exactly what they are hearing. Still, a third reason is that the fun and upbeat style causes the audience to pay more attention.

The Prezi approach serves talks that break down a whole into parts. PowerPoint and most slideware programs create individual frames that are arranged in a deck. In contrast, the slide software program Prezi has a huge map that allows the presenter to zoom into portions of the map and then zoom out again. Because the scenes seamlessly focus in or focus out, a Prezi talk does not look like a talk built with slides. Also, because of these seamless transitions, Prezi talks are particularly effective for explaining a whole system that is divided into parts. Examples of such systems would be a timeline, a diagram, or a map.

One disadvantage of a Prezi talk is that the program takes more time to learn than other software for visual aids. A second disadvantage is that once you focus onto a scene, you cannot animate in additional details. In other words, what is on your large canvas is what you show. Still, you can simulate an animation by enlarging the view to show an additional detail. A caution about Prezi is that some transition choices, particularly the twisting and rotating selections, unsettle audiences. In fact, audience members describe the experience of viewing some presentations as riding a roller coaster. For that reason, you should stay with zooming in and zooming out and avoid the twisting and rotating transitions unless those motions actually capture the physical movements of your subject.

Summary. Specific situations are well served one by of the four mentioned sequencing strategies. For instance, an evidence-assertion sequencing is often effective for teaching technical content to students or introducing complex or controversial assertions. Also, *pecha kucha* is an effective strategy for managers and professors to require for a presentation session when those managers and professors do not have the time to teach a more sophisticated structure. In addition, the Lessig approach is a fun way to sequence scenes that follow the TED-style structure. Occasions in which you might choose this style as the main strategy would be a keynote address or an after-dinner talk. Finally, the sequencing approach of a Prezi offers a way to communicate either assertion-evidence scenes or TED-style scenes in a way that shows the physical relationship of those scenes. This approach is particularly effective for showing a large system or timeline in which you want to zoom in or zoom out to show how the pieces fit into the larger puzzle.

Effective slide structures exist for the wide variety of presentations

When slides are an appropriate medium to use in a scientific presentation, two effective slide structures and several different sequencing strategies exist to handle the many situations that engineers, scientists, and technical managers face. The assertion-evidence structure is effective for handling situations in which scientists and engineers communicate technical information. In this structure, the assertion serves as a safety net for the audience in case they miss the transition into the slide. Also, with this structure, you can incorporate the projected assertion-evidence slides into an effective handout by adding secondary details to the notes pages.

In addition, as the many excellent scientific talks on TED.com attest, the TED slide structure of Nancy Duarte and Garr Reynolds is effective for communicating to the general public. As with the assertion-evidence structure, the TED slide structure calls on the presenter to define the main assertion of each slide or scene. That act of defining the slide's assertion serves as a filter to make sure that every slide contributes to the talk. That act also serves to make the presenter more focused about what he or she will say.

Sadly, both of these effective slide approaches occur in only a small percentage of scientific presentations. The dominant practice for scientific presentations is still the topic-subtopic approach of PowerPoint.[41] As discussed in this chapter, this approach consists of a topic-phrase headline supported by a bullet-list of subtopics. I do not recommend this approach.

Title slides aside, the topic phrase that arises from PowerPoint's headline default does not convey enough information for the valuable space that the phrase consumes. A superior choice would be a succinct assertion headline or no headline at all. When no headline occurs, the advantage is that the additional space on this slide can be used for enlarging the graphic. The disadvantage of not having a headline is that the speaker's spoken words, and only those spoken words, have to convey the message.

Even weaker than having topic-phrase headlines is having bulleted lists of subtopics in the slide's body. These bulleted lists do not show connections, often lead to too many words projected, and cause many presenters to deliver in a sleep-inducing turn-and-read rhythm. Some people argue that such slides are useful in a discussion to generate ideas. I would counter that a writing board, not slides, would be a better medium for that situation.

Given the ineffectiveness of the topic-subtopic structure at communicating science and engineering, one would think that use of this structure would be declining. However, the topic-subtopic structure is ubiquitous. You find it to be the common practice for presentations at conferences, in meetings, and in classrooms. Why? Perhaps the main reason is inertia. In 1986, Robert Gaskins and Dennis Austin selected this topic-subtopic structure as the default structure for the computer program that became PowerPoint.[42] Because

PowerPoint filled a huge void for software to produce presentation slides, it was quickly adopted. Then because of how easy these defaults are for presenters to apply, the topic-subtopic structure has become entrenched. Despite its ineffectiveness, the topic-subtopic structure of PowerPoint will be challenging to replace. Examples of this structure abound in government, industry, and education, influencing the current and next generation of scientists and engineers. Worse yet, respected colleges, conferences, laboratories, and companies have created templates that compel students and professionals to follow this structure.[43]

Still, a wonderful opportunity has arisen for you to have your presentations stand apart from the commonplace talks that from the audience's perspective are so unfocused, tiresome, and cloaked by noise. Many students from our classrooms and professional workshops have seized this opportunity to create presentations that have won proposal competitions, secured job positions, and earned best presentation awards at conferences. This opportunity to rise above the common practice certainly requires more effort from you, but if your content is strong, the additional effort is worth it.

Notes

[1] G. Jaffe, Slide fatigue: In U.S. Army, PowerPoint rangers get a taste of defeat—top brass orders retreat from all-out graphics assault, Wall Street J. (26 Apr 2000), p. 1

[2] C. Atkinson, author of *Beyond Bullet Points*, phone interview with author (2008)

[3] I. Parker, Absolute PowerPoint, *The New Yorker* (28 May 2001)

[4] T.M. Nathans-Kelly, C.G. Nicometo, Presenting with power, not just PowerPoint, in *Proceedings of the 2011 ASEE National Conference* (ASEE, Vancouver, June 2011)

[5] G. Reynolds, *Presentation Zen* (New Riders, Berkeley, 2008)

[6] N. Duarte, *Slide:ology* (O'Reilly Media, Sebastopol, 2008)

[7] Adapted from M. Stelzer, Failure analysis of an ice detector in the Austria 13 helicopter, presentation (United Technologies, Farmington, 30 Apr 2004)

[8] G. Reynolds, *Presentation Zen* (New Riders, Berkeley, 2008)

[9] N. Duarte, *Slide:ology* (O'Reilly Media, Sebastopol, 2008)

[10] Adapted from M. Stelzer, Failure analysis of an ice detector in the Austria 13 Helicopter, presentation (United Technologies, Farmington, 30 Apr 2004)

[11] Adapted from S. Lynch, K. Thole, Aerodynamics and heat transfer for Airfoil-Endwall Junctures in gas turbine engines, master's thesis presentation (Mechanical Engineering Department, Virginia Tech, Blacksburg, 2006)

[12] Adapted from K. Shi, Y. Liu, Micro-air-vehicles equipped with dragonfly wings may perform poorly at low Reynolds numbers, presentation (School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, June 2011)

[13] C. Schmidt, Methods to reduce sulfur dioxide emissions from coal-fired utilities, class presentation (Mechanical Engineering Department, the University of Texas, Austin, 8 Dec 1989)

[14] Idem

[15] A. Paivio, *Mental Representations* (Oxford University Press, New York, 1986), p. 53

[16] Adapted from K. Aspmo, T. Berg, G. Wibetoe, Atmospheric mercury depletion events in polar regions during arctic spring, presentation (University of Oslo, Oslo, 16 June 2004)

[17] Idem

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[23] A. Carr-Chellman, Bring back the boys: gaming to re-engage boys in learning, www.TED.com, slides designed by Tara Tallman (Penn State, TEDxPSU, University Park, 10 Oct 2010)

[24] Idem

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[27]A. Carr-Chellman, Bring back the boys: gaming to re-engage boys in learning, www.TED.com, slides designed by Tara Tallman (Penn State, TEDxPSU, University Park, 10 Oct 2010)

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Critical Error 9
Not Accounting for Murphy's Law

> *Today I start my experimental lectures. They are also lectures of anxiety because with the setting up of every experiment comes the feeling: Will it go according to plan? For the best preparations are by no means an absolute safeguard against nature's perversity.*[1]
>
> –Heinrich Hertz

The legend goes that a new physics professor at a Midwestern school wanted to impress the undergraduates with his teaching.[2] In his first semester, he requested to teach one of the large sections of freshman physics. Held in a huge lecture hall, each class period consisted of a lecture about a major topic and then a demonstration of a principle associated with that topic. For the class period that discussed motion in a plane, the new professor refused to use the six-foot air table that everyone else used. Instead, he had the technicians build him something twice as large. Likewise, for the class period on Newton's laws, he refused to use the tabletop spring balance that everyone else chose; he had the technicians build him something much larger.

When the time came to demonstrate the motion of a pendulum, he put aside the tabletop pendulum that everyone else used and called for a hook to be mounted in the lecture hall's ceiling. Then he had tethered to the hook a medicine ball: one of those heavy leather balls that athletes in the 1950s tossed around for exercise. The medicine ball was fixed so that it could swing freely from one wall to the other. The day for the pendulum class came, and the new assistant professor began by saying that he was to perform an experiment that would place himself in physical danger. Although he said that he could be seriously injured in the experiment, he claimed that he had not practiced it because he was confident that the laws of physics would keep him safe.

So, after preliminary discussion about a pendulum's trajectory, its period, and its minimum and maximum speeds, the new professor pulled the medicine ball to one wall of the room and climbed on top of a stepladder. With his back against the wall, the professor held the medicine ball to his chin and said that he was going to release the ball with zero velocity and that when it returned to this position, by the laws of physics, the velocity would again be zero. Well, this new professor's goal had been to engage the students, and as he stood on top of that ladder with the huge ball against his chin, he certainly had them engaged. When the professor let the ball go, it swung through its arc attaining a maximum velocity at the low point of the arc and rising almost to touch the far wall. Then the ball started its return trajectory. Apparently, because the new professor had not practiced this demonstration, he was unprepared for the sight of the huge ball making its way back toward him. According to students in the room, although his eyes grew large, he refused to bail out. Instead, he braced himself, but in so doing, he must have leaned forward ever so slightly.

What the new assistant professor ended up demonstrating was not so much the motion of a pendulum, but the conservation of momentum. The students saw that a large mass (the medicine ball) with little velocity struck a small mass (the new assistant professor's head) and imparted to it a relatively fast velocity. The new assistant professor's head snapped back and hit the wall, and he fell unconscious to the floor.

For a moment, no one in the class moved. Then a few students rushed down to the new professor's aid. Later, after the smelling salts arrived and the professor returned to consciousness, the class slowly wandered out.

This professor's demonstration followed the Law of Murphy, which was named for Edward A. Murphy, Jr., an engineer who worked on rocket-sled experiments for the US Air Force in 1949.[3] Over the years, Murphy's Law has taken on many forms. With regard to presentations, the most fitting form is, "What can go wrong will go wrong, and at the worst possible time." Examples of Murphy's Law abound in presentations. One example occurred in a demonstration by Microsoft Corporation of its Office XP version of PowerPoint. The presentation occurred before technical professionals and government workers packed into the MCI Center in Washington, D.C. During the demonstration, the program crashed, locking up the computer.[4]

Yet another instance of Murphy's Law reigning during a presentation occurred with an architectural firm that had bid on the design of a new baseball stadium in Milwaukee. The firm had a design similar to the sky dome in Toronto in which the roof could retract on sunny days and close on rainy days. In the presentation of the proposed design, the firm set out to demonstrate the roof's movement on its three-dimensional model of the stadium. This demonstration was planned for the culmination of the presentation and was accompanied by "The Star Spangled Banner." With the music playing loudly and the audience focused on the beautiful model of the stadium, the presenter flipped the switch for the roof to open. Nothing happened. "The Star Spangled Banner" continued to play, and the audience continued to keep its focus on the beautiful model, but the roof did not retract. The presenter tried everything that he could, but the demonstration failed. As you might expect, in the stiff competition for the contract, this architectural firm did not win the bid.[5]

Not only does Murphy's Law wreak havoc during demonstrations, but it also causes mischief when presenters project slides or films. For instance, when you use a computer projection system, you can encounter all sorts of problems: no projected image; no sound; no internet access to access a film you wanted; a mismatch between your software and the software on the room's computer; or a mismatch between resolution of your computer and the room's projector. In my own experience of making presentations at dozens of different institutions on five different continents, it is about equal odds that something will be amiss at the start rather than the system will work.

To reduce occurrences of Murphy's Law, you should weigh the risks of incorporating visual aids

To reduce occurrences of Murphy's Law, you should balance your desire to include great visual aids with the risks associated with those visual aids. For instance, if you are speaking in a room that is new to you, you should not have your presentation depend solely on access to the internet. Many companies and laboratories, because of security or proprietary reasons, have limited access to the web. Instead of relying on the internet, have all your images and films incorporated into a file on your computer. In addition, have a back-up of that folder on a jump drive or CD. Having the computer file folder in two places is good insurance, because you never know what obstacles await you.

If your presentation will be transmitted by teleconference, keeping things simple becomes important. For instance, films that work fine in your presentation room might very well lock up when transmitting to remote sites. In addition, sound clips that work fine in a single room might produce feedback in a teleconference setting.

In addition, if your presentation slides have unusual typefaces, settings, image forms, or films, then you should use your own laptop. Note, however, that using your own laptop can introduce another set of problems, as discussed later in this chapter.

The purpose of this discussion is not to dissuade you from incorporating demonstrations, projected slides, films, or other visual aids. Rather, the purpose is to make you sensitive to the hurdles of their incorporation. Your decision as to whether to incorporate a visual aid should account for three factors: (1) the complexity of the demonstration or the difficulty in handling the projection equipment; (2) the gain for the presentation should the visual aid succeed; and (3) the loss for the presentation should the visual aid not succeed. If the benefit of incorporating the visual aid outweighs the risk of it not working, you should go forward. In that case, though, you should find ways to respond to the occurrence of Murphy's Law.

To minimize the effect of Murphy's Law, you should rehearse

For each of his spectacular high-voltage demonstrations, Nikola Tesla reportedly rehearsed at least 20 times.[6] Rehearsal is invaluable. By rehearsing, you learn the pitfalls that could startle you during the actual performance. For instance, if the professor at the Midwestern school had practiced with the medicine ball mounted on the pendulum, he would have realized the problems inherent in that demonstration (namely, his own fear of the ball) and reworked the experiment.

Rehearsing is certainly no guarantee of success. The architectural firm that was competing for the contract for the baseball stadium had practiced opening and closing the roof several times before the big proposal presentation. Moreover, Microsoft had undoubtedly practiced the demonstration of its XP software several times before its presentation in the MCI Center. Nonetheless, while rehearsing does not guarantee success, it greatly increases the odds.

For instance, during a rehearsal with a computer projection system that had a remote control to advance the slides, I learned an important lesson. For this remote device to work, you have to insert the antenna *before* placing the program into the slideshow mode. Otherwise, the program would block the computer from recognizing the remote. Learning that lesson during rehearsal likely saved me from being confounded at the beginning of an important talk.

To troubleshoot problems arising from Murphy's Law, you should arrive early to the room

When I taught at the University of Wisconsin, I had to give a large lecture each semester in an auditorium to about 150 upperclassmen. This room had a projection system that operated from a computer within the room, and each semester I would carry over two computer disks (two were brought in the event that one failed). For the first four semesters, everything worked well. Although I revised the slides each semester, all four presentations went smoothly.

For the presentation in the fifth semester, though, I was thrown for a loop. When I loaded my presentation onto the auditorium's computer and opened the file, I was shocked to see that each letter of my presentation had been replaced by a little box. In other words, someone had removed the typeface that I had been using for this presentation (Arial Narrow). The audience, which was already filtering in, did not know my dark secret, because I had not yet projected what was on the computer. All was not lost, though. Because I had arrived 10 minutes early, I had the opportunity to highlight all those slides and replace my typeface with one on the machine, Arial. Because Arial is significantly wider than Arial Narrow, I had to finagle some of the text boxes. Although that took time, I was ready to go when the bell rang and the 150 students expected me to deliver.

What saved me from embarrassment in that presentation was my early arrival to the lecture hall (granted, bringing my own laptop or bringing my own fonts on the disk would have circumvented the problem). By the way, in that same lecture hall, I saw presenters irritate audiences because these presenters arrived just as the bell rang only to find that something unexpected had happened. In some cases, their typefaces had been removed from the computer as mine had been. In other cases, their computer disks did not work. In still other cases, their laptop computers did not have the right connections with the projector. In all those cases, the speakers taxed the patience of a 100 or more members of the audience. Few scenes in scientific presentations are as painful as the one when the moment for the presentation arrives, the large crowd quiets down and focuses its attention on the speaker, and the speaker is frantically working on his or her computer, unprepared to begin.

With presentations, you should prepare for the worst

Before a presentation, when my structure and projected slides are set, I imagine what to do if the worst were to occur. Often, I imagine this nightmare while taking a noontime run or walking my dogs. In imagining the worst, I am not psyching myself out by dwelling on failure; rather, I am trying to devise a plan should the equipment fail. Such thinking is good preparation.

For instance, in one presentation before 75 people at one of the national laboratories, I had requested a computer projection system. This presentation occurred when the technology for computer projectors was new. I was skeptical about the equipment working because I had never presented at this laboratory. For that reason, I had designed the presentation such that I could give it from just my handouts. Sure enough, the unexpected happened: The computer technician went on vacation the day before my arrival to speak, and the backup person did not receive word about my request until 5 minutes before the presentation. For the 75 people crowded in the room, I began the presentation on time using the handouts. Fifteen minutes later, the computer was up and running, but those important minutes, as well as the patience of the audience, had not been lost.

As mentioned earlier, using your own laptop can introduce another round of problems: cables are missing, sound does not work, and because of screen resolution problems, the image shown on the projector does not match what is on your laptop. For that reason, when presenting in an unfamiliar room, consider bringing a troubleshooting kit: a cable for the video, another cable for the sound, and a small speaker that can run off your computer. How many times each of those items has saved me, I have lost count. In regard to the problem of the projector projecting only a portion of your slide, it is wise to learn how to change the screen resolution on your laptop to match that of the projector.

Imagining potential problems is a good exercise, but imagining the worst is even better. Disasters usually do not occur for just one reason but for a series of reasons. Consider a case much more serious than a failed presentation: the sinking of the *Titanic* and the loss of more than 1,500 people. In the *Titanic*'s case, the reasons for the disaster were numerous: The captain had apparently wanted to set a speed record for the voyage; the sea was unusually calm, so that the lookouts could not see waves lapping against the iceberg; a lookout had misplaced the binoculars; the pilot did not hit the iceberg head on (which many believe would have allowed the *Titanic* to stay afloat for several hours), but hit it with a glancing blow that created a long gash along the hull; the crew had not practiced filling or lowering the lifeboats; earlier in the evening, the wireless operators of the *Titanic* had chastised the wireless operator of the *California*, the nearest ship, for sending them a warning about the ice (the *Titanic*'s operators were busy sending personal messages to New York); the *California*'s wireless operator, rebuffed by the *Titanic*'s operators, went to bed early, less than an hour before the striking of the iceberg.[7] Such a string of events could cause even the best prepared presentation to fail.

Although you might rehearse, arrive early, and anticipate the worst, you will probably encounter in your career at least one set of circumstances in which Murphy's Law will reign. In such a situation, you should keep your cool and, as Michael Faraday did, keep control of the situation. Michael Faraday performed many experiments in his lectures and therefore took many risks. His skill at experimenting impressed even the best scientists of his day, including Joseph Henry. Still, Faraday's experiments were not immune to Murphy's Law. As Faraday's biographer Geoffrey Canter commented, Faraday was in "apparent total command of himself and therefore of the proceedings. This is not to say that experiments did not sometimes fail to function as expected, but on such occasions he could turn the apparent failure to advantage and not lose control of the situation."[8]

Notes

[1] H. Hertz, letter to his parents (21 April 1885), *Heinrich Hertz: Erinnerungen, Briefe, Tagebücher*, arranged by Johanna Hertz, translation by L. Brimmer, M. Hertz, C. Susskind (Physik Verlag, Weinheim, 1977), p. 205

[2] Dr. S. Wald, Assistant Professor of Physics, Texas Tech University, story related in freshman physics lecture (1976)

[3] N.T. Spark, *A History of Murphy's Law* (Periscope Film LLC, Los Angeles, 2006)

[4] A. Linn, *Microsoft's Office XP Rolled out at Lavish Events* (Associated Press, Seattle, 2001)

[5] P. Dorner, private communication to author (Apr 1998)

[6] M. Cheney, *Tesla: Man out of Time* (Simon & Schuster, New York, 2001), p. 76

[7] R. Gannon, What really sank the Titanic, Popul. Sci. **246**(2), 49–55 (1995)

[8] G. Cantor, *Michael Faraday: Sandemanian and Scientist* (St. Martin's Press, New York, 1991), p. 153

Delivery: You, the Room, and the Audience

> *[Feynman] absolutely riveted the attention of everyone in the room for the entire time he was there…. For Feynman, the lecture hall was a theater, and the lecturer a performer, responsible for providing drama and fireworks as well as facts and figures. This was true regardless of his audience, whether he was talking to undergraduates or graduate students, to his colleagues or the general public.*[1]
>
> –David L. Goodstein

Delivery is your interaction with the audience and with the room. Voice, gestures, eye contact, stance, movement—all of these contribute to delivery. How you deliver your presentation affects not only how intently the audience listens to you, but also whether your audience trusts you. According to Michael Faraday, "[Lectures] depend entirely for their value on the manner in which they are given. It is not the matter, not the subject, so much as the [person]."[2] What Faraday meant here was not that the quality of the content was unimportant, but that no matter what the subject is, the audience will be engaged only if the speaker delivers that subject in an engaging way. For instance, over the years, one of the most popular courses at Cornell has been beekeeping. Is that because so many students attend Cornell because they want to become apiarists? No. The reason for the course's popularity has been that the faculty members are so passionate about beekeeping and know the subject so well that students naturally have become interested.

M. Alley, *The Craft of Scientific Presentations*,
DOI 10.1007/978-1-4419-8279-7_5,

The appropriate delivery depends on the speaker and the situation

So, for what kind of delivery should you strive? The answer to this question is not simple. Certainly, Richard Feynman provided an excellent model. He enthralled audiences—not an easy task when one's topic is as technical and abstract as Feynman's studies on quantum electrodynamics were. Linus Pauling also affected audiences in this way. However, not all of us are suited to deliver with the charisma of these two.

Several presenters have influenced the way that I give presentations. Two of these are Kamalaksha Das Gupta, a former physics professor at Texas Tech University, and Patricia Smith, a director at Sandia National Laboratories. Das Gupta and Smith reveal a stark contrast in delivery styles. Smith is the consummate professional: well prepared, poised, and appropriately dressed. One of Smith's strengths is how well she handles questions, even the caustic ones. In handling difficult questions, Smith maintains a calm, but resolute, voice. By keeping her cool, she shows that she, not the caustic questioner, controls the presentation. Also, by methodically considering several different perspectives to the concern raised, Smith refuses to be boxed into the *either–or* traps that such questioners often lay.

Das Gupta was quite different in his delivery from Smith. Das Gupta, who studied x-ray physics under the great Bose, probably broke every prescribed rule of dress, eye contact, and stance. He wore sandals, no socks, and a green plaid jacket caked in chalk dust. As he talked through difficult points, he often closed his eyes, leaned against the blackboard, and pressed a fist against his forehead. Despite giving the appearance of being self-absorbed, Das Gupta actually had a keen sensitivity to his audience and could make sense of the most poorly phrased question. What distinguished Das Gupta, though, as a presenter was his sincere passion for his subject and his deep knowledge about that subject.

The delivery style of Das Gupta falls more in the category of Feynman's. Das Gupta's personality was more suited, though, for that type of delivery. Conversely, the delivery style of Smith is more low-key, which is more like the delivery style of Lise Meitner. In developing your own style of delivery, you should reflect on what kind of delivery you feel comfortable giving. For instance, do you prefer to move around before the audience or are you more at ease standing behind a podium?

One's personality is not the only thing that shapes one's style of delivery. A second effect on delivery style is the audience. For instance, standing before an audience with whom you are comfortable and who boosts your confidence with smiles and nodding heads, you are more comfortable and more inclined to walk around, tell stories, take chances with humor, and vary the loudness and pitch of your voice. However, standing before an audience with whom you are not familiar or who are decidedly antagonistic, it is natural for you to be more serious and businesslike. You are not as inclined to vary movements or the loudness or pitch of your voice. In 1951, Rosalind Franklin faced an antagonistic audience in a presentation of her x-ray crystallographic work on DNA. Given the hostility that she faced, James Watson's criticism of her lack of warmth in that talk was unfair.[3]

Yet a third effect upon one's delivery style is the occasion. While many occasions allow for a delivery that is animated, some occasions call for a more somber delivery. An aspect of occasion that significantly affects one's delivery is the room. A presenter's delivery in a cozy conference room differs significantly from the delivery in a lecture hall with vaulted ceilings and tiered seats. In the large lecture hall, a formal barrier exists between the speaker and the audience. Although the speaker can engage the audience by moving up to the people seated in the first rows or along the aisles, the barrier poses a formidable challenge. In addition to the size of the room, an equally important consideration is how filled the room is. Engaging an audience in a half-filled room is much more challenging than engaging an audience in a filled room. In a filled room, if you happen to say something witty and the audience responds with laughter, that laughter fills the room. However, in a half-filled room, the laughter quickly dissipates. Yet another consideration for the room is its layout. If you desire discussion among the audience, a U-shaped seating arrangement works much better than a room with seats arranged in rows, because in a U-shaped arrangement, the audience can make better eye contact with one another.

You can significantly improve your delivery with practice and reflection

Delivery is an aspect of presentations in which you can make marked improvement with conscious effort. For instance, the initial lectures of Heinrich Hertz were marked by his avoiding eye contact with the audience. In those initial lectures, he looked either at the blackboard or down at his paper. Moreover, not only did he read his presentations, but he read them quickly. In fact, at a job-interview lecture at Kiel, every member of the evaluation panel commented that Hertz had spoken too quickly, a sign that he must have raced through his talk, because at least one person in most audiences is too polite to criticize. At that particular lecture, Hertz did not have a clock and was concerned about keeping his talk within the time limit of 45 minutes. Unfortunately, the more concerned he became about the time limit, the more quickly he spoke.[4]

However, Hertz's delivery improved with time. Interestingly, his self-critiques of his later presentations differed significantly from his earlier self-critiques. When writing about his first few lectures, he showed the false assurance that one has when he or she knows that things have not gone well but does not know how to correct the matter.[5] However, when writing about a later presentation (his inaugural address at the University of Karlsruhe), he criticized himself harshly, even when his audience had given him only praise. In a letter to his parents, he wrote the following about that lecture:

> Yesterday I shook off at least one threat, the inaugural lecture. The professors nearly all attended, as did *Ministerialrat* Arnsperger and *Staatsrat* Nokk (the minister of education). My speech did not satisfy me at all. In my opinion it failed terribly (you will get a chance to

> see for yourselves). Likewise the manner in which it was presented left more to be desired than strictly necessary. The fact that I nevertheless heard only kind reactions shows only the modest expectations of the audience.[6]

No doubt Hertz had improved from his earlier presentations, but no doubt he had established much higher goals for himself.

Hertz's pinnacle for presentations occurred in a lecture given to more than 300 spectators at the Polytechnic in Bonn. At the end, "there was so much applauding and cheering" that his wife became embarrassed. Afterwards, one man wrote to say that he was quite "shaken" by the lecture; another claimed that although the lecture "cost him a sleepless night," he did not regret it.[7]

So how does one improve one's delivery? Hertz's improvement from the nervous student in Berlin to the composed lecturer in Bonn occurred over nine years (1880–1889). His method was one of continual reflection and revision. For instance, in 1883, he reduced the notes for one of his lectures by almost one-half and slowed his tempo. Afterwards, he worried that he had spoken too slowly, but his audience of professors and students assured him that the pace had been "quite right."[8] What is important to note here is that Hertz made the effort to query his audience—a sign that he desired to improve.

For most of us, nine years is a long time to improve our delivery, even if we were to achieve the dramatic changes that Hertz experienced. How then could we improve our delivery in a shorter time?

One of the best ways is to have colleagues critique your presentations. These critiques should not only mention those aspects that are weak, but also discuss what aspects of delivery were strong (for a set of critiquing guidelines, see the Appendix). Also effective is to videotape yourself making a presentation and then to review the videotape with a critical eye. Although this exercise might be uncomfortable at first, it is enlightening to see your movements and expressions and to hear your voice.

In improving your delivery, one thing to be careful of is that you do not try to orchestrate every individual part of the delivery: posture, stance, hand movements, body movements, facial expressions, eye contact, loudness of voice, variation in voice, and avoidance of filler phrases. If you consciously worry about every one of these aspects, you might neglect the bigger things such as genuine enthusiasm that are needed for success. In other words, in trying to improve all the aspects of your delivery, you might become so stiff and self-conscious that your presentation does not engage the audience.

In my experience, the most captivating speakers in science and engineering have been the ones who loved their subjects and knew them well. If you do not convey your interest for the subject, how can you expect your audience to become interested? Conveying enthusiasm does not mean that you sing and shout. If you put on pretences, the enthusiasm will not be sincere, and the audience will see through the act. Moreover, scientific audiences are suspicious of deliveries that contain too much dazzle, particularly at the beginning; these audiences often assume that the presentation is more style than substance. In truth, a presenter can show a genuine enthusiasm for the subject in many ways: a sincere voice, sustained eye contact, animated facial expressions, and natural gestures that contribute to the audience's understanding of the subject.

Another way to improve your delivery in a relatively short time is to study the delivery of others with a critical eye, as Michael Faraday did. Nobel winner Rosalyn Yalow also adopted this technique before her first teaching assignment. According to Yalow, "Like nearly all first-year teaching assistants, I had never taught before—but unlike the others, I also undertook to observe in the classroom of a young instructor with an excellent reputation so that I could learn how it should be done."[9]

In using this technique, you might try to imagine someone who is an excellent speaker making your presentation. Imagine the rhythm of his or her voice. Imagine his or her movements on stage. Ideally, this imagination should occur soon before you go on stage.

This strategy for learning to deliver a presentation follows the advice of Tim Galloway for learning to play tennis.[10] Rather than having his students worry so much at the beginning about how to grip the racket, position the feet, bend the knees, and address the ball, Galloway has his students simply watch a videotape of a great tennis player making a series of forehand shots, backhand shots, volleys, or serves and then has his students go out onto the court and do likewise. Even though I learned to play tennis years ago, I continue to use this strategy. For instance, just before hitting a topspin forehand, I imagine Steffi Graf hitting a topspin forehand. On television, I have watched Graf hit hundreds of such forehands, and so in my mind I replay the images of her moving across the court, positioning herself, and swinging through the ball. And then I try to do likewise. With speaking, I do a little of the same. I imagine one of my model speakers—Patricia Smith or Kamalaksha Das Gupta—and try to emulate that person's style. Having these individuals as models does not diminish my individuality as a speaker. Rather, it helps me bring out those traits in my own delivery that I value so highly in theirs.

Notes

[1] D.L. Goodstein, Richard P. Feynman, Teacher, in *"Most of the Good Stuff": Memories of Richard Feynman*, ed. by L.M. Brown, J.S. Rigden (American Institute of Physics, New York, 1993), p. 118

[2] *Report of H.M. Commissioners Appointed to Inquire into the Revenues and Management of Certain Colleges and Schools and the Studies Pursued and Instruction Given Therein*, Parliamentary Papers [3288] **4**(69), 379 (1864)

[3] J.D. Watson, *The Double Helix* (Atheneum, New York, 1968), p. 68

[4] H. Hertz, letter to his parents (25 Jan 1881), *Heinrich Hertz: Erinnerungen, Briefe, Tagebücher,* arranged by J. Hertz (Physik Verlag, Weinheim, 1977), pp. 143, 173, 181

[5] Ibid, p. 205

[6] Ibid, p. 205

[7] Ibid, p. 285

[8] Ibid, p. 183

[9] S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 339

[10] T. Galloway, *The Inner Game of Tennis* (McGraw-Hill, New York, 1972)

Critical Error 10
Not Preparing Enough

> *A young [person] doesn't realize how much time it takes to prepare good lectures, for the first time, especially.*[1]
>
> –Richard Feynman

After his work at Los Alamos during the war, Richard Feynman began teaching at Cornell. During that first semester, he became depressed at how little research he was doing. He claimed to feel "tired"[2] and was unsure what was making him feel that way. It was not until his second semester that he realized how much time and energy preparing his class presentations required. Years later, because of the time that preparing a new lecture demands, Feynman hesitated to do the set of freshman physics lectures that ended up bringing him so much acclaim. As he predicted, the freshman lectures did consume his time, causing him to put aside his research. Although he spoke only twice a week, he "worked from eight to sixteen hours per day on these lectures, thinking through his own outline and planning how each lecture fit with the other parts."[3]

Preparing a strong presentation does take time. Time is needed to understand the content well enough to organize it in a fashion that is readily comprehended by the audience. Time is also needed to gather the important images, to graph the important results, and to incorporate those images and graphs into a set of well-designed slides. Moreover, time is needed to rehearse the material so that you can find the right words to explain the difficult concepts and to smooth the transitions between ideas.

Before opening the computer, you should decide upon the story of the talk

Many people begin their presentations on the computer by opening up PowerPoint or similar software and listing phrases that they intend to say. Unfortunately, beginning in this way leads to talks that contain much unneeded information. Before opening up the computer, you want to think hard about the "story" of your talk: what your main message is and what assertions you will have to persuade the audience of before they will accept that message.

As Garr Reynolds and Nancy Duarte recommend,[4,5] an excellent way to develop this story is to write out the main message and supporting assertions on separate sticky notes and place those on a wall. For instance, in a research talk, one supporting assertion would be your main hypothesis. Another would be the reason for testing that hypothesis. Still another would be what distinguishes your methods for testing that hypothesis. Yet others would be the individual results from that test. Once you have those takeaways, you can arrange the sticky notes into an order that tells the best "story."

Put another way, this "story" is your argument to the audience. In this argument, the supporting assertions are the steps of the story that will lead the audience up the mountain to the main message (or vista). Moreover, this act of defining your main message and the assertions is an excellent way to focus your talk. If a detail does not support one of these takeaways, you exclude it. The main reason that so many scientific talks are awash with extraneous details is that the presenters have not expended the time and energy to perform this step.

Once you have your story, you are in position to create your visual aids

Once you have established your story or your argument, you are in position to create the visual aids. Creating the visual aids at this point is important because preparing effective visual aids consumes much time. For instance, to craft a set of assertion-evidence slides, you need time to revise your assertion headlines. Granted, in the story stage, you determined the main message and drafted the supporting assertions that will lead the audience to that message. Now in the visual aid stage, you need to tighten those headlines to a length that the audience can comfortably read during a presentation.

Preparing effective visual aids also requires time to create graphics that will support those assertion headlines. Many presenters mistakenly use the same graphics in their presentation that they have used in their documents. However, a graph or table that works well in a paper often contains too much detail or has lettering too small to be effective in a presentation. Not only do you need to prepare the visual evidence, but you need to incorporate that evidence on the slide, inserting blank space so that the slide breathes and using animations when necessary. Yet more time is required for you to rehearse with those slides so that you can make the appropriate transitions between slides. Finally, if you are providing a handout, time is needed to create that. For instance, the handout might involve you placing secondary details, transitions, and reference citations onto the notes page of each slide.

When the presentation is collaborative, even more time is needed to prepare a set of presentation slides, because each speaker should have the chance to comment on a draft of those slides. Ideally, in a collaborative presentation, one person should have the task of creating the slides. That scheme makes it easier to obtain both a consistent slide format and a set of slides that reveals the presentation's organization. Even though one person is tapped to design the slides, everyone should meet early on to contribute to the story of the talk, and everyone can help create the supporting visual evidence.

In addition to preparing visual aids, you should prepare yourself to speak

One day my wife lamented about how one of her graduate students had spent far too much time—the better part of six months—preparing a proposal of his doctoral work for his committee. "If he had put that time into his research," she complained, "he would be a good portion of the way finished with his project."[6] The communication requirements for this proposal were not so high: a five-page document and a 20-minute presentation. This student, though, had written more than 60 pages and had prepared more than 35 slides. The day before the presentation, my wife tried to persuade this student to stop working on the slides and to spend time rehearsing the presentation. Unfortunately, the student continued tinkering with the slides up to the hour of the presentation. By the student's own admission, the presentation was a failure. He had problems, as he said, "finding a rhythm." Things never clicked for him, and he struggled to find transitions between the different scenes.

As mentioned in the previous section, a speaker needs time to practice, even if he or she has an excellent set of presentation slides. Practice helps the speaker with transitions from one assertion to the next. Practice also helps the speaker work through the explanations of difficult concepts so that all the words are, in fact, inside the speaker and ready to come out. Most important, perhaps, practice reassures the speaker that he or she can, in fact, make the presentation. Perhaps the greatest source of nervousness for speakers is the fear that they will stand before an audience and not know what to say. By having walked through the presentation, even if in a mumble, the speaker knows that the words are there.

To prepare themselves to speak, many presenters require time alone before the presentation. For example, Jane Goodall said, "Even when I am giving a talk for the tenth time, I still sit down for at least thirty minutes and go through the talk…It is rude not to do that and disrespectful to the audience."[7]

Likewise, when Heinrich Hertz began teaching, he claimed that he could think of nothing else but each lecture for at least one hour before he gave it.[8] Also, according to one of her daughters, Marie Curie required the entire afternoon to prepare herself for her five o'clock lecture to her graduate students.[9] Finally, as mentioned earlier, in preparing his freshman lecture series on physics, Richard Feynman spent 8–16 hours a day preparing for the series.[10] That time might seem excessive, but if the content is strong and the audience is important, the time is well spent.

Speaking in a second language requires additional preparation

Anyone who attempts to make a scientific presentation in a language different from his or her own deserves much respect. Elisabeth Pain, a writer for *Science*, has much practical advice for this topic.[11] Much of her advice is common sense. For instance, one tip is to enrich the vocabulary in your field. Another is to practice the pronunciation of common words in your field. A third is to use assertion-evidence slides that give the audience the main takeaway for each scene and provide visual support for your speech. Yet a fourth is to prepare podium notes for each talk that you can refer to, should you become stuck—forgetting a key word or forgetting how to phrase an important idea.

To be successful at giving talks in your non-native language, one important skill for the presenter is listening in that language. Listening is especially important for understanding questions. In other words, just memorizing and practicing a speech in the other language is not enough, as Niels Bohr found out in his first (and last) meeting with Winston Churchill.[12] You have to be able to understand the questions and respond on the spot. If your listening comprehension is not strong, one suggestion is to have a colleague in the audience who knows the language well enough to help you understand difficult questions. That person can also help you during the presentation by feeding you a word or two that you cannot remember.

A second important trait for being successful at giving talks in your non-native language is a willingness to accept that mistakes will occur. All too often, a person learning a new language will make mistakes (as is natural), but then will feel embarrassed and will avoid speaking. Becoming better at that language then becomes impossible, because to learn a new language you have to speak that language. Although you will make mistakes in speaking in a different language, there is no reason to be embarrassed by those mistakes. Although the great physicist Chien-Shiung Wu never felt at ease with English, she did not back down from speaking it. After earning her Ph.D., she went on a lecture tour across the United States. In her presentations, Wu often confused the pronouns *he* and *she*, and left out articles from her sentences. Because of her struggles, she wrote out her entire presentations and practiced them repeatedly beforehand.[13] Still, Wu did not shy away from speaking, and her tenacity at continuing to speak before crowds served her well in her career.

Notes

[1] H. Hertz, letter to his parents (21 Apr 1885), *Heinrich Hertz: Erinnerungen, Briefe, Tagebücher,* arranged by J. Hertz, translation by L. Brimmer, M. Hertz, C. Susskind (Physik Verlag, Weinheim, 1977), p. 205

[2] R.P. Feynman, *Surely, You're Joking, Mr. Feynman!* (W. W. Norton & Company, New York, 1985), p. 171

[3] J. Metra, *The Beat of a Different Drum* (Clarendon Press, Oxford, 1994), p. 484

[4] G. Reynolds, *Presentation Zen* (New Riders, Berkeley, 2008)

[5] N. Duarte, *Slide:ology* (O'Reilly Media, Sebastopol, 2008)

[6] K.A. Thole, professor and department head of Mechanical and Nuclear Engineering, Pennsylvania State University (Apr 2001), private communication to author

[7] J. Goodall, primatologist, interview with author (26 Mar 2011)

[8] H. Hertz, letter to his parents (27 May 1883), *Heinrich Hertz: Erinnerungen, Briefe, Tagebücher*, arranged by J. Hertz (Physik Verlag, Weinheim, 1977), p. 183

[9] E. Curie, *Madame Curie: A Biography* (Literary Guild of America, New York, 1937), p. 370

[10] J. Metra, *The Beat of a Different Drum* (Clarendon Press, Oxford, 1994), p. 484

[11] E. Pain, Presentation tips for non-native speakers, *Science Careers* (17 June 2011)

[12] R.V. Jones, Bohr and politics, in *Niels Bohr: A Centenary Volume,* ed. by A.P. French, P.J. Kennedy (Harvard University Press, Cambridge, 1985), p. 285

[13] S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 255

Critical Error 11
Drawing Words from the Wrong Well

It is hard to overestimate the dismay and resentment of an audience that has to put up with a paper read hurriedly in an even monotone.[1]

–P. B. Medawar

Toward the end of World War II, Niels Bohr set up a meeting with Winston Churchill to warn him about an atomic arms race that Bohr correctly predicted would occur after the war. Bohr wanted all countries to establish guidelines to contain these weapons. A few months earlier, Churchill had diminished hopes for such guidelines by signing away British rights to nuclear development. Because Bohr, who had recently fled Denmark, did not speak English very well, he decided to write out the presentation in his best English and have a friend, R.V. Jones, go over the draft and polish the language. For three days, the two men worked on this presentation, and when Bohr was pleased with the product, he memorized it. The day of the meeting arrived, and Bohr was brought to Churchill by an aide who was sympathetic to Bohr's position. Unfortunately, as soon as Bohr and the aide met Churchill, Churchill put both the aide and Bohr on the defensive by claiming that the meeting was nothing more than a reproach for England's signing away of the rights to nuclear development. Bohr tried to improvise, but according to R.V. Jones, "no doubt suffered from his usual anxiety to be precise."[2] Within 20 minutes, Churchill lost patience and had Bohr ushered out of the office.

How should scientists and engineers deliver their words in a scientific presentation? Should they read those words or should they memorize them? Another possibility would be that scientists and engineers speak extemporaneously—that is, the speaker commits to memory the organization of the talk, but not the exact wording. In an extemporaneous talk, the speaker practices the talk several times to be sure that he or she can fashion the words on the spot. Still another possibility is that scientists and engineers speak impromptu, which is often referred to as speaking off the cuff. Before deciding upon an answer, you should consider the advantages and disadvantages of each approach, as listed in Table 5-1. What might surprise you is that occasions arise, as shown in Table 5-2, in which each approach is appropriate.

Table 5-1. Advantages and disadvantages of different sources for speech.

Sources	Advantages	Disadvantages
Extemporaneous	Credibility earned	Wording not exact
	Easy to adjust speech	Much preparation
	Eye contact	Natural pace
Impromptu	No preparation time	Potential for disaster
	Eye contact	Difficulty in organizing
		Lack of visual aids
Memorizing	Precision	Potential for disaster
	Smooth delivery	Unnatural pace
	Credibility earned	Inability to adjust speech
	Eye contact	Most preparation
Reading	Precision	Unnatural pace
	Smooth delivery	Lack of eye contact
		Inability to adjust speech
		Significant preparation
		Lack of credibility

Table 5-2. Appropriate occasions for each source of speech.

Sources	Situation
Extemporaneous	Conference presentation
	Presentation at business meeting
	Seminar or university lecture
Impromptu	Answering a question during a talk
	Asking a question during a talk
	Participating in a roundtable discussion
Memorizing	First sentence or two of presentation
	Short quotation within presentation
	Last sentence or two of presentation
	Short introduction of another speaker
Reading	Press conference
	Quotation within a presentation
	Management talk in which wording is scrutinized
	Emotional speech, such as a eulogy

For most scientific presentations, a practiced extemporaneous talk is the best overall strategy

For most occasions, the most logical and accepted way to make a scientific presentation is to speak extemporaneously, which means to give a practiced talk that follows an established organization. That organization you might have committed to memory, written down as notes, or conveyed through visual aids. P.B. Medawar strongly recommended this strategy,[3] as did Michael Faraday.[4] Another proponent of this strategy was Richard Feynman. For instance, for his famous set of lectures on freshman physics, Feynman brought to each class only one sheet of notes, which he placed discreetly on a podium. Einstein used this strategy for his lectures as well, bringing to class only one note card, which he kept out of view in his pocket.[5]

This strategy differs significantly from the ineffective, but all-too-common, approach mentioned earlier in which the presenter projects portions from a large percentage of spoken sentences onto the slides. What happens with this strategy is that the presenter reads the text aloud while the audience members do one of three things. Some in the audience will read the text and tune out the speaker—in such cases, the speaker is a distraction. Others in the audience will ignore the text and listen to the speaker, who is looking at the screen. Still others will try to read the text and listen to the speaker—which is the most difficult because the two readings occur at a different pace. None of these three situations is effective for audience comprehension.

In an extemporaneous strategy, if the speaker uses projected slides, the speaker should place only a small fraction of the spoken sentences on those slides. For instance, the assertion-evidence structure calls for one succinct sentence headline that summarizes what the speaker will cover typically for the next 1 or 2 minutes. In other words, one sentence exists on the slide for 10 or so sentences spoken during the talk.

This extemporaneous strategy also differs significantly from the note-cards-in-the-hand approach unfortunately taught in many college speech classes. In this approach, the speaker carries note cards in his or her hands during the talk. Having the note card visible to the audience for the duration of the speech not only distracts the audience but, as Hans Rosling says, undermines the "authority" of the speaker.[6] That undermining is especially true in science and engineering, because in science and engineering, the expectation is that the speaker will look the audience in the eye and speak from what he or she knows. True, Feynman and Einstein silently looked at their notes every now and then, but when they were speaking, their eyes were on the audience and the notes were out of view. The exception about keeping eye contact on the audience when speaking would be those times when the speaker explains a graphic, equation, or film on the screen. However, in those instances, it is natural for the presenter to look at the projected images, equations, or films because the audience will be looking there as well.

The advantages of presenting extemporaneously are numerous, one of the most important being the regard that the audience holds for the speaker. Because the speaker is fashioning the words, the audience perceives that the speaker owns this information.

Ideally, you should practice your extemporaneous presentations to the point of speaking without any notes at all. In other words, you should practice the talk enough that you can memorize its organization. A good measure is that you know what the next slide is before you advance to it. Knowing that next slide helps you make the transition to that scene. In fact, if I am on my game, I will often fashion the next headline on the spot just before advancing to that slide. That way, those in the audience who understand the assertion can focus on the visual evidence. As for those who did not understand the assertion, they have the headline as a safety net to help them catch up with the talk.

Boltzmann did not use notes in his talks, and that was not just for his conference presentations. Boltzmann used that delivery for a series of university lectures that spanned 4 years and included such varied topics as classical mechanics, hydrodynamics, elasticity theory, electrodynamics, and the kinetic theory of gases.[7] Hans Rosling, the Swedish statistician, prefers to use this approach as well, even though it requires more preparation: "If I do a good lecture, I do not bring a paper. I have it all in my head."[8]

For his many public talks about the CERN particle accelerator,[9] Brian Cox uses this strategy of not speaking with any notes. Cox divides these public talks into 4–5 minute segments that he has given many times and is comfortable presenting. In his preparation for a longer talk, he decides which segments he will present and then spends much time on the transitions into and out of each segment. In his talks, although Cox knows the segments well, he is not too rehearsed. As he says, "My talks look spontaneous, because they are, but within a structure that keeps me from wandering off."[10]

Another advantage of speaking extemporaneously is that because the speaker must find the words from within, he or she ends up working through the subject at a pace that is much closer to the way that the audience understands the material. In other words, when the speaker comes upon a difficult idea, the speaker naturally slows to explain that idea because the words do not come as easily. Paralleling that decrease of the speaker's pace is the decrease of the audience's comprehension rate. The more difficult the idea, the more time the audience needs to understand that idea. Similarly, when the speaker covers material that is relatively easy, the words come more easily, but that is fine for the audience because the understanding comes more readily as well.

Yet another advantage of this strategy is that the speaker has ample opportunity to make eye contact with the audience. Because the lion's share of the wording comes from within, the speaker can keep his or her eyes trained upon the audience. That opportunity allows the speaker to read the audience and to adapt the presentation to their level of understanding.

A final advantage is that because the words are not set in stone, the speaker can change the presentation to accommodate the audience. Should the speaker perceive that the audience does not understand something or that the audience is bored and wants the presentation to move more quickly, the speaker can make the desired adjustments.

The main disadvantage with this strategy is that because the words are not set in stone, the speaker runs the risk of not having the exact words during the presentation. The speaker might become stuck as he or she gropes for the right word. The fear of that situation is heightened for those making a presentation in a language different from their native tongue. To counter this disadvantage, the speaker should, as Medawar suggested,[11] practice the presentation repeatedly until the speaker is sure that the words will come. Another counterargument to this disadvantage is that an audience for a scientific presentation does not expect the words to flow as from an actor in a dramatic performance. If the speaker in a scientific presentation must pause to come up with the right word, the audience does not judge the speaker harshly. In fact, such pauses if properly spaced can emphasize key points. Also, if the speaker desires exact wording, say for a difficult concept or for the incorporation of a law or statute, the speaker can include that exact working on the slides or in discreetly placed notes.

A second disadvantage of speaking from points is that the preparation time is generally higher than for simply reading. The reason is that for the speaker to gain confidence that the words will come, the speaker has to practice the presentation several times.

While not the approach to choose for a planned talk, impromptu speaking is an important skill

For a scheduled talk, the principal advantage of speaking impromptu, or off the cuff, would have to be that you do not have to spend any time in preparation. If a second advantage exists, it is probably that the presenter can maintain steady eye contact with the audience.

Given the cost, though, in assembling a professional audience for a presentation, such a strategy for an entire presentation is unsound. For a complex subject, the likelihood is low that an impromptu speaker would come up with an efficient and effective structure that emphasizes the most important points and that makes smooth transitions between those points. Moreover, the potential for disaster—the speaker becoming lost—is high. This potential for disaster might also be a deep source of nervousness for the speaker. After all, the best countermeasure against nervousness is preparation. Also, given the inefficiency in organization that comes with speaking impromptu, the likelihood is high that the speaker will lose the audience, should the presentation go into depth on a subject. Yet another disadvantage is that little chance exists for visual aids, other than a writing board.

Although such a strategy is discouraged for a conference presentation, lecture, or business meeting, practicing short impromptu talks is time well spent, because often in conference presentations, lectures, and business meetings, one is often forced to speak off the cuff during question periods. As a speaker, you are called upon to answer questions from an audience. Likewise, as an audience member, you often have to pose questions for the speaker. The more practice that a presenter has at speaking impromptu, the more confidence that presenter is likely to exhibit in those situations.

When asked a question, it is important to pause and think before answering. Such a pause not only allows you to consider what you will say, but also provides emphasis to the first sentence of your answer. The audience is patient with a speaker who silently thinks about the question for a moment, much more patient than if the speaker fills the silence with empty chatter or a filler phrase such as *uh*, *um*, or *you know*.

How do you eliminate filler phrases from your speech? The process generally takes several days, with the first step being to learn what filler phrases you say. That step you can accomplish by having a colleague critique a presentation of yours. Once you have discovered what your filler phrases are, your subconscious will work to eliminate them from your speech. Your subconscious is powerful. Do not underestimate its abilities. When you notice yourself saying one of your filler phrases, you are well on your way to eliminating that phrase from your speech. Not surprisingly, you are much more likely to say filler phrases when you are tired, which is reason enough to get a good night's sleep before an important presentation.

A final step is to appreciate, even covet, the sound of silence. Silence has tension. Silence can be powerful. At least a couple of times in your speech, you should pause long enough that you can hear the low frequency hum of the air ventilation system. One master of the pause is Al Brockett, a vice-president at Pratt & Whitney. A tall Oklahoman with piercing eyes and a country preacher's cadence, Brockett can hold a pause longer than any scientific speaker I know. Brockett's pauses serve his presentations. For him as a speaker, his pauses provide emphasis. For his audiences, Brockett's pauses provide reflection. Once you begin enjoying the silent moments of your presentations, you will find that silence becomes too valuable to waste on filler phrases.

Memorizing can be effective for short portions of talks such as first and last sentences

One advantage of having memorized a speech is that the speaker can deliver the words in a dramatic fashion, much as an experienced actor does in a play. Another advantage is that because the words come from within, the speaker can maintain constant eye contact with the audience. Yet a third advantage is that because the speaker chooses the words beforehand, the speaker has control over the exact wording, as long as the speaker's memory does not fail.

A major disadvantage of memorizing a speech is that for most of us, memorizing a speech takes too much time. In a presentation, the typical person says about 130–140 words per minute. For that reason, a 15-minute presentation then calls for memorizing more than 2,000 words. That is quite a task! Screen actors in supporting roles have won academy awards for saying far fewer words. Given the frequency with which scientists and engineers have to make presentations, most scientists and engineers simply do not have the time to memorize their talks.

Another disadvantage of memorizing a presentation is that memorization does not leave much opportunity for changing the presentation in midstream, which is one of the reasons that scientists and engineers make presentations about their work, as opposed to just documenting their work in writing. In fact, Bohr's failed presentation to Churchill suffered for this very reason.

A third disadvantage of memorization is that the pace of words recalled from memory does not necessarily reflect the pace at which the audience understands those words. Stated another way, our memory often recalls words more quickly than the audience can understand those words.

Given these disadvantages, you might think that memorization has no place in scientific presentations. That is not true. When you have only a few words to say before an audience, such as the introduction of a colleague, memorization might be the best approach. Also, you might memorize the first couple of sentences of a difficult or important presentation just so that you create a good first impression with the audience and so that the words begin to flow as you transition to speaking extemporaneously. For many people, the beginning of a talk is the biggest struggle. Much of that difficulty arises from the nervousness that speakers often feel before a presentation. Having the first couple of lines memorized allows you to get started and to get to what Feynman refers to as that miraculous moment when you concentrate on the science and are "completely immune to being nervous."[12]

Reading is sometimes necessary when the audience will scrutinize your every word

The principal advantage of reading a speech is that you say the exact words that you intended to say. Given the disdain that so many engineers and scientists including Medawar[13] and Faraday[14] have for speeches that are read, you should think long and hard before selecting this mode of delivery. The disadvantages are numerous.

A read speech often occurs at too fast a pace for the audience to understand. Without preparation and practice, complex ideas that should be presented slowly are rattled off. Also, when someone reads a speech, that person's eye contact is usually on the page (or the slide) and not on the audience. The lack of eye contact prevents the speaker from assessing the reactions of the audience. The lack of eye contact also prevents the audience from assessing the intentions of the speaker. The audience gathers much from the eyes of the speaker in terms of emphasis. When the speaker's eyes are on the page, the audience cannot read those eyes. A third disadvantage of reading a speech is that changing the presentation is more difficult to do. Because the details of the speech are already ordered on the page, rearranging that speech poses problems.

Perhaps the main disadvantage of a speech that the speaker reads (or even carries around note cards for) is that the audience wonders whether the speaker actually knows the subject or is just repeating what others have gathered. Granted, some disciplines such as literary criticism have a tradition of reading papers at conferences. For those disciplines, a read speech does not cast shadows on the credibility of the speaker in the same way that a speech read in science or in engineering does.

Although reading a speech has many disadvantages in conference presentations, business meetings, or university lectures, its one main advantage of being precise might cause you to choose this strategy for highly scrutinized situations such as a press conference, a welcome address to a large conference, or a management talk about a controversial issue. For the situation in which the audience examines every word or phrase, the precision that a read speech offers can outweigh the disadvantages. Reading would prevent slip-ups such as the one about the United Negro College Fund that continues to haunt former Vice-President Dan Quayle. Instead of repeating the fund's slogan, "A mind is a terrible thing to waste," Quayle inadvertently said, "What a waste it is to lose one's mind or not to have a mind is being very wasteful."[15] In searching for the right words, everyone on occasion makes such mistakes. Quayle's mistake was particularly embarrassing because his critics from *The New York Times* and other publications were monitoring his every word.[16] When the exact wording of your talk is under such scrutiny, then reading a prepared statement makes sense.

Aslak Tveito, who is the managing director of Simula Research Laboratory in Norway, often reads addresses that he gives to his laboratory or to government officials. Tveito's talks work well for three reasons. First, the sentences he says are engaging, provocative, and often surprising. Put another way, every idea in his text counts. Second, much care goes into the wording of those sentences. Not only are the word choices precise, but the sentence rhythms are pleasing, which is challenging because often he writes the text in English, rather than his native Norwegian. Third, it is clear that Tveito has practiced delivering the talk a number of times because he often looks up at the audience as he delivers the lines. Moreover, he delivers the speech at a natural pace that the audience can follow and with powerful pauses that provide emphasis. Put another way, Tveito's read speeches do not come across as being read by a speaker—they comes across as being delivered spontaneously to the audience.

So far, this category of read speeches has considered the case of someone reading from a script at a podium. What about the situation in which the speaker reads full text or significant portions of the text from a projected slide (such as a phrase for almost every sentence that is spoken)? In short, this style is a disaster. Such talks have spawned the phrases "PowerPointless" and "Death by PowerPoint." Because the audience can read the text or guess at the gist of the ideas before the speaker says them, the power of surprise, as in Tveito's speeches, is lost. Also, the delivery dynamic is poor. Both the speaker and the audience are looking at the text on the screen—not at each other.

The rare strong examples of such a talk are ones given in the Lessig style. As mentioned in Chapter 4, Lawrence Lessig, an economics professor from Stanford, has developed a style in which he flashes short phrases or images on the screen behind him as he talks through the speech. The effect has the energy of an MTV video. In the strong examples of this style, such as keynote for the 2005 O'Reilly Open Source Convention given by Dick Hardt, the founder of Sxip Technologies,[17] the speaker has rehearsed the speech so much that the short phrases, usually one to four words, flash at the same time or just after they are spoken. Because the audience is not reading ahead of the speaker, the speaker can still incorporate surprise into the talk. In addition, many of the words spoken are accompanied not by words on the screen, but by images on the screen. For that reason, the speaker builds credibility with the audience by relaying much information without notes.

Notes

[1] P.B. Medawar, *Advice to a Young Scientist* (Harper & Row, New York, 1979), p. 59

[2] R.V. Jones, Bohr and politics, *Niels Bohr: A Centenary Volume*, ed. by A.P. French, P.J. Kennedy (Harvard University Press, Cambridge, 1985), p. 285

[3] P.B. Medawar, *Advice to a Young Scientist* (Harper & Row, New York, 1979), p. 59

[4] M. Faraday, Letter to Benjamin Abbott (11 June 13) *The Correspondence of Michael Faraday*, ed. A.J.L. James, vol. 1, letter 25 (IEEE, London, 1991), p. 61

[5] A. Pais, *'Subtle Is the Lord…': The Science and Life of Albert Einstein* (Oxford University Press, Oxford, 1982), p. 417

[6] H. Rosling, Professor of Global Health, Karolinska Institute, Stockholm, phone interview with author (3 Mar 2009)

[7] E. Broda, *Ludwig Boltzmann: Mensch, Physiker, Philosoph* (Franz Deuticke, Wien, 1955), pp. 9–10

[8] H. Rosling, Professor of Global Health, Karolinska Institute, Stockholm, phone interview with author (3 Mar 2009)

[9] B. Cox, CERN's supercollider, www.ted.com (TED Talk sponsored by Autodesk, Monterey, Mar 2008)

[10] B. Cox, Professor of Physics, University of Manchester, correspondence with author (5 Mar 2009)

[11] P.B. Medawar, *Advice to a Young Scientist* (Harper & Row, New York, 1979), p. 59

[12] R.P. Feynman, *Surely You're Joking, Mr. Feynman* (Norton, New York, 1985), pp. 79–80

[13] Idem

[14] M. Faraday, Letter to Benjamin Abbott (11 June 13) *The Correspondence of Michael Faraday*, ed. A.J.L. James, vol. 1, letter 25 (IEEE, London, 1991), p. 61

[15] D. Quayle, address to the United Negro College Fund, *New York Times* (25 June 1989)

[16] C. Hanson, Dan Quayle: The Sequel, *Columbia Journalism Review*, www.cjr.org/year/91/5/quayle.asp (CJR, New York, Sept/Oct 1991)

[17] D. Hardt, "Identity 2.0," keynote address of OSCON 2005 conference, www.identity20.com/media/OSCON2005/ (O'Reilly Open Source Convention, Portland, 2005)

Critical Error 12
Not Paying Attention

> *Since we couldn't understand what [Oppenheimer] was saying, we watched the cigarette. We were always expecting him to write on the board with it and smoke the chalk, but I don't think he ever did.*[1]
>
> –James Brady

In describing how he felt giving a paper to a geological society, Charles Darwin said, "I could somehow see nothing all around me but the paper, and I felt as if my body was gone, and only my head [was] left."[2] The sense of being disconnected that Charles Darwin experienced reflects the way that many presenters carry themselves during a presentation, as if they have no idea about the elements around them: the room, themselves, the audience, or the time.

Pay attention to the room

For years now, I have had dogs—large, outdoor dogs. As a rule, these dogs are unruly. They do sit, stay, and come, but only after hesitation. Moreover, they are restless creatures who in a few minutes of entering a veterinary waiting room can exhaust me with their squirming and pacing. One thing I have noticed, though, is that within seconds of my vet entering the examination room, they become still and attentive, almost subservient. So one day I asked my vet how she was able to exert that effect on these animals. The vet, whom I had known for several years, confided that much of it arose from her demeanor when entering the room. When entering, she did not make eye contact with the dog. Rather, she began setting up and rearranging things in the room. The dog was sizing her up at this point, and by taking control of the room, she let the dog know that this room was her room. Then, when she finally turned to the dog, it was with purpose. Dogs do not have much patience for being probed and pricked. So, when she attended to the dog, she did so with efficiency.

Although the audience that a vet faces in the examination room is much different from the audience that we face in a scientific presentation, we can learn much from this approach. When an audience attends a scientific presentation, they want the time to be worthwhile. However, they have had so many empty experiences at scientific presentations that they often fear the worst. For that reason, when you make a presentation to a new audience, show them early on that you mean business and that you will deliver. Granted, you should not be as cold to the audience as my vet first appears to my dogs, but you should exhibit control of the situation. The lights, the arrangement of the front of the room, and sometimes the arrangement of the audience seating—all of these are part of your domain.

Unfortunately, I often see presenters remain passive about these elements, much to the detriment of their presentations. For instance, because many speakers do not rearrange the front of the room, they often find themselves in awkward positions—on the wrong side of the screen or boxed in by the furniture. Also, because many speakers do not check out the different possibilities for the lights, they end up projecting slides that are washed out or in rooms that are too dark for eye contact to be made. The advice here is simple: Take charge. After all, you are the one who will be credited or blamed for the presentation. So, if you prefer to walk around during your presentation, bring a remote advancer so that you do not have to stand beside the computer. If a table is in your walking space, move it. If the lighting is too bright, lower the lights in the front or adjust the shades.

Granted, when you are at a conference and are speaking in a session with other presenters, you do not have as much freedom to rearrange the room as when you are doing a stand-alone presentation. Still, you should arrive early to your session, become familiar with the setup, and decide how best to work with the arrangement. Do not show up one minute before the session, as the opening speaker did for a session at a recent national conference. This speaker not only arrived late but announced that he needed an overhead projector, which was different from the computer projector that the other four speakers had already set up. In his rush to change to that overhead projector, he inadvertently closed the second speaker's laptop computer and caused it to go into a deep sleep. The result was that the beginning of the second presentation was delayed, and the second speaker had to cut short her talk.

As you are making the presentation, you still have the responsibility to exercise control of the room. For instance, if distracting noises are coming from an open door, take control and shut it. If someone in the audience stands up to leave early, mitigate the disruption by looking to the audience on the opposite side of the room. If an outside disturbance occurs that is so loud that no one can hear you, stop speaking until the loud noise ceases. Over the years, I have witnessed speakers being drowned out by the rattling of heating pipes, the hammering from a laboratory, the emptying of garbage dumpsters, and on one occasion the roar of a passing train. Although you cannot control the train schedule or the sources for many of these noises, you can control your reaction to them.

During my wife's welcome speech in the keynote session of a large international conference, the bright stage lights began flickering. The goal of this speech was to welcome the more than 2,000 attendees to Copenhagen and to introduce the keynote address. The conference focused on gas turbine engines that are used to fly planes and to provide electrical power. Because the speech was so formal and the wording could be scrutinized, my wife had her speech written in front of her. The lights continued to flicker. Still, my wife kept going and with good reason: The sound system was working fine, and everyone could hear her. Then, about one-third through her welcome, the stage lights went off. My wife could not see the remaining four pages of her speech. However, she continued, as if nothing had happened. Because she had practiced this talk so much, she knew what she wanted to say. For three minutes, she spoke from a dark stage. During this portion, she recalled from memory the number of attendees and number of papers this year, she named three highlights from past conferences, and she introduced the conference theme: "operating gas turbines in extreme environments." At the end of her talk, just as she was naming the three keynote speakers, the lights returned. When she finished naming the three keynote speakers, all of whom had a hand in the design of turbines for electrical production, she added, "… and they will make sure the lights stay on." The room filled with laughter. What could have been an uncomfortable situation, my wife turned into an opportunity.

Pay attention to yourself

Besides paying attention to your surroundings, you should pay attention to yourself: what you wear, how your voice projects, and how you move.

Attire affects the way a new audience sees you. As a speaker, you can significantly influence the formality of an occasion by what you wear. Granted, scientists and engineers do not have the reputation for being well dressed. For instance, the first time that Einstein taught a university class, he arrived in "somewhat shabby attire, wearing pants that were too short."[3] Emmy Noether, the great mathematician, was also noted for having a disheveled appearance.[4] Likewise, to give a presentation at a conference in France, the microbiologist James Watson once wore clothes purchased at an army PX—his other clothes had been stolen on a train in Italy.[5]

On the other hand, Albert Michelson dressed formally for his class lectures in a "black square-cut morning coat, stiff high collar, and knife-edged, pinstripe trousers."[6] Even more impressive, Nikola Tesla wore a white tie and tails to make his presentations.[7] A professional appearance can give an audience a good first impression. That strategy was used by Nobel winner Rita Levi-Montalcini. To promote her work on nerve growth factors, Levi-Montalcini adopted an elegant and chic appearance for presentations.[8] Dressing in the flair of her native Italy, Levi-Montalcini showed up to presentations in a black sleeveless dress, of her own design, with a matching jacket, pearls, and four-inch heels.

These examples are not to say that the appropriate attire is always formal. Steve Jobs often presented in his black mock turtleneck and blue jeans. For Jobs, that appearance was appropriate to contrast Apple with its competitors. Jobs relished having Apple in the role of the outsider—cool, hip, natural.

Your voice is an instrument to project your ideas. Besides paying attention to dress, you should also think about your voice. Voice is a distinctive feature of a presenter. Ernest Rutherford, for instance, had a booming voice that was recognizable from the next room. Marie Curie had a soft but steady voice. Nikola Tesla had a "high-pitched, almost falsetto voice."[9] Einstein had an equally distinctive voice with a German accent. Although you cannot do much with the pitch or accent of your voice, you can control the inflection and loudness. If your voice has no change in loudness or speed, you will quickly tire an audience. Heinrich Hertz, for instance, disliked meeting with Hermann Helmholtz, because Helmholtz spoke so slowly and deliberately that Hertz found it "impossible" for him to listen attentively.[10] James Watson also complained about the presentations at one international biochemical conference because there was "so much droning" that he found it difficult to "stay alert for the new facts."[11]

Changing the speed and loudness of your voice not only engages the audience, but it helps you emphasize key details. The best speakers, Feynman and Pauling, changed their loudness and speed dramatically during a presentation. Such changes, though, should occur naturally; otherwise, the audience senses that the speaker is acting. In other words, the speaker should have the same voice inflections in loudness and speed that the speaker naturally has in conversation.

Your movements can communicate or distract from your message. Equally important to paying attention to your voice is paying attention to your movements. These include your stance and the movements of your hands and feet. With your stance, you want to find a stance that conveys confidence to the audience and that makes you comfortable. Having your hands relaxed at your side conveys confidence, although many speakers find that stance unnatural. If there is a podium, you might try placing your hands lightly on the podium. Clenching the podium conveys a defensive posture. On more than one occasion, I have seen a speaker clench the podium so tightly that veins bulged from the neck.

Besides wanting to exude confidence, speakers often want to convey that they are relaxed. A hand in a pocket conveys this demeanor, but I would not recommend this position at the beginning of a talk. If later in a talk, you slide a hand into a pocket, the hand should not move. Such a movement distracts. Also, in regard to the pockets, remove your keys or change before the presentation. You might absentmindedly rattle them and distract the audience.

Some presentation books spell out a number of positions to avoid: both hands in the pockets, hands folded across the chest, a fig-leaf position (hands locked in front), reverse fig-leaf (hands locked in back), leaning against the podium, and so forth. In general, that advice is fine and well-intended, but it should not inhibit your energy. In the middle of his presentations, Richard Feynman moved into a number of these positions—both hands in his pockets, for instance—but he adopted these positions only after he had engaged the audience, and these positions he held only briefly.

In addition to the way you stand, an important consideration is the way you move. The best presenters move during their presentations, but they move with purpose, and those movements contribute to the presentations. For instance, walking toward the audience can be a powerful movement to emphasize a point. Using your hands to illustrate points, as demonstrated in Figure 5-1 by Caitlin Tice, an industrial engineer,

Figure 5-1. Caitlin Tice, an industrial engineer, giving an Engineering Ambassador presentation to more than 200 high school students and parents at Penn State.[12] In this image, Tice demonstrates an effective stance, eye contact, and hand movements.

is also a powerful means of communication, because the audience not only hears what you are saying, but also sees what you are saying.

Because audiences notice movements of your feet and hands, you should be particularly aware of those movements. Many movements of hands and feet by less experienced presenters do not contribute to the effectiveness of the presentation. One common example is playing with a tie, necklace, or belt. In general, you should avoid repetitive movements such as shifting weight from one foot to the other or pacing as a caged lion does from one spot to another. These movements can have a hypnotic effect, much like a hypnotist's watch, on the audience.

Other types of movement to be careful about are movements involving projection equipment. As mentioned in Chapter 4, you should practice with projection equipment so that you can efficiently turn on the equipment, change slides, and incorporate films and demonstrations. Many stories exist about presenters who could not get the computer projection to work or could not correctly operate a remote advancer. Equally important with projecting images onto the screen is blanking the screen when the equipment is not needed. Many speakers make the mistake of leaving projectors on when nothing but a bright white light shows on the screen. Blanking the projector either by using the remote or by inserting a black slide not only eliminates unwanted light, but allows you to occupy the part of the room normally in the projected light.

In addition to turning on the projector, advancing slides, and blanking the projector, another movement associated with a projected slide is to point out features on the projected image. A long metal or wooden pointer works well, because the speaker can point out the feature and stay out of the projector's light, which can be blinding. Moreover, a long metal or wooden pointer allows the speaker to ground the pointer against the screen.

Besides wooden or metal pointers, another common pointer is a laser pointer. Certainly you should be careful with where you aim laser pointers. Stories abound of audiences ducking beneath a laser beam that a presenter inadvertently aimed at them. Also be careful with how steady you hold a laser pointer, because laser pointers amplify a person's nervous movements. A slight quiver of the hand becomes amplified into a wild vibration on the screen. A speaker with a nervous hand should try anchoring the laser pointer against his or her side. If you use a laser pointer, the amount of laser pointing should be kept to a minimum. Some presenters highlight almost every word and image—a strategy that in the end provides no emphasis.

Eye contact is important for engaging the audience. A different type of movement to consider involves your eyes. Your eyes affect the audience. If you look at the floor, the audience will look at the floor. If you stare out the window, your audience will stare out the window. If you engage the audience with your eyes, the audience will return the look and will concentrate more on what you have to say. Granted, part of that increased concentration arises from guilt. When you are looking at an audience member, the person thinks, "I better pay attention because this speaker is looking at me." Another part of the increased concentration, though, arises because the audience member feels a part of the presentation.

How much should you look at the audience? Much advice exists in books about the number of seconds that you should look at someone. Rather than becoming self-conscious about that, you should just make sure that before the presentation is over, you have made eye contact with everyone in the room if the audience is small. If the audience is large, make sure that before the presentation is over, you have looked several times at every section of the room and that you have made eye contact with individuals in those sections. One myth about eye contact is that you should look above the heads of people to the wall in the back. Such a strategy makes no sense. With eye contact, you are both trying to engage the people in the room and to discern how they are responding to what you have to say. What could a presenter possibly learn from looking at a wall?.

Pay attention to the audience

For a presentation that she gave, the physicist Lise Meitner described her interaction with the audience in the following way: "[I] spoke loudly and looked at the audience and not the blackboard, although under the circumstances the blackboard seemed far more appealing than some of the people."[13] Looking at the audience is important, because even when they are not asking questions, your audience communicates to you. They speak to you with their eyes. When they stare intently at you, they tell you that they are concentrating on your message. When they nod their heads, they indicate agreement with your message. When they close their eyes or stare at the floor, they tell you that they have probably quit concentrating.

Many in the audience also speak to you with their facial expressions. Although some audience members maintain a poker face through the entire presentation, most reveal if they are delighted, confused, angered, or bored. A good speaker pays careful attention to the audience and adjusts the presentation to engage the audience again if they drift off. Such changes might involve slowing the pace if the audience appears to be confused, speeding the pace if the audience seems bored, or deleting tangential points if the audience appears to be tired.

Although you should be sensitive to the mood of the entire audience, you should not overreact to the expression of any one individual. For instance, you might encounter an audience member whose countenance is so angry that it frightens you to the point of distraction. In such cases, it is best not to look directly at that person. Perhaps that person has had an awful day and the expression of anger is not for you, but for someone else. Other times, you might have an audience member who is going to fall asleep on you no matter how well you present. In such cases, let the person sleep and focus on the rest of the audience. Perhaps that person has a new baby, and for that person your presentation is going to be the only quiet hour of the day.

During the asking of a question, the audience speaks to you directly, and your most important task is to listen. Such a statement might seem obvious, but more than once I have pushed through a difficult presentation, taken a deep sigh when I concluded speaking about my last slide, and then completely missed what the first questioner asked me. In those situations, the best I could do was to politely ask for a repeat of the question.

In his first presentation, Feynman made this same mistake and regretted it years later, because Wolfgang Pauli had made a comment as to why Feynman's theory was incorrect. Feynman believed that had he listened, perhaps he could have corrected the theory.[14] Feynman's experience points out one of the values of taking questions: the opportunity to receive feedback on our work from the audience. Although often a source of fear for presenters, question periods are opportunities to gain insights into the work from colleagues who are looking at that work with fresh eyes.

Although the issue of handling questions is discussed in more detail in Critical Error 13, given here is one example of how a panel of three speakers failed to pay attention to the audience during a question period. This panel had just given an interesting discussion about a scientific topic to a crowded room. Each of the three speakers had spoken for 5 minutes, and then the three had discussed four prearranged questions for another 15 minutes. The floor was then opened to questions for an additional 15 minutes. The first questioner stood and began speaking—*rambling* would be a more accurate word. The questioner continued rambling for another 10 minutes. Perhaps the person went on even longer, but several in the audience (including me) became so disgusted that we left. At first, we were disgusted with the questioner, but after 2–3 minutes, our anger turned toward the speakers. They sat confused on the stage and continued waiting for the question to end. The questioner had no intention of ending the question because the questioner had no question. All the questioner had was a desire to talk.

After 1 minute, it was clear to most of the audience that this questioner had no question. Many of us in the audience gave signals to the speakers on stage: We looked away from the questioner and glanced down at our watches. The speakers on the stage did not pick up on our impatience. Later, many of us in the audience became even more demonstrative by speaking to one another, letting out our breaths in disgust, and raising our watches in front of their eyes. Still, the speakers remained passive. The audience had done everything that it could do to motivate the speakers to seize control of the presentation. Now the speakers had to act. That they did not was a mistake on their part, and their failure to seize control undermined what had been a worthwhile presentation.

The point of this example is that a strong scientific presentation is a two-way form of communication. The speaker certainly has the primary role of preparing, organizing, and presenting the information; however, the speaker has a responsibility to learn from the audience and to adjust the presentation for that audience.

Pay attention to the time

In 1841, William Henry Harrison gave a two-hour presidential inaugural address in a freezing rainstorm. Shortly after the address, he caught a cold and developed pneumonia. Two months later he died.

Most likely, catching pneumonia will not be a speaker's penalty for going too long, but taking too much time can have serious consequences. For instance, speaking for too long damaged the reputation of an engineer at a recent international conference. The conference had designated a memorial session to honor the work of an engineering researcher who had unexpectedly passed away during the past year. The memorial session brought in more than 200 audience members. One of those audience members, seated in the front row, was the researcher's widow. With five presentations scheduled, the memorial session was to reflect upon the work of the researcher. The first presenter was a colleague who had worked with the researcher very early in his career, and the fifth presenter was a colleague who had been working with the researcher at the time of his passing. For this session, the presenters were to show the work of this researcher as it had progressed over three decades and to emphasize this researcher's large contribution to the field. Everything went smoothly until the last speaker's presentation. This speaker, like the others, had 20 minutes to make the presentation, but unlike the previous speakers, this speaker did not stop his presentation after 20 minutes.

The session chair quietly signaled the speaker that the end had arrived, but to no avail. The speaker continued speaking through the 10-minute break that had been scheduled between this memorial session and the concurrent sessions that were to follow. Meanwhile, the audience became restless. Several in the audience were scheduled to give talks at the concurrent sessions, and they wanted to head into their rooms and set up things. Because the session was a memorial session for a respected researcher, though, no one left.

After a few more painful minutes, the session chair stood and asked the speaker to end his presentation. Still, the stubborn speaker continued; he had a stack of overhead slides and he was determined to get through them. People became increasingly uncomfortable. Exasperated, the session chair walked up and removed the overhead currently being projected, but the hardheaded speaker put another one in its place. Finally, after this speaker had placed all his slides onto the overhead projector, he ended his talk, and the session abruptly dispersed. The consensus afterwards was that this memorial session, which was to leave participants with the memory of work by a departed colleague, ended up leaving participants with an uncomfortable mixture of emotions: anger at the speaker who had not planned for the situation and embarrassment for the departed researcher's wife, who had to endure the awkward exchanges between the session chair and the bullheaded speaker.

So how do you stay within the time limit of a presentation? Like most questions posed in this book, the answer depends upon the situation. In presentations in which the speaker is not interrupted by questions, the speaker has control over the time. In presentations, though, in which the audience can interject questions, the control of time is shared between the speaker and audience.

Consider first the situation in which the presenter is allowed to speak without interruption from the audience. For this situation, the most important step in making the deadline is preparation. This preparation includes defining a scope that you can cover adequately in the time allotted. It also includes planning to show no more slides than the time allots. For instance, unless you have a Lessig sequence as part of your slides, planning to show 20 slides for a 15-minutes talk makes no sense, because the audience needs what my colleague Harry Robertshaw called "soak time" to process each scene. Even a title slide should be allotted 60 seconds, not only so that the audience can become oriented to the topic, but also so that the audience can become accustomed to the speaker's delivery. Moreover, if a slide includes a complex graphic, even more time is needed.

Another important aspect of preparation is to practice the presentation all the way through with the slides. That practice is important not only for giving yourself the confidence that you can find the words to explain each idea, but also to develop some confidence that your presentation will stay within the time limit. Certain variables cause the time achieved during the rehearsal to differ from the time achieved in the actual presentation. One variable is the effect of nervousness. Although most people, when nervous, will speak more quickly before a live audience than they will speak alone in a hotel room, a few people actually speak more slowly. If you are that second type of person, then you have to factor in that difference as well.

Another variable is digression. Some people, myself included, are inclined to add a story or dwell too long on an interesting point, especially if the audience is responding positively to the material. For those of us who have this habit, having a benchmark during the presentation is important. One benchmark might be finishing the introduction by a certain time. Another might be beginning the second main point of the presentation at a certain time. A quick glance of your watch or the room clock as you change slides allows you to check your progress. Another tip that works well when one is using benchmarks is to have an optional point to cover. If you are on time at your benchmark, then you would cover that point; if you are running behind, you would skip it.

PowerPoint offers a means for skipping slides during a presentation: keying in the slide number you want to jump to and then pressing Enter. For instance, if you are on the slide 10 and want to jump to slide 13, you can do so by pressing 1 and then 3 and then pressing Enter. That way, you can skip a portion of the talk without the audience ever knowing. Typically, in a talk, I will have one or two possible jumps. In addition, I have the necessary slide numbers written on a sticky note placed beside the laptop. Also included on this note are other slide numbers that I might want to access during the question period.

When the occasion is such that the audience can interrupt you, meeting the time limit is more difficult. In essence, the audience becomes part of the presentation. Although the audience members are players in such a presentation, you are still the leader, and, if appropriate, you should exercise your authority to keep things moving. One way to do that is to postpone questions that are premature—in other words, questions that will be addressed later in the presentation. Another way to keep things moving is not to address questions that are outside the scope of the presentation. In such cases, you could offer to speak with the individual after the presentation and then get the presentation back on track. If you are diplomatic in your responses to such questions, most questioners will accept your decision. Some audience members, however, are not so respectful. In such cases, you have to read the situation. If the person is your manager, you will probably have to allow the manager to have his or her time on that issue. Also, if several people in the audience want to discuss a tangential issue, it might make sense to defer. However, if only one person is holding back the others and that person is not the source of the work's funding, you should keep things moving. Otherwise, the audience's irritation at the person pressing the question might turn to anger at you for allowing the presentation to go off track.

Notes

[1] P. Goodchild, *J. Robert Oppenheimer* (Houghton Mifflin Company, Boston, 1981), p. 25

[2] C. Darwin, attributed

[3] C. Seelig, *Albert Einstein* (Europa Verlag, Zurich, 1954), p. 171

[4] S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 78

[5] J.D. Watson, *The Double Helix* (Atheneum, New York, 1968), p. 138

[6] D.M. Livingston, *The Master of Light: A Biography of Albert A. Michelson* (Charles Scribner's Sons, New York, 1973), p. 98

[7] M. Cheney, *Tesla: Man out of Time* (Simon & Schuster, New York, 2001), p. 76

[8] S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), pp. 217–218

[9] M. Cheney, *Tesla: Man out of Time* (Simon & Schuster, New York, 2001), p. 76

[10] H. Hertz, letter to his parents (27 May 1883), *Heinrich Hertz: Erinnerungen, Briefe, Tagebücher*, arranged by J. Hertz (Physik Verlag, Weinheim, 1977), p. 133

[11] J.D. Watson, *The Double Helix* (Atheneum, New York, 1968)

[12] C. Tice, Engineering Ambassador presentation (Penn State, University Park, July 2010), photograph by Melissa Marshall

[13] R. Sime, *Lise Meitner: A Life in Physics* (University of California Press, Berkeley, 1996)

[14] R.P. Feynman, *Surely, You're Joking, Mr. Feynman!* (Norton & Company, New York, 1985), p. 80

Critical Error 13
Losing Composure

On Monday and Wednesday, my mother was nervous and agitated from the time she got up. At five o'clock on these days she lectured. After lunch she shut herself into her study in the Quai de Béthune, prepared the lesson, and wrote the heads of chapters of her lecture on a piece of white paper. Towards half-past four she would go to the laboratory and isolate herself in a little rest room. She was tense, anxious, unapproachable. Marie had been teaching for twenty-five years, yet every time she had to appear in the little amphitheater before twenty or thirty pupils who rose in unison at her entrance she unquestionably had "stage fright."[1]

–Eve Curie

To watch a presenter lose composure is a painful experience. In some cases, the presenter has so much stage fright that he or she loses composure before the presentation even begins. For instance, a graduate student of one of my colleagues had that experience at a conference. This graduate student, who had to present two papers back to back, was so nervous that he simply read the papers rather than look at the audience members and speak to them about what he knew. Moreover, he read so quickly that he finished both papers in less than the time that was allotted for just one. As you might expect, no one in the audience had any questions. Instead, there loomed that uncomfortable silence when no one in the audience has understood enough to pose a question.

In other cases, the loss of composure arises during the presentation because something unexpected occurs. More often than not, these cases occur during questioning. A loss of composure during the question period often follows a certain sequence. A question trips up a speaker, and the speaker loses confidence. Some members in the audience sense a flaw in the work and ask more questions on the same point. The speaker loses even more confidence, and the questions become more biting.

Preparing, thinking positively, and having the proper focus are keys to handling nervousness

Just the act of speaking before an audience generates much nervous energy for presenters. There is nothing unusual about feeling nervous before a presentation. Many great scientists such as Marie Curie and Richard Feynman have shared these same feelings. What is important is that the nervousness does not pull down the presentation. In many instances, nervousness causes the speaker to withdraw into what Rick Gilbert, the founder of PowerSpeaking, calls a "zombie state," in which the face lacks expression and the voice lacks energy.[2]

In other instances, nervousness has inhibited a number of excellent scientists and engineers from even making presentations. The chemist Fritz Strassmann, for instance, allowed Otto Hahn to make the presentations of their work on nuclear fission. Interestingly, for their work, Otto Hahn (and Otto Hahn alone) won the Nobel Prize. Many believe that Strassmann should have shared in that prize.[3] Moreover, many more feel that Lise Meitner, who shied away from making presentations in the early years of her career, should have also shared in that award.[4] Yet another shy scientist was Robert Corey. Corey, who collaborated with Linus Pauling, allowed Pauling to make the presentations and in so doing allowed Pauling to receive the lion's share of the credit.[5] Still another scientist who was shy before crowds was the Nobel winner Christiane Nüsslein-Volhard, who sometimes had her graduate students give presentations that she should have made herself.[6]

Overcoming your nervousness to the point of simply making the presentation is not enough. What distinguishes the best speakers is their ability to channel that nervous energy into positive energy that serves their presentations. When you do not channel the nervous energy in a positive manner, it often comes out in distracting movements: jingling coins in a pocket, playing with a pointer, dancing a slow samba. One effective way to control the dancing is to scrunch your toes when you are nervous. That act, which the audience will not see, allows you to channel the nervous energy in a non-distracting way.

Nervousness also affects the voice. For a talk that she had spent many hours preparing, Christiane Nüsslein-Volhard was so nervous that her voice shook for several minutes.[7] Nervousness affected Richard Feynman's voice in a different way. For the second talk that he ever gave, a 10-minute presentation at the American Physical Society Meeting in New York in February 1941, Feynman lost the nerve to speak to the audience and simply read his speech in what he termed a fashion that was "dull" and "impossible for people to understand."[8] In yet another example, the nervousness of Luis Glaser caused him to speak much too quickly for a seminar talk that he gave as a graduate student. The talk was for his research group, which was run by Nobel winners Gerty and Carl Cori. Although the talk was scheduled to last 50 minutes, Glaser rushed through it in 30. To teach him a lesson, Gerty Cori had everyone remain in the room, essentially in silence, until the 50 minutes was up.[9]

Often a bad case of nervousness means that the speaker has not prepared enough for the presentation. Before an important presentation, you should have two or three practice runs. On these practice runs, you should incorporate your visual aids. If you are unsure about the presentation, have a colleague or two attend. These critiques should occur early enough that you have enough time to incorporate valid criticisms. Making major changes just before a presentation might end up causing more harm than good.

If you have done your preparation, then the structure, speech, and visual aids of your presentation should be ready. What are left are the little things that take place in the presentation room to smooth your delivery: making sure that your slides project on the screen, checking the advancer, and adjusting the lights.

Once you have set things up in the room, you can assuage the nervousness by shifting the focus off yourself. Instead, concentrate on your listeners. Meet them before the presentation and ask them questions. By concentrating on your listeners, you shift your thoughts, and worries, away from yourself and give needed attention to your audience. Remember: You are working for them. If you can focus your attention onto your audience, then any residual nervous energy is going to work for the presentation, not against it.

Another way to lessen the effects of nervousness is to think positive thoughts. The nervousness that a presenter feels is similar to the nervousness that an athlete feels. How do athletes handle nervousness? Many successful tennis players imagine success. Steffi Graf, for instance, believes that positive thinking is a powerful force in playing tennis.[10] So does Jimmy Connors. Connors, while waiting to return a service, imagines not only hitting the ball but also the flight of his service return across the net. In his book *The Inner Game of Tennis*,[11] Tim Galloway presents an excellent discussion of the power of positive thinking in one's tennis game. Many athletes adopt this strategy: baseball pitchers imagining the pitch striking the catcher's glove before pitching; golfers imagining the flight of the ball before swinging; basketball players imagining the shot going in before shooting.

If you are combatting nervousness before a presentation, adopt a positive attitude. Imagine yourself delivering a successful presentation. Imagine yourself delivering each of your main assertions. Imagine the audience focused on your message and nodding in agreement.

Another way to overcome nervousness is to understand its cycle. David Bogard, a mechanical engineering professor at the University of Texas, claims that each of his bouts with nervousness subsides as soon as he begins the presentation.[12] Bogard says knowing that the churning and wrenching of his stomach will end is a comfort to him in the days leading up to the presentation. Richard Feynman made the same claim. For his first presentation, Richard Feynman faced an intimidating audience: the mathematician John von Neumann, the astronomer Henry

Norris Russell, and the physicists Wolfgang Pauli, Eugene Wigner, and Albert Einstein. Feynman remembered how nervous he was before that presentation.[13] His hands shook noticeably in removing his notes from the envelope. What Feynman also recalled was that the nervousness subsided as soon as he began the presentation and concentrated on the subject.

Still another way to combat nervousness before the session chair calls your name is to take deep, but quiet, breaths. Receiving enough oxygen into your lungs allows your body to counteract the chemicals that nervousness creates. If you do not receive enough oxygen, the nervousness can escalate. Some successful speakers claim that tightening and then relaxing their muscles is effective: tightening the muscles, holding the position for a few seconds, and then relaxing. Seated before being called to give a talk, these speakers will work their way from the muscles in their feet, to the muscles in their calves, and so forth.

A final piece of advice to combat nervousness before a presentation comes from Mark Twain. Once, when standing backstage with a nervous presenter, Twain said, “Don’t worry—they don’t expect much.”[14] As much as any piece of advice I have received, Twain’s advice has helped me change my attitude about nervousness. Once I see the tentative looks of the audience filing in, I realize that most of them are resigned to yet another boring presentation. At that moment, the presentation becomes a challenge in the positive sense. To myself I say, “They think that I am going to bore them. Well, I’ll show them.”

In addition to fighting nervousness before the presentation, speakers sometimes have to battle nervousness during the presentation, especially when things do not go as expected. About two-thirds of the way through one of my first presentations, which was to an audience of about 100, half of the audience got up and walked out. Up to that moment, I had been feeling positively about this presentation. Everyone had been attentive and there were no signs of boredom. However, all those people walking out crushed me on the inside. I felt like throwing up my hands and quitting, but I focused on those who remained in the room and finished, trying to act as though nothing had occurred. What I learned later was that those people who walked out had to attend a required meeting. From that incident I learned an important lesson: "No matter how bleak things look, do not lose your cool."

Distractions often occur in presentations. Light bulbs for projectors periodically go out. Fire alarms occasionally go off. People in the audience sometimes have to leave, sometimes cannot stay awake, sometimes stare absentmindedly at your shoes, sometimes talk with another, and sometimes are so preoccupied with personal problems that they wear scorns on their faces. The first time that each of these incidents occurred in one of my presentations, my stomach started churning. Although I kept my cool on the outside, the experience was wrenching. Looking back, though, I see that none of those incidents were that important. The audience did not hold me responsible for the light bulbs, the fire alarms, or the reactions of other audience members—only for the way that I reacted to those incidents.

Another time that he had to give a seminar for the Coris' research group, Luis Glaser had a surprise waiting for him. Just before the talk, Gerty Cori asked him what the subject of his talk was. When he told her, she said, "That bores me." Glaser's reaction was to go on up and give his talk as best he could. As he reasoned, "What else could I do?"[15] I admire that response. In the face of such devastating criticism from such an admired figure, another presenter would have folded. However, Glaser, who went on to become the provost at the University of Miami, did the best that he could in that presentation with the cards that were dealt. In the end, that is really all each of us can do.

In handling a question, you should understand what was asked, think about that question, and answer honestly

How should one handle questions? As mentioned in Critical Error 12, the first step in handling a question is to listen to the question. That step might seem obvious, but after finishing the formal presentation part of a talk, many presenters relax, forgetting that the talk is not over.

If you do not understand the question, you should not hesitate to ask for clarification. After all, the question is likely something that the audience member has fashioned on the spot. Once you understand the question, you should repeat or rephrase the question if the room is so large that other audience members have not heard it. You should also think before answering. A pause is justified and often appreciated by the audience. If you know an answer to the question, you should then answer, but be sure to balance two concerns: satisfying the questioner, but doing so concisely so that others have a chance to ask questions.

What if you do not know the answer to a question? Many people fear receiving a question that they cannot answer. Much about this fear is unfounded. For one thing, the audience does not expect you to know everything about the topic. For another thing, many questions concern topics outside the scope of the presentation. If you do not know the answer to a question, you should think about whether that question actually lies within the scope of the presentation. If the question does not, then you should state that, but try to make a connection between the question and what you do know.

If the question does lie within the scope of the presentation and you do not know the answer, you should *not* try to bluff an answer. If you do try to bluff and are exposed (and the chances are significant that you will be), your credibility will quickly sink. Worse yet, the sharks in the audience will smell blood and begin to circle. If you do not have a complete answer, you should admit that you do not have a complete answer, but then state what you do know about the issue questioned. In some cases, the actual answer might be something that no one knows. If that is the case and if you know that no one knows the answer, stating as much might win you respect. At the least, such an answer would show that you know the subject's literature. If the question is something that you should know, but have forgotten, you should promise the questioner that you will look up the answer after the presentation—and then you should do so.

One of the most difficult situations occurs when a questioner challenges you. In many cases, the purpose is not a personal attack. Many great scientists such as Wolfgang Pauli,[16] Rosalyn Yalow,[17] and Gerty Cori[18] rigorously challenged work that they felt was inaccurate. Although such challenges often strengthen the science, these challenges also overwhelm many presenters. What should you do in such a situation? One of my advisors, Kamalaksha Das Gupta, who studied under the great Bose, would tell us that whenever someone challenged our work in the question period, we should stand very straight and answer in a loud voice for everyone to hear. Das Gupta said that even if all we knew to say about that point was just what we had said in the formal part of the presentation, we should say it loudly and confidently.

Another strategy is to fight back. Erich Kunhardt, who was another advisor of mine, was a fighter. When I was his student, Kunhardt was young, just a few years older than I. He was so young that older professors would challenge him. However, Kunhardt had two aces up his sleeve. First, he was brilliant (he started college at the age of 14), and second he worked hard. If someone posed a sincere question, Kunhardt would give a polite answer. However, if someone attacked him during a question period, perhaps challenging one of his assumptions, Kunhardt would fight back. Typically he would give an indignant look, say something to the effect "That's not true," and then start quoting the pertinent literature. If someone attacked Kunhardt in a public place, they did it only once.

On her comprehensive examination at the University of Illinois, Rosalyn Yalow came under attack from the department chairman. After she had solved the examination problem that he had posed, he asked her to solve the problem a different way. She refused, saying that Goldhaber and Nye (two respected faculty members in the department) had taught her this way and that if there was anything wrong with that method, then he should speak with them about it. The chairman walked out of her exam and did not return.[19]

In her first scientific presentation, the Nobel winner Gertrude Elion also stood her ground when a distinguished researcher questioned her conclusions.[20] Holding one's ground does not mean that animosity has to develop between the speaker and the questioner. In Elion's case, for example, immediately after the presentation the researcher invited her to lunch, where she had the opportunity to explain her work in depth.

Finally, in one of his first presentations, David Bogard, from the University of Texas, was challenged on the assumptions of his work. Because the questioner's voice had a sarcastic tone, Bogard felt that the questioner was going after him. Such a challenge demanded a strong response, because if the audience were to consider the assumptions flawed, then the work would lose much value. Fortunately, Bogard had done his homework on the literature. Knowing that he had the goods on this question, Bogard calmly placed a foot on a chair and began counting his reasons for making his assumptions. First, he recalled one paper in the literature that supported his assumptions. Then he recalled a second, and then a third and a fourth and a fifth. By the end, two things were clear to the audience: Bogard had read the literature, and the sarcastic questioner had not.[21]

To see the sharks circle as a speaker loses confidence is a sad thing. More than once I have felt the waters begin to churn and the thought has flashed that I am losing control of the presentation. In such cases, my instinct has been to do what Das Gupta advised: stand up straight, raise my voice, and repeat my strongest evidence for the assertion.

When attacked by a harsh question, President Ronald Reagan took a different tack. In such cases, he lowered his voice rather than raising it. His voice adopted that grandfatherly sound. In lowering his voice this way, Reagan guided the sympathies of the audience to his side. The audience subconsciously thought, "Why is that questioner being so mean to that old man?" Lowering your voice can be effective as long as you remain resolute. For example, Marie Curie spoke softly, but resolutely.[22] What you do not want to do is to stumble with filler phrases such as "um" and "uh." Those make you appear weak and confused.

President John F. Kennedy showed yet another strategy to handle attacking questions. When questioned harshly about whether it was ethical for him to have named his own brother as attorney general, Kennedy paused and fixed his eyes on the questioner. Then, he suddenly said no, turned, and called upon another questioner in a different part of the room. In acting so decisively, Kennedy did not give the original questioner a chance to follow up.

What do you do if a questioner attacks your work and you realize that the questioner is correct? Einstein provides us with a courageous example of what we should do, but what few of us would dare. After a presentation, Einstein fielded a question from a young, unknown Russian whose broken German conveyed something along the lines that what Einstein had said "was not so stupid."[23] The Russian turned out to be Lev Landau, who became one of the Soviet Union's greatest theoretical physicists. In the question, Landau pointed out an error in one of Einstein's equations. While everyone in the room was chastising Landau for his rudeness, Einstein studied the blackboard and thought about what Landau had said. Finally, Einstein turned back to the audience and quietly said that the point that the young man had raised was correct and that what had been presented today beyond a certain step was incorrect. This statement reveals that Einstein's quest was not personal glory, but the search for truth.

Niels Bohr also had similar aims and never hesitated to admit when he was in error,[24] a trait in his character that earned him much admiration. Perhaps that is the best sign of one's security: the willingness to admit when one is wrong.

Passion fuels preparation, which leads to confidence

In my presentation workshops for young engineers and scientists, one of the most commonly asked questions is, How do I handle nervousness? Although the reason behind the question is justifiable, especially for young presenters, that question is not the best one to ask. A much better question would be, How do I achieve confidence?

To that question, the biologist Sheila Patek, who gave a TED talk in 2004 on measuring fast feeding strikes of manna shrimp, had the following to say: "Confidence in a presentation is a matter of total denial. I don't think about the audience once I'm there. If I had thought about the more than 800 people watching my TED talk that day, I never could have done it. Instead, I focused on the science and my passion for the ideas, and I let that carry me."[25]

Passion is certainly a source of confidence, but as my teaching colleague Melissa Marshall asserts, it is the combination of passion with preparation that leads to the strongest form on confidence. In her talk, Patek clearly demonstrated that she had prepared in the effective and efficient ways that she incorporated films of feeding strikes. No doubt Patek had practiced many times with those films.

About her preparation for a typical talk, Patek claims to go through the beginning of her talk 10–15 times. Such levels of preparation are not uncommon for excellent speakers in science. For instance, on her TED talk in 2008, Jill Bolte Taylor claimed to have practiced the talk 2–3 times a day in the two months leading up to the talk. Taylor's TED talk to the general public was a milestone in her career. After giving the talk in February, she was invited that summer to appear on the Oprah Winfrey show, and in November she was chosen by Time magazine as 1 of the 100 most influential people of the year. According to Taylor's web-site,[26] those accolades and opportunities were because of "that one 18-minute talk to the general public" given back in February.

Just as Taylor had much to say about her preparation strategy in the weeks and days before her TED talk, Hans Rosling has much to say about his preparation in the hours just before his TED talk in 2006. During this time, Rosling holed himself up in his room and practiced.[27] He had spent the first day of the conference meeting people and gaining a feel for who they were, what motivated them, and what they knew about his work. However, in the hours before the talk, Rosling preferred to be alone. As far as what he was thinking in the minutes before speaking, Rosling said the following:

> I spent the last 10 or 15 minutes before going up on stage rehearsing, very calmly rehearsing what I am going to tell them, in the same way that…when you are going through a [downhill ski] slalom track, you really memorize, 'I am going there and going there and there and there.'[28]

Rosling's preparation in the hours before his TED talk is similar to what Jane Goodall said about her own preparation—wanting a quiet block of time to rehearse what she was going to say, even though she had already given the talk several times in the days before.[29] Rosling and Goodall's preparation strategy mirrors my own. Certainly, scheduling might mean this quiet time occurs the night before or the early morning hours before a talk rather than in the minutes before. Still, that quiet time for final rehearsing is essential to solidify the structure and incorporation of visual aids that I have prepared in the days and sometimes weeks leading up to the talk.

While all of the TED speakers mentioned in this section claimed to spend much time in their preparations of the structure, only Taylor claimed to have memorized the actual speech. However, Taylor said that the memorization of the TED talk was unusual—she had much to say, but only 18 minutes to speak, and therefore she had to be efficient. For Taylor, the norm is to give a practiced, but extemporaneous, talk.

Sheila Patek, Hans Rosling, Jane Goodall, and Jill Bolte Taylor—all of these epitomize the confidence that scientists and engineers should strive for in their presentations. They know their subjects, they love their subjects, and they genuinely enjoy explaining their subjects. They have prepared, their passion has fueled that preparation, and in front of audiences, even large ones, they stand confident.

Notes

[1] E. Curie, *Madame Curie: A Biography* (Literary Guild of America, New York, 1937), p. 370

[2]R. Gilbert, *Speaking Up: Surviving Executive Presentations* (PowerSpeaking Inc., Redwood City, 2012)

[3]S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 51

[4]R. Sime, *Lise Meitner: A Life in Physics* (University of California Press, Berkeley, 1996).

[5]A. Serafini, *Linus Pauling: A Man and His Science* (toExcel, San Jose, 1989), p. 72

[6]S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 396

[7]Ibid., p. 400

[8]R.P. Feynman (American Institute of Physics, Pasadena, Jan 1988), interviews with Charles Weiner

[9]S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 110

[10]S. Graf, Interview: 1994 U.S. Open, www.asapsports.com/tennis/1994usopen/ (Fast Scripts, New York, 10 Sept 1994)

[11]T. Galloway, *The Inner Game of Tennis* (McGraw-Hill, New York, 1972)

[12]D. Bogard, Professor of Mechanical Engineering at the University of Texas, Austin, interview with author (Apr 1987)

[13]R.P. Feynman, *Surely, You're Joking, Mr. Feynman!* (Norton & Company, New York, 1985), p. 79

[14]M. Twain, attributed

[15]S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 110

[16]O. Frisch, *What Little I Remember* (Cambridge University Press, Cambridge, 1996), p. 48

[17]S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 343

[18]Ibid., p. 110

[19]Ibid., p. 340

[20]Ibid., p. 291

[21]D. Bogard, Professor of Mechanical Engineering at the University of Texas, Austin, interview with author (Apr 1987)

[22]E. Curie, *Madame Curie: A Biography* (Literary Guild of America, New York, 1937), p. 202

[23]O. Frisch, *What Little I Remember* (Cambridge University Press, Cambridge, 1996), p. 36

[24]Ibid., p. 101

[25]S. Patek, associate professor of biology, University of Massachusetts Amherst, correspondence with author (28 Apr 2008)

[26]J.B. Taylor, http://drjilltaylor.com, home page for Dr. Jill Bolte Taylor (2009)

[27]H. Rosling, professor of statistics, Karolinska University, phone interview with author (5 Apr 2008)

[28]Idem

[29]J. Goodall, primatologist, interview with author (26 Mar 2011)

Chapter 6

Conclusion

[The lecturing of Boltzmann] was the most beautiful and stimulating thing I have ever heard.... He was so enthusiastic about everything he taught us that one left every lecture with the feeling that a completely new and wonderful world had been revealed.[1]

– Lise Meitner

In our careers, we as scientists and engineers make many presentations. These presentations are important not only for our own careers, but also for the world around us. Our presentations often concern ways to improve society's health, comfort, and safety. Yet all too often, our presentations are not nearly as effective as they could be. For instance, one common error is selecting a scope so broad that we cannot achieve a satisfying depth. Another error is projecting slides that bury the main message in the noise of bulleted lists. Still another error is to deliver our message without the passion or confidence that the message deserves.

In a strong presentation, the presenter not only delivers the information, but truly engages the audience. For that to happen, the speaker first must understand the subject. The speaker is not expected to know everything about the subject, but what the speaker imparts has to be worth the audience's time. Second, the speaker has to show a genuine enthusiasm for the subject. Not every speaker has to present with the charisma of Linus Pauling or Jill Bolte Taylor, but every speaker should instill in the audience a respect for the subject. Third, the speaker must have a keen awareness of the audience: what they know about the subject, what about the subject will engage them, and what biases they have.

M. Alley, *The Craft of Scientific Presentations*,
DOI 10.1007/978-1-4419-8279-7_6,

A great presentation is remembered for a long time. Decades later, Lise Meitner claimed that she could remember every detail from the first lecture that she heard Einstein give (it was one in which he explained that energy is trapped in mass, according to the now famous equation $E = mc^2$).[2] This book has highlighted what distinguished the presentations of Albert Einstein and other model presenters: Richard Feynman, Jane Goodall, Steve Jobs, Jill Bolte Taylor, and Robert Ballard. The presentations of these individuals have touched many people and continue to have long-lasting effects.

Perhaps the greatest contribution of this book is that it exposes weaknesses in the way that most scientists and engineers design their presentation slides. PowerPoint's default structure of a phrase headline supported by a bulleted list is ineffective for communicating science and engineering. In place of this weak practice, this book offers a much more effective alternative: the assertion-evidence structure.

Although assertion-evidence slides take much more time to create, if the message is important, the benefits outweigh the cost. One benefit is a much better comprehension by the audience of the message. Moreover, the more technical that message is, the greater this increase in comprehension is. A second benefit is a better connection by the speaker with the audience. In an assertion-evidence presentation, the speaker engages the audience rather than continually turning to read speaking points off the slides. Perhaps the most important benefit, though, is that adopting this structure leads the speaker to create a more focused talk. This increased focus occurs because the speaker has identified the main takeaways of the talk and then used those takeaways as a filter to come up with supporting evidence.

If there were one piece of advice about presentations that I could whisper into the ears of every scientist and engineer, it would be to aim higher. In other words, do not be content to present in the staid fashion to which so many scientists and engineers resign themselves. Rather, for your audience, purpose, and occasion, you should strive to craft a presentation that is truly worthy of your audience's time, a presentation that your audience will not forget.

Notes

[1] E. Broda, *Ludwig Boltzmann: Mensch, Physiker, Philosoph* (Franz Deuticke, Wien, 1955), pp. 9–10

[2] S.B. McGrayne, *Nobel Prize Women in Science* (Citadel Press Book, Secaucus, 1998), p. 50

Appendix:

Critique Sheet for Scientific Presentations

Effectively critiquing a scientific presentation entails examining the presentation from multiple perspectives and determining what was strong about the talk and what in the talk could be stronger. The following list presents key criteria to consider when critiquing a presentation. That presentation could be given by a colleague, a student, or yourself. Certainly not all of these perspectives apply to every presentation. For instance, not all talks need visual aids. Also, for presentations given by a team, as opposed to an individual, additional criteria are required. Still, these criteria provide a solid starting point in a critique.

Content and Speech

Audience targeted?
Purpose achieved?
Occasion met?

Needed information conveyed?
Terms defined; background given?
Emphasis appropriate?

Structure

Organization: Beginning
Scope?
Importance?
Background and credibility?
Memorable mapping?

Scope and Depth
Scope engages?
Key limitations given?
Depth satisfies?

Organization: Middle
Assertions emphasized?
Assertions supported?

Transitions
Beginning → middle?
Between main points of middle?

(Continued)

M. Alley, *The Craft of Scientific Presentations*,
DOI 10.1007/978-1-4419-8279-7,

Sources acknowledged?	Middle → ending?
Organization: Ending	***Emphasis***
Main assertions summarized?	Repetition used effectively?
Closure achieved?	Placement used effectively?

Visual Aids: Presentation Slides[1]

Headlines	
Each slide conveys a message	Each slide serves the audience?
Each headline states key assertion?	Each headline succinct (1 or 2 lines)?
Visual Evidence	
Visual evidence supports?	Visual evidence explained?
Level of detail appropriate?	Extraneous details excluded?
Bullet lists avoided?	Text blocks kept to 1 or 2 lines?
Ref listings [author, year] given?	Less than 20 words/minute projected?
Format	
Type easy to read?	Blank space used effectively?
PowerPoint's weak defaults avoided?	Slide breathes?
Animation, if used, purposeful?	Animation, if used, professional?

Delivery

Speaker shows passion?	Effective eye contact made?
Speaker controls nervousness?	Movements contribute?
Speaker exudes confidence?	Equipment handled properly?
Voice clear and engaging?	Questions handled convincingly?
Speed is appropriate?	Questions handled succinctly?
Filler phrases ("uh") avoided?	Time is appropriate?

[1] See Tables 4-2 and 4-3 for more detail. Also, see Chapter 4 for additional criteria on special slides: title slide, mapping slide, and conclusion slide.

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