Berk, R. A. (2011). Research on PowerPoint®: From basic features to multimedia.
International Journal of Technology in Teaching and Learning, *7*(1), 24-35.

Research on PowerPoint: From Basic Features to Multimedia

Ronald A. Berk
The Johns Hopkins University

PowerPoint® has become the predominant technology platform for teaching in academia. However, the research on PowerPoint® is not widely known and, as a consequence, is not reflected in classroom practices. The instructional applications of PowerPoint® are virtually untapped. This review synthesizes the research evidence on what are known to be effective practices in terms of (1) the basic features and uses of PowerPoint® with which educators are familiar, and (2) the use of "rich media," including movement, music, still images, and videos. Particular emphasis is given to the latter category involving multimedia because of its potential to increase comprehension, understanding, memory, and deep learning and the substantial research base on multimedia slide design. A PowerPoint® state-of-the-art top-10 list summarizes possible "evidence-based practices" from all of the sources examined. Finally, the types of research that still need to be conducted within the context of PowerPoint® are identified.

Keywords: PowerPoint, PowerPoint research, PowerPoint animation, evidence-based practice, music and learning, music and the brain, videos and learning, videos and the brain, multimedia learning, multimedia in PowerPoint, rich media in the classroom

INTRODUCTION

DISCLAIMER: This article is written from the perspective that PowerPoint® slides are one of many tools a teacher can use to present information and create learning experiences for students. You are the instructional leader in what may be called a learner-centered environment. The PowerPoint® technology and slides do not replace you; they are designed to support, facilitate, and augment your message with elements most of you couldn't possibly do by yourself, such as add animation to a diagram, display real-life images, and play a music or video clip to illustrate a concept, as part of a seamless presentation. You remain in control as the instructional producer, director, writer, and choreographer of your classroom production, although you are also the star actor in that production and the slides represent your supporting cast.

Ronald Berk is a Professor Emeritus in Biostatistics and Measurement at The John Hopkins University. Please contact Ronald Berk at rberk@son.jhmi.edu.

There are more than 300 million users (30 million presentations per day) of PowerPoint® worldwide (Lowenthal, 2009). It has become the predominant technology platform in the classroom, despite the alternatives currently available, such as Keynote (for Macs), Prezi, IMPRESS, Beamer, and TurningPoint Anywhere. However, the research on PowerPoint® is not widely known and educational practices usually take the form of conservative proxies for the traditional lecture. PowerPoint® is typically not used in conjunction with learner-centered activities that engage students (Berk, 2011), nor does it incorporate multimedia that can increase comprehension, understanding, memory, and deep learning (Berk, in press). The instructional potential of PowerPoint® is virtually untapped. Synthesizing the research evidence on what are known to be effective practices is one starting point to understand that potential.

There are stacks of books, articles, and blogs, plus outsourcing businesses that describe the "appropriate uses" of PowerPoint® and extol its virtues. You have probably followed their ubiquitous guidelines for preparing the content on your slides, such as titles, lists, text, and graphics (see Abela, 2008; Altman, 2007; Atkinson, 2008; Cooper, 2009; Duarte, 2008; Paradi, 2000, 2010; Reynolds, 2008; Tufte, 2003). Unfortunately, none of those sources reports the effectiveness of recommended techniques based on mounds of "PowerPoint®" research (Abela, 2008; Lane & Wright, 2011). That's right.

This review tackles the research on (1) the basic features and uses of PowerPoint® with which educators are familiar, and (2) the use of "rich media," including movement, music, still images, and videos. A final PowerPoint® state-of-the-art top-10 list will summarize "evidence-based practices." Hold on to your remote, you may be surprised at some of the findings.

BASIC FEATURES AND USES OF POWERPOINT®

Do we know for sure what works, when, with whom, how, or why? Is there enough research evidence to design a simple deck of PowerPoint® slides so that your students actually learn and retain the content you present? Can those slides really make a difference in the way you present content in your classroom?

Unfortunately, there is only a fist-full of studies on the basic features and instructional uses of PowerPoint® over the past decade. One unpublished review by Kammeyer (2007) analyzed some of the findings. Here are my top-10 conclusions:

1. Most students prefer PowerPoint® to traditional lecture (Amare, 2006; Hastings & Attila, 2000; Levasseur & Sawyer, 2006; Savoy, Proctor, & Salvendy, 2009), despite how boring some students perceive it to be (Mann & Robinson, 2009);
2. Traditional lecture-format PowerPoint® doesn't produce significant differences in learning (review by Levasseur & Sawyer, 2006) compared to several alternatives;
3. Reading text verbatim off of an on-screen slide decreases learning and retention ("redundancy principle") (Mayer & Johnson, 2008);
4. Gill Sans, Souvenir, and similar fonts are more comfortable to read, interesting, attractive, and professional compared to other fonts (Mackiewicz, 2007a)
5. High-contrast colors and easy-to-read text, graphs, and graphics increase learning (Bradshaw, 2003)
6. High-contrast slides are not more effective than medium-contrast slides in learning and satisfaction (Earnest, 2003)
7. Full-sentence headline (written as an assertion) compared to a word or phrase increases retention of slide content, especially with a clear supportive graphic (Alley & Neeley, 2005; Alley, Schreiber, Ramsdell, & Muffo, 2006; Garner, Alley, Gaudelli, & Zappe, 2009)

8. Irrelevant pictures accompanying text and sound effects decrease learning (Bartsch & Cobern, 2003)
9. 2D graphs are preferable to 3D graphs for clarity and comprehension (Mackiewicz, 2007b; Stewart, Cipolla, & Best, 2009)
10. Cool color (blue or green) high-contrast graphs are preferred over warm colors (yellow or red) (Mackiewicz, 2007b)

Obviously, with the exception of the reviews for conclusions 1 and 2, these results from less than a dozen studies don't tell us exactly how to prepare our slides. The PowerPoint® applications in most of the studies were based on Office 2003 version or earlier with very traditional, text-on-the-screen formats and some graphics, resembling *electronic overheads*. Research testing more recent designs using various multimedia would have been more informative.

Although the sheer scarcity of studies is inadequate to guide best PowerPoint® practices in teaching, those tentative conclusions suggest certain preferences you might want to consider in your slide designs. The research by Mayer (2009) and others on multimedia options described in the final section of this article will amplify upon several of those conclusions involving both words and pictures.

WHERE ARE THE MULTIMEDIA IN POWERPOINT®?

Beyond the basics of PowerPoint®, how can multimedia be utilized effectively with PowerPoint® in the classroom? Other than posting "dead words" on a screen, can you use movement, music, still images, and videos in PowerPoint® to facilitate learning? To date, those elements have been virtually disregarded and even discouraged by PowerPoint® gurus when the technology to embed or stream those media is readily available? For example, among the most popular volumes on PowerPoint®, Duarte (2008) and Reynolds (2008) give them miniscule attention, yet acknowledge the powerful active cognitive processing effects they can have. They usually caution users to integrate them either sparingly or not at all or to "not overdo it." Teaching Net Generation students who have no patience and are bored with traditional PowerPoints® suggests that faculty may need "to do" and, maybe, "over do" (Berk, 2009b).

With *FREE* software readily accessible, such as Audacity (music) and Movie Maker (videos), why do so few teachers incorporate media into their PowerPoints®? Granted, in-house IT staff may not have the time to assist faculty to do the animations or actual media extractions and conversions. By default, then, teachers are forced either to learn it themselves or to outsource it to techies who know how to do it; otherwise, it won't get done.

Do any of those PowerPoint® add-ons contribute to the effectiveness of instruction? Do they increase attention, engagement, or understanding of the content? Should teachers move literally and figuratively beyond dead words on the screen? They may already have slides with bright, high-contrast colors, flashy templates, and/or strong graphics. That's great, but what are the words doing? If they're still cadaver-like, teachers will immediately shift their Net Geners from *boring* to *snoring*. Say it with me: *"DEAD WORDS ARE BORING!"* Got it?

MOVEMENT, MUSIC, AND VIDEOS IN POWERPOINT®

The purpose of this section is to survey the research on those three neglected elements to determine how they can contribute to your PowerPoint® and improve

learning: (1) movement, (2) music, and (3) videos. Do they have the potential to raise the PowerPoint® bar to a new level of "best practices" in the classroom? You decide.

MOVEMENT

When something moves, your eyeballs move to track it. That's perfectly natural. However, when the movement slows up or stops in your classroom, students may get bored and click to something else. PowerPoint® permits transitions of slides and animation of letters, words, and graphics. When that movement is systematically choreographed throughout a presentation, it can grab and maintain attention. Used inappropriately, it can annoy and distract your students from the content being covered and decrease learning.

Research evidence. Is there research on the use of transitions and animation in the classroom? There isn't any on transitions, but there's a smidgen on text animation. The technique of introducing bits and pieces of text information incrementally on slides with animation has been tested by a couple of studies (Mahar, Yaylacicegi, & Janicki, 2009a, 2009b). Despite students' preference for animation in PowerPoint® lectures, the results indicated that students shown static lecture slides learned more about new concepts than those who viewed the animated slides. The animation required greater concentration with a shorter exposure time.

Contrary to these results is the research that found that animated graphics are significantly more effective than static graphics (Höffler & Leutner, 2007; Lowe, 2001, 2003; Mayer & Moreno, 2002; McLean, Brown, & Bellamy, 2003; Tversky, Morrison, & Betrancourt, 2002; Yu & Smith, 2008). Properly designed animations to illustrate concepts and procedures can generate interest, motivation, and engagement, which can promote deep learning (Mayer & Anderson, 1991; Ruffini, 2009). There are no studies testing different types of animation. Multi-step techniques or processes, in particular, may benefit most from animation.

Applications. With PowerPoint® slides, you have at least four movement options: slide transitions, and letter, word, and graphics animation. Use transitions systematically. Animation can be used for (a) the entrance of letters and words, (b) the emphasis of words or graphic elements already visible on the slide, (c) exit, and (d) motion paths. Here are a few slide opportunities to insert transitions and animations:

1. Opening and closing slides
2. Slide titles
3. Segue into next section or topic
4. Bullet-point lists revealing content incrementally, one point at a time
5. Graphic material and illustrations of processes

MUSIC

When you're listening to music or watching a TV program, movie, YouTube clip, or a commercial, your feelings and emotions, such as excitement, anger, laughter, relaxation, sadness, love, whimsy, or even boredom, are often triggered or heightened by the music playing behind the action. These emotions occur reflexively. You are responding to the mood created by the music and/or the scene. The music can have a strong effect on how you react (Levitin, 2006, 2008). A single song or the entire soundtrack is so powerful that you may download it off the Internet so you can listen again and again to relive the experience. Is there any evidence to support these effects? You bet!

Research evidence. The research indicates that music elicits emotional reactions of liking or disliking and excitement or arousal (North & Hargreaves, 1997; Robazza, Macaluso, & D'Urso, 1994; Sloboda & Justin, 2001). It can set the tone or mood instantaneously (Sousou, 1997; Stratton & Zalanowski, 1994). Music is also the emotional source of "chills" or "your hair standing on end" (Panksepp, 1995; Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011).

The best news is that music taps both hemispheres of your brain: the left side processes rhythm and lyrics AND the right side listens for melodies, sounds, and harmonic relationships (Bever & Chiarello, 1974; Hébert & Peretz, 1997; Schlaug, Jancke, Haung, Staiger, & Steinmetz, 1995), and the connections between the two hemispheres increase as you age (Schlaug et al., 1995). In fact, music listening engages nearly every area of the brain and involves almost every neural subsystem (Levitin, 2006).

Physiologically, there is mounting evidence that music can effectively elicit highly pleasurable emotional responses (Krumhansl, 1997; Rickard, 2004; Sloboda & Justin, 2001). Neuroimaging studies have confirmed those responses (Blood & Zatorre, 2001; Menon & Levitin, 2005; Koelsch , Fritz, Cramon, Muller, & Friederici, 2006). Most recently, however, music-induced emotional states have been linked to dopamine release, the chemical that sends "feel good" signals to the rest of the body (Salimpoor et al., 2011). The kicker here is that the PET and MRI scans recorded this release and the intense physiological responses based on students' listening to *their preferred music* rather than just someone else's tunes.

This evidence strongly indicates that catchy melody, fast, up-tempo, major-key music can activate sensory functions that create the emotional connection to excite and snap your students to attention. The music must not only be familiar, but should be within their choice pool. Music embedded throughout a PowerPoint® presentation can sustain attention, while slipping the content into long-term memory (Berk, 2001, 2002, 2008; Millbower, 2000). Even background "passive" music can increase attention levels, improve retention and memory, extend focused learning time, and expand thinking skills (Brewer, 1995).

Applications. How can you make those effects happen in your PowerPoint®? You want to establish an emotional connection from the get-go. Where do you stick music in a content-driven, "serious" PowerPoint®? Here are a few examples:

1. Slide title animation synched with the music
2. Segue into next section or topic (create mood: upbeat, serious, or humorous)
3. Accompanying text animation or bullet points with appropriate lyrics
4. Adding music or sound effects to pictures or graphic material for greater impact
5. Introduction to demonstrations/skits/dramas with student participation

VIDEOS

Preface. Much has been written in the basic PowerPoint® references about the power of visuals in PowerPoint®. Pictures, graphs, charts, diagrams, and a variety of graphic designs can stimulate emotional reactions and increase attention and retention of content more than words alone (Lane & Wright, 2011; Markel, 2009). In fact, students learn more from the combination of visuals AND words than words alone (Mayer, 2009, in press). The stronger the images, the more powerful the slides, the more effective your presentation will be.

Beyond these visuals and infographics are the uses of video clips embedded in PowerPoint® slides (Berk, 2009a) and streaming videos into the presentation (Eddy & Bracken, 2008; Miller, 2009). Since there are few guidelines for videos in the most

popular PowerPoint® sources on the topic, this section addresses the value and impact of videos. A few of these studies also relate to still and animated images.

Cognitive and learning theories. Several theories of learning have examined the dual coding of *verbal communication*, including visual, auditory, or articulatory codes, and *nonverbal communication*, which may include shapes, sounds, kinesthetic actions, and emotions. The theories have been linked to multimedia and the research has tested a variety of applications.

Multimedia refers to the presentation of material in two forms: *words* (spoken or written) and *pictures* (photo, graph, chart, diagram, or video) (Mayer, 2009, in press), such as on-screen text and animation, narration and graph, and video with dialogue or music. *Multimedia in PowerPoint® is learner-centered when it is presented in ways consistent with how the human mind works and research-based principles.* Strategies have included PowerPoint® (Gellevij, Ven Der Meij, De Jong, & Pieters, 2002; Mayer & Johnson, 2008) and games (Moreno & Mayer, 2004, 2005) in a variety of content areas.

Mayer's (2009) *cognitive theory of learning* is activated through five steps: "(a) selecting relevant words for processing in verbal working memory, (b) selecting relevant images for processing in visual working memory, (c) organizing selected words into a verbal mental model, (d) organizing selected images into a visual mental model, and (e) integrating verbal and visual representations as well as prior knowledge" (p. 54). His theory represents an amalgam of Sweller's (1999) *cognitive load theory* (Chandler & Sweller, 1991; Kirschner, Kester, & Corbalan, 2011), Baddeley's (1999) *working memory model*, and Paivio's (1986) *dual-coding theory* (Clark & Paivio, 1991).

Multimedia learning promotes acquisition, retention, and transfer (application) of information. However, students possess separate channels to process visual and auditory information and are limited in the amount they can process. The latter is defined in terms of particular principles that increase learning by decreasing extraneous information (or overload that exceeds one's cognitive capacity) on each slide. Mayer (2009) conducted research along with others to support five basic principles:

1. *Coherence*—Content should exclude interesting but extraneous material, such as too many ideas, distracting background design, nonessential text, unrelated music and sound effects, irrelevant images (Bartsch & Cobern, 2003; Moreno & Mayer, 2000), and a tangential verbal story;
2. *Signaling*—Attention should be focused with specific cues to highlight key content and its organization, such as adding a headline that briefly summarizes content (Alley & Neeley, 2005; Alley et al., 2006), numbers, blanks, and contrast-colored words or phrases;
3. *Redundancy*—Material should NOT be delivered as redundant, such as reading verbatim the text or bullet points off the screen or presenting the same information in different ways (Mayer & Johnson, 2008); learning increases from narration and animation without on-screen text;
4. *Spatial contiguity*—Words should appear near relevant visual images (Mayer & Anderson, 1992) and a full headline close to the graphic (Alley & Neeley, 2005); and
5. *Temporal contiguity*—Narration or dialogue should accompany visual images simultaneously, not sequentially (Mayer & Anderson, 1991).

Research evidence. The results of Mayer's research indicate that the contiguous presentation of verbal and visual material as in videos with integrated narration or dialogue and the preceding principles produced the strongest effects for low-knowledge and high-spatial learners (e.g., Ventura & Onsman, 2009). That is, the use of meaningful video clips and other forms of multimedia in PowerPoint® may be most appropriate for

introductory as well as complex topics and for lower achieving and visual/spatial learners.

The empirical findings of research over the past half century on the effectiveness of videos embedded in multimedia classes or modules are noteworthy. Overall, most of the investigations support the "dual-coding theory" that more is better: *multimedia auditory/verbal and visual/pictorial stimuli increase comprehension, understanding, memory, and deeper learning than any single stimulus by itself* (Kirschner, Kester, & Corbalan, 2011). Learning in the pictorial conditions tested (video and audiovisual) was superior to learning in the verbal (audio) conditions. This is consistent with the *picture superiority effect* (Nelson, Reed, & Walling, 1976; Paivio, Rogers, & Smythe, 1968).

Applications. So how can the potential of videos in your PowerPoint® systematically increase the comprehension and memory of your content message in the minds of your students? Here are a few opportunities to insert videos into your slides:

1. Opening presentation to set tone or introduce problem, issues, concept, etc.
2. Exaggeration or emphasis of a point or concept
3. Providing an example of real-life application
4. Presenting an opposing viewpoint or debate
5. Creating a stimulus for discussion (Q & A, small group, etc.)

POWERPOINT® STATE-OF-THE-ART

After this review of nearly 70 studies related to basic features and multimedia in PowerPoint® over the past decade, what guidelines can be extracted to improve your use of that platform for teaching? Beyond the basics you already know as you prepare your slides, here is a top-10 summary of "evidence-based practices" that reflect the potential of this technology:

1. **Slide Background:** Choose a simple template or solid color background that will not distract from word or image content; avoid logos and other irrelevant graphics or minimize their size;
2. **Font:** Use a minimum of 20PT (text) and 32PT (heads); pick Gill Sans, Sans Serif, Arial, or similar fonts, which are clear, interesting, attractive, and professional; make sure every word can be read easily from the back of the room;
3. **Text or Bullet Points:** Apply "less is more" rule with minimal amount of text and number of bullet points (3−6), plus highlight key points and order with UPPER and lower cases, **bold**, *italics*, numbers, blanks, and high-contrast colored words or phrases;
4. **Titles and Headings:** Create a full-sentence heading (written as an assertion) that briefly summarizes content compared to a word or phrase, especially with a clear supportive graphic;
5. **Color:** Pick high-contrast colors with a cool background (blue or green) and warm text (yellow, orange, or red), which is easy to read (*Note:* Colors and resolution may vary with projectors, so adjust colors during rehearsal.);
6. **Images:** Add bold, colorful, 2D (not 3D), high-impact, high-quality, strong, dynamic (animated) graphics (photos, charts, graphs, tables, diagrams) that make a specific point with no detail; words should appear near images and narration or dialogue should accompany images, where appropriate; avoid irrelevant images;
7. **Engagement:** Infuse all active, cooperative, and collaborative learning activities into slides so students are connected from beginning to end (see Berk, 2011);
8. **Movement:** Use slide transitions systematically throughout presentation; letter, word, and graphic animation can be effective, especially when accompanied by familiar music or sound effects;

9. **Music:** Sync music with which students are familiar to animated heads, text, lists, images, and demonstrations to create emotional connections; avoid irrelevant sounds, except for humor; and
10. **Videos:** Embed video clips from YouTube, TV, movies, or student projects into slides or stream in clips for powerful, memorable multimedia learning experiences.

Among the top-10 practices, the first five are basic and the last five pertain to multimedia. Despite all of the studies examined, those that undergird 6−10 are the most important. There is a solid foundation of cognitive psychology, learning theory, and physiological research and experience with "rich media" (Ayres, Marcus, Chan, & Qian, 2009; Höffler & Leutner, 2007; Kirschner et al., 2011; Lane & Wright, 2011; Mayer, 2009; Metiri Group, 2008). Including animations, especially in graphics, and media systematically in your slides with intended learning outcomes will positively affect just about every aspect of your teaching. Distinctions should be drawn among media that are designed (1) to grab and maintain attention, (2) to improve learning, and/or (3) to increase retention or transfer of information.

Despite the extensive multimedia research base, there is still an urgent need to test the range of movement and media applications in the specific context of the latest versions of PowerPoint® to determine their effects and limitations under controlled experimental conditions in the classroom at all levels (e.g., Bartsch & Cobern, 2003; Levasseur & Sawyer, 2006). There are a variety of options and uses of multimedia in PowerPoint® listed in the applications in the preceding sections for which evidence does not exist.

Finally, after processing all of these results, what are you going to do with your PowerPoints®? Among all of them, which one is your best? What grade would you give it? Hopefully, the review of research in this article, the 15 suggested applications, and the final top-10 practices will help you pinpoint areas for improvement and provide you with a strong justification and some traction in gliding your progress toward multimedia PowerPoints® that will WOW! your students.

REFERENCES

Abela, A. (2008). *Advanced presentation by design: Creating communication that drives action.*San Francisco: Pfeiffer.

Alley, M., & Neeley, K. (2005). Rethinking the design of presentation slides: A case for sentence headlines and visual evidence. *Technical Communication, 52*(4), 417–426.

Alley, M., Schreiber, M., Ramsdell, K., & Muffo, J. (2006). How the design of headlines in presentation slides affects audience retention. *Technical Communication, 53*(2), 225–234.

Altman, R. (2007). *Why most PowerPoint presentations suck: And how you can make them better*. Pleasanton, CA: Harvest Books.

Amare, N. (2006). To slideware or not to slideware: Students' experiences with PowerPoint vs. lecture. *Journal of Technical Writing & Communication, 36,* 297–308.

Atkinson, C. (2008). *Beyond bullet points: Using Microsoft Office PowerPoint 2007 to create presentations that inform, motivate, and inspire*. Redmond, WA: Microsoft Press.

Ayres, P., Marcus, N., Chan, C., & Qian, N. (2009). Learning hand manipulative tasks: When instructional animations are superior to equivalent static representations. *Computers in Human Behavior, 25*(2), 348–353.

Baddeley, A. D. (1999). *Human memory*. Boston: Allyn and Bacon.

Bartsch, R. A., & Cobern, K. M. (2003). Effectiveness of PowerPoint presentations in lectures. *Computers & Education, 41*(1), 77–86.

Berk, R. A. (2001).Using music with demonstrations to trigger laughter and facilitate learning in multiple intelligences. *Journal on Excellence in College Teaching*, *12*(1), 97–107.

Berk, R. A. (2002). *Humor as an instructional defibrillator: Evidence-based techniques in teaching and assessment*. Sterling, VA: Stylus Publishing.

Berk, R. A. (2008). Music and music technology in college teaching: Classical to hip hop across the curriculum. *International Journal of Technology in Teaching and Learning, 4*(1), 45–67.

Berk, R. A. (2009a). Multimedia teaching with video clips: TV, movies, YouTube, and mtvU in the college classroom. *International Journal on Technology in Teaching and Learning, 5*(1), 1–21.

Berk, R. A. (2009b). Teaching strategies for the net generation. *Transformative Dialogues: Teaching & Learning Journal*, *3*(2), 1–23.

Berk, R. A. (2011). "PowerPoint engagement" techniques to foster deep learning. *Journal of Faculty Development, 25*(2), 45−48.

Berk, R. A. (in press). How to create *Thriller* PowerPoint presentations in the classroom! *Innovative Higher Education*.

Bever, T., & Chiarello, R. (1974). Cerebral dominance in musicians and non-musicians. *Science, 185*, 537–539.

Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate withacti vity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences, 98*, 11818–11823.

Bradshaw, A. C. (2003). Effects of presentation interference in learning with visuals. *Journal of Visual Literacy, 23*, 41–68.

Brewer, C. B. (1995). *Music and learning: Seven ways to use music in the classroom*. Tequesta, FL: LifeSounds.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*, 293–332.

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review, 53*(2), 445–459.

Cooper, A. B. (2009). *PowerPoint presentations that sell*. NY: McGraw-Hill Professional.

Duarte, N. (2008). *Slide:ology: The art and science of creating great presentations.* Sebastopol, CA: O'Reilly Media.

Earnest, W. J. (2003). Developing strategies to evaluate the effective use of electronic presentation software in communication education. *Dissertation Abstracts International, Section A: Humanities & Social Sciences, 65*(3-A), 764.

Eddy, P. L., & Bracken, D. (2008). Lights, camera, action! The role of movies and video in the classroom. *Journal of Faculty Development, 22*(2), 125–134.

Garner, J. K., Alley, M., Gaudelli, A. F., & Zappe, S. E. (2009). Common use of PowerPoint versus the assertion-evidence structure. *Technical Communication, 56*(4), 331–345.

Gellevij, M., Ven Der Meij, H., De Jong, T., & Pieters, J. (2002). Multimodal versus unimodal instruction in a complex learning context. *Journal of Experimental Education, 70*, 215–239.

Hastings, M., & Attila, S. (2000). Using IT in the undergraduate classroom: Should we replace the blackboard with PowerPoint? *Computers & Education, 35*, 175–187.

Hébert, S., & Peretz, I. (1997). Recognition of music in long-term memory: Are melodic and temporal patterns equal partners? *Memory and Cognition, 25*, 518–533.

Höffler, T. N., & Leutner, D. (2007). Instructional animation versus static pictures: A meta-analysis. *Learning and Instruction, 17*(6), 722–738.

Kammeyer, J. (2007). Technology leaders' presentation visuals: Are they multimedia? Retrieved March 8, 2011, from http://www.jenniferkammeyer.com/Research_files/TechLeadersPPT.pdf.

Kirschner, F., Kester, L., & Corbalan, G. (2011). Cognitive load theory and multimedia learning, task characteristics and learning engagement: The current state of the art. *Computers in Human Behavior, 27*(1), 1–4.

Koelsch, S., Fritz, T., Cramon, D., Muller, K., & Friederici, A. D. (2006). Investigating emotion with music: An fMRI study. *Human Brain Mapping, 27*, 239–250.

Krumhansl, C. L. (1997). An exploratory study of musical emotions and psychophysiology. *Canadian Journal of Experimental Psychology, 51*, 336–353.

Lane, R. (2011). Tailoring your message to the audience is everything. Retrieved from http://officemicrosoft.com/en-us/powerpoint-help/tailoring-your-message-to-the-audience-is-everything-HA010232630.aspx.

Lane, R., & Wright, R. (2011). And the research says? PowerPoint meets cognitive science. Retrieved from http://officemicrosoft.com/en-us/powerpoint-help/and-the-research-says-powerpoint-meet-cognitive-science-HA010198311.aspx.

Levasseur, D. G., & Sawyer, J. K. (2006). Pedagogy meets PowerPoint: A research review of the effects of computer-generated slides in the classroom. *The Review of Communication, 6*, 101–123.

Levitin, D. J. (2006). *This is your brain on music: The science of a human obsession.* NY: Dutton.

Levitin, D. J. (2008). *The world in six songs: How the musical brain created human nature.* NY: Dutton.

Lowe, R. K. (2001). Beyond "eye-candy": Improving learning with animations. Retrieved from http://auc.uow.edu.au/conf/conf01/downloads/AUC200.

Lowe, R. K. (2003). Animation and learning: Selective processing of information in dynamic graphics. *Learning and Instruction, 13*(2), 157–176.

Lowenthal, P. R. (2009). Improving the design of PowerPoint presentations. In P. R. Lowenthal, D., Thomas, A. Thai, & B. Yuhnke (Eds.), *The CU online handbook. Teach differently: Create and collaborate* (pp. 61–66). Raleigh, NC: LuLu Enterprises.

Mackiewicz, J. (2007a). Audience perceptions of fonts in projected PowerPoint text slides. *Technical Communication, 54*(3), 295–306.

Mackiewicz, J. (2007b). Perceptions of clarity and attractiveness in PowerPoint graph slides. *Technical Communication, 54*(2), 145–156.

Mahar, S., Yaylacicegi, U., & Janicki, T. (2009a). Less is more when developing PowerPoint animations. *Information Systems Educators Journal, 7*(82), 1−11.

Mahar, S., Yaylacicegi, U., & Janicki, T. (2009b). The dark side of custom animation. *International Journal of Innovation and Learning, 6*(6), 581–592.

Mann, S., & Robinson, A. (2009). Boredom in the lecture theatre: An investigation into the contributors, moderators, and outcomes of boredom amongst university students. *British Educational Research Journal, 35*(2), 243–258.

Markel, M. (2009). Exploiting verbal-visual synergy in presentation slides. *Technical Communication, 56*(2), 122–131.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). NY: Cambridge University Press.

Mayer, R. E. (in press). Applying the science of learning to multimedia instruction. In J. Mestre & B. Ross (Eds.), *Psychology of learning and motivation: Cognition in instruction*. NY: Cambridge University Press.Mayer, R. E., & Anderson, R. B.

(1991). Animations need narrations: An experimental test of the dual-coding hypothesis. *Journal of Educational Psychology, 83*, 484–490.

Mayer, R. E., & Johnson, C.I. (2008). Revising the redundancy principle in multimedia learning. *Journal of Educational Psychology, 100*(2), 380–386.

Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review, 14*, 87–99.

McLean, D., Brown, S., & Bellamy, K. (2003). Digital images and animation in PowerPoint. *Journal of Audiovisual Media in Medicine, 26*(4), 174–177.

Menon, V., & Levitin, D. J. (2005). The rewards of music listening: Response and physiological connectivity of the mesolimbic system. *Neuroimage, 28*, 175–184.

Metiri Group. (2008). Multimodal learning through media: What the research says. Cisco Systems, Inc. Retrieved from http://www.cisco.com/web/strategy/docs/education/Multimodal-Learning-Through-Media.pdf.

Millbower, L. (2000). *Training with a beat: The teaching power of music.* Sterling, VA: Stylus Publishing.

Miller, M.V. (2009). Integrating online multimedia into college course and classroom: With application to the social sciences. MERLOT *Journal of Online Learning and Teaching, 5*(2), 395–423.

Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology, 92*(1), 117–125.

Moreno, R., & Mayer, R. E. (2004). Personalized messages that promote science learning in virtual environments. *Journal of Educational Psychology, 96*(1), 165–173.

Moreno, R., & Mayer, R. E. (2005). Role of guidance, reflection, and interactivity in an agent-based multimedia game. *Journal of Educational Psychology, 97*(1), 117–128.

Nelson, D. L., Reed, V. S., & Walling, J. R. (1976). Pictorial superiority effect. *Journal of Experimental Psychology: Human Learning and Memory, 2*, 523–528.

North, A. C., & Hargreaves, D. J. (1997). Liking, arousal potential, and the emotions expressed by music. *Scandinavian Journal of Psychiatry, 38*, 45–53.

Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, UK: Oxford University Press.

Paivio, A., Rogers, T. B., & Smythe, P. C. (1968). Why are pictures easier to recall than words? *Psychonomic Science, 11*, 137–138.

Panksepp, J. (1995). The emotional source of "chills" induced by music. *Music Perception, 13*, 171–207.

Paradi, D. (2000). *The visual slide revolution: Transforming overloaded text slides into persuasive presentations.* Mississauga, Ontario, CA: Communications Skills Press. (available at http://www.thinkoutsidetheslide.com)

Paradi, D. (2010). *102 Tips to communicate more effectively with PowerPoint.* Mississauga, Ontario, CA: Communications Skills Press. (available at http://www.thinkoutsidetheslide.com)

Reynolds, G. (2008). *Presentation Zen: Simple ideas on presentation design and delivery*. Berkeley, CA: New Riders.

Rickard, N. S. (2004). Intense emotional responses to music: A test of the physiological arousal hypothesis. *Psychology of Music, 32*, 371–388.

Robazza, C. Macaluso, C., & D'Urso, V. (1994). Emotional reactions to music by gender, age, and expertise. *Perceptual and Motor Skills, 79*(2), 939–944.

Ruffini, M. F. (2009). Creating animations in PowerPoint to support student learning and engagement. *EDUCAUSE Quarterly, 32*(4)1−4.

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience, 14*, 257–262.

Savoy, A., Proctor, R. W., & Salvendy, G. (2009). Information retention from PowerPoint and traditional lectures. *Computers & Education, 52*(4), 858–867.

Schlaug, G., Jancke, L., Haung, Y., Staiger, J., & Steinmetz, H. (1995). Increased corpus callosum size in musicians. *Neuropsychologia, 33*(8), 1047–1055.

Sloboda, J., & Justin, P. N. (2001). Psychological perspectives on music and emotion. In J. Sloboda (Ed.), *Music and emotion: Theory and research* (pp. 71–104). Oxford, UK: Oxford University Press.

Sousou, S. D. (1997). Effects of melody and lyrics on mood and memory. *Perceptual and Motor Skills, 85*, 31–40.

Stewart, B. M., Cipolla, J. M., & Best, L. A. (2009). Extraneous information and graph comprehension: Implications for effective design choices. *Campus-Wide Information Systems, 26*(3), 191–200.

Stratton, V., & Zalanowski, A. (1994). Affective impact of music vs. lyrics. *Empirical Studies of the Arts, 12*, 173–184.

Sweller, J. (1999). *Instruction design in technical areas*. Camberwell, Australia: ACER.

Tufte, E. R. (2003). *The cognitive style of PowerPoint*. Cheshire, CT: Graphics Press.

Tversky, B., Morrison, J. B., & Betrancourt, M. (2002). Animation: Can it facilitate? *International Journal of Human-Computer Studies, 57*(4), 247–262.

Ventura, S., & Onsman, A. (2009). The use of popular movies during lectures to aid the teaching and learning of undergraduate pharmacology. *Medical Teacher, 31*(7), 662–664.

Yu, C., & Smith, M. (2008). PowerPoint: Is it an answer to interactive classrooms? *International Journal of Instructional Media, 35*(3), 271–280.

* The author is extremely grateful to Linda Nilson (Clemson University), Derek Bruff (Vanderbilt University), and Michael Miller and Jose Vazquez (University of Texas, San Antonio) for their insightful comments on an earlier draft of this article. I also thank three anonymous reviewers for their suggested additions that forced me to rethink and rewrite several sections to improve this contribution.