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HARNESSING MULTIMEDIA AND INTERACTIVE-ASSESSMENT TECHNOLOGIES TO PROMOTE AND EVALUATE COGNITIVE PROGRESSION AND CRITICAL THINKING IN THE CLASSROOM

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Abstract

Bloom's Taxonomy of Cognitive Development provides a model of learning that offers an approach for designing student-centered classroom experiences that promotes critical thinking and constructivist learning approaches. The authors explain how multimedia and interactive-assessment technologies can be combined with other pedagogical techniques, such as “storytelling,” to create a rich and engaging learning environment that promotes the cognitive progression suggested by Bloom's Taxonomy. To assist in visualizing the ideas and suggestions discussed in this paper, the authors have provided several examples in which they have used these technologies to assist students in understanding, applying, and evaluating subject matter (e.g., competing theories of international trade, international tax law, etc.).

KEYWORDS: Bloom's Taxonomy, classroom response technology, interactive learning, learning modalities, multi-media, storytelling, technology

COGNITIVE PROGRESSION

Bloom's Taxonomy of Cognitive Development [1956] offers a model of learning that identifies and ordinally ranks intellectual behaviors that culminate in the attainment of critical thinking skills. The Taxonomy is premised on the notion that learning occurs in a hierarchy that progresses from less complex to more complex intellectual behaviors. It suggests that a student must generally pass successively through each of six conceptually discrete levels of learning to achieve higher-order critical thinking skills in a particular subject area. Pragmatically, the Taxonomy is a tool that can assist educators in designing and implementing student-centered classroom experiences that actively promote the development of higher-order thinking skills, rather than merely transmitting subject-matter content and instructor knowledge to a passive student audience.

Bloom's Taxonomy suggests that to facilitate learning, material should be presented in a way that takes this natural progression into consideration. Concept comprehension, which is the second level of the hierarchy, cannot generally begin until the student has first succeeded in mastering the first level of the hierarchy: knowledge of the facts associated with the concept.

The six levels of the Taxonomy are:

- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation
Knowledge includes the recognition and recall of facts such as names, dates, and definitions. This may involve the recall of specific facts or complete theories. All that is required is bringing to mind appropriate information. Knowledge represents the lowest level of learning outcomes in the cognitive domain.

Comprehension implies that students can not only recite the facts, but can also explain them to others in their own words. Comprehension is one step beyond the simple remembering of material—it is the ability to grasp the meaning of material. Comprehension is the lowest level of understanding.

Application is the ability to use learned material in new, concrete situations. It involves building concepts from the facts, and then using the concepts to solve a problem or to address a situation that is different from those the student has previously encountered. Application requires a higher level of understanding than Comprehension.

The student is operating at the Analysis level when he/she can break down a concept into its component parts, understand its organizational structure and the relationships between its component parts, and make comparisons to other concepts or ideas. Analysis is a higher intellectual level than Comprehension and Application in that it requires an understanding of both the content and the structural form of the material.

At the Synthesis level, the student can put parts together to form a new whole or to use one concept in conjunction with other related concepts to formulate creative solutions to more complex problems.

Evaluation involves making judgments about the value of the concept or how it can be used. Evaluation can also include making a decision about which concept applies in a given situation and being able to defend the decision. Evaluation is the highest level in the cognitive hierarchy because it requires assimilating elements of all of the lower levels and then developing value judgments based on clearly defined criteria.

Traditional teaching approaches typically emphasize the presentation of information, and define “learning” as the ability to recall and summarize that information. The principal goal of “constructivist” teaching, on the other hand, is the intentional, systematic development of the students’ critical thinking skills. Student learning objectives for a particular class session (or series of sessions) can be expressed in terms of one or more Taxonomy levels. To direct, facilitate, and motivate the students’ progression through these levels, the instructor will generally present and develop the facts, concepts, ideas, ramifications, and implications in a similar progression.

The creative use of multi-media and interactive-assessment technologies in the classroom can greatly enhance the efficiency and effectiveness of this process. Thoughtfully designed multi-media presentations that are responsive to different learning modalities clarify meaning, enhance retention, and capture and maintain students’ attention and interest. This is especially true of presentations designed around stories, anecdotes, and metaphors that are used by the instructor to convey facts, concepts, ideas, etc. to the class.

Real-time interactive assessment tools help to elevate and maintain the engagement of students in the learning process. They also provide contemporaneous feedback that can assist the instructor in making the most effective use of class time by enabling him/her to identify and correct problems (before progressing to material that requires more complex cognitive processes) or to confirm mastery (and thereby avoid unnecessary reviews).

**USING MULTIMEDIA PRESENTATION TECHNOLOGIES TO PROMOTE COGNITIVE PROGRESSION**

**LEARNING MODALITIES**

The “multiple intelligences” theory was developed by Harvard psychologist Howard Gardner and his team of researchers at the Graduate School of Education. [Gardner, 1983]. This theory recognizes that people think, learn, understand, problem solve, and relate to the world differently. Gardner suggested a system of eight distinct intelligences: (1) verbal-linguistic, (2) logical-mathematical, (3) visual-spatial, (4) bodily-kinesthetic, (5) musical-rhythmic, (6) interpersonal, (7) intrapersonal, and (8) naturalistic. (Other researchers have suggested up to 150 different types of intelligences!) According to Gardner, everyone possesses all eight intelligences to a greater or lesser degree, and it is the combination of how all eight operate that is unique to each person.
For each of these intelligences, certain learning activities and presentation strategies are more effective than others. "[L]earning modalities . . . vary from person to person, day to day, and topic to topic; therefore, it is essential to use a variety of techniques in order to be effective." [Rosetti, 1997]. The greater the diversity of these different learning activities and presentation strategies incorporated into a program, the more inclusive and thorough learning will be.

The three predominant learning modalities (or learning "styles") are auditory, visual, and kinesthetic. Auditory learners process information primarily through their sense of hearing. They are particularly sensitive to the tone, inflection, and energy of the speaker’s voice and their principle mode of learning is through listening to the speaker’s words. Auditory learners are most responsive to speakers whose messages are communicated with passion and vigor, using rich vocabularies and vibrant expressions.

Visual learners need to see the speaker’s message. Visual aids help them assimilate what they are hearing. Visual learners tend to be most responsive to speakers who are animated, use facial expressions and dramatic gestures, move around the room, and make frequent eye contact. But lecture alone is not as effective as lecture combined with good presentation graphics, displayed text, and/or purposeful animation. Thoughtfully designed multi-media presentations that are responsive to both auditory and visual learning modalities help clarify meaning, enhance retention, and capture and maintain students’ attention and interest.

Kinesthetic learners are more sensory and tactile, they learn by doing and being involved. Kinesthetic learners are most responsive to speakers who allow them to become involved, rather than forcing them to sit quietly as a passive recipient of enlightenment. The process of developing critical thinking skills is more likely to take place if students are actively involved in doing something other than listening [Dufresne, 1996, p. 5]. Real-time interactive response systems, discussed below, contribute a kinesthetic component to the classroom mix.

STORY TELLING

How does knowledge move from one person's spoken words to the mind of another? One of the most powerful and effective tools available is to use stories, anecdotes, and metaphors to help get the messages across. Stories are narrative frameworks created to make sense of the world, to share experiences, to convey meaning, and to pass on knowledge. Storytelling appeals to different learning styles. It increases the instructor’s connection with the audience and helps students see the relevance of the technical content.

Stories help to efficiently disseminate information and to convey meaning at a high level of understanding. Stories convey so much understanding because they are told in context. And context conveys emotions, triggers individual and group memories, helps build memory frameworks, and provides intuition and insight in ways that other forms of communication cannot. Storytelling is also perhaps the best way method for conveying tacit knowledge: stories capture things that cannot be captured in any other way.

Many instructors believe that their job begins and ends with identifying the material to cover, organizing it in a logical manner and presenting it clearly to their audience. Important though these activities are, they are not enough. The ultimate goal is to deliver information in a way that motivates the audience to listen, to reflect, to retain, and to act. Boring speakers talk to their audience’s left-brain from their own left-brain. The most effective speakers communicate with and to both sides of the brain. They illustrate the facts, rules, and statistics with stories, and back up their stories with the facts, rules, and statistics that support them.

Storytelling is inherently auditory: good storytellers tell their stories using changes in volume, tempo, pitch, and inflection to help them tell their stories with passion and conviction. Stories are inherently visual: good storytellers do not just tell their stories, they act them out and, ideally, use rich visual images, color, purposeful animation, etc. to assist them in doing so. Stories are inherently kinesthetic: good storytellers do not just narrate; they draw their audience into the experiences and emotions of the story.

Of course, the most useful stories are the ones that drawn from personal experiences. But this can leave gaps that need to be filled. Good stories can also be found in articles in business publications (Barrons, Wall Street Journal, Forbes, The Economist, etc.), professional journals and magazines, and business school cases. Those who have access to the WESTLAW or LEXIS-NEXIS databases can use key word searches to try to find cases, news stories, and articles that provide good stories that suit
the subject matter. With a little practice, these services are relatively easy to use and they are updated daily.

**POWERPOINT PRESENTATION TECHNIQUES THAT ENHANCE STORYTELLING AND APPEAL TO MULTIPLE LEARNING STYLES**

For many, the phrase "PowerPoint presentation" conjures up visions of bullet points laid out, slide after slide, on a fancy background with an occasional clip art image and gratuitous animation effect thrown into the mix. This is unfortunate. PowerPoint XP (and higher) has actually evolved from its humble beginnings into a powerful authoring tool. It has a wide range of impressive animation effect routines, hyperlink capabilities and action settings, support for insertion of several multimedia file types, and custom slide shows that allow one presentation to be adapted to multiple audiences.

Although there are over a dozen programs on the market that can be used to author impressive presentations (e.g., Macromedia Flash, Adobe LiveMotion, Macromedia Authorware, Click2Learn Toolbook, Mentergy Quest, MaxIt DazzlerMax), PowerPoint is a common authoring tool of choice because it is easy to learn and to use, it is relatively inexpensive, and it has most or all of the capabilities required to create powerful and impressive presentations. Furthermore, PowerPoint slides and slide shows (including narration and animation effects) can easily be converted into AVI videos, QuickTime movies, RealMedia streaming videos, GIF animation files, or, best of all, very compact Flash movies, for distribution to students or for inclusion in other programs authoring programs (e.g., Authorware) for distribution on CD or over the Web.

Here are a few techniques that the authors' experience, cognitive theory, and research evidence suggest can lead to more effective classroom presentations. Most of these techniques are illustrated in the presentation on international trade theory that accompanies this paper (described below under the last heading).

**The Multimedia Principle: Use words and relevant graphics, rather than words alone.**

"A picture is worth a thousand words." There are few things more uninteresting, discouraging, and, ultimately, forgettable than a lengthy progression of bullet point overheads or line after line, paragraph after paragraph of text. People are more likely to understand and retain information when they engage in active learning. Multimedia presentations, i.e., any presentation that contains both words and graphics enable and encourage students to engage in active learning by mentally representing the material in both words and pictures and by mentally making the connection between these representations.

The graphics used in a presentation should be purposeful, they should help tell the story or explain the concept. They should encourage and enable the learner to make sense out of the words.

**The Continuity Principle: Place printed words near the related graphics.**

Research indicates that people learn and retain substantially more from slides that tightly integrate printed words and pictures [Mayer, 1989; Mayer, Steinhoff, Bower, and Mars, 1995; Moreno and Mayer, 1999; Chandler and Sweller, 1991; Paas and Van Merrienboer, 1994; Sweller and Chandler, 1994; Sweller, Chandler, Tierney, and Cooper, 1990]. The psychological advantage of spatially integrating text and graphics is that it eliminates confusion and uncertainty and allows viewers to concentrate on understanding the content.

**The Modality Principle: Present Text as Audio Narration in Multimedia Presentations**

There is substantial evidence that presenting words in the form of audio rather than as onscreen text enhances learning when words are used with graphics. With audio, the information is split between two separate cognitive channels: words are processed through the auditory channel and graphics through the visual channel. The capacity of each of these channels is limited. Research indicates that many learners experience visual channel overload when they are required to simultaneously process animation, graphics, and the printed words that explain them, especially animation, graphics, and printed words are presented simultaneously and at a rapid pace [Mayer and Moreno, 1998; Moreno and Mayer, 1999; Moreno, Mayer, Spires, and Lester, 2001; O’Neil, Mayer, Herl, Niemi, Olin, and Thurman, 2000; Mousavi, Low, and Sweller, 1995]. Using audio in lieu of lengthy printed text reduces the demands on visual processing.
Research also indicates that graphics explained by audio alone is more effective than graphics explained by audio and redundant onscreen text [Mayer, Heiser, and Lonn, 2001; Moreno and Mayer, 2002; Kalyuga, Chandler, and Sweller, 1999]. However, narration of onscreen text may improve learning where the presentation contains no graphics, where the presentation proceeds at a pace that provides ample time to process the information, and where non-native language students or students with learning disabilities have more difficulty processing spoken text than they do with printed text [Moreno and Mayer, 2002].

The Coherence Principle: Avoid the Gratuitous.

Many presenters try to capture and retain the attention of their audience with extraneous stories, comments, clip-art images, background music, sounds and animation effects. Research suggests that interesting-but-unnecessary information can overload the cognitive system, distract the audience, disrupt the learning process, and result in diminished levels of learning and retention. Instead of spicing up a presentation with irrelevant adjuncts, time should be spent on finding ways to present the material itself in a way that is more interesting. “When things have to be made interesting, it is because interest itself is wanting.” [Dewey, J., 1913]. Moreover, throwing in interesting, but gratuitous, adjuncts will not make an otherwise boring presentation interesting, the material itself is just as uninteresting as it was before.

Except on splash pages that might be used at the beginning of a presentations, it is generally best to avoid or minimize the use of gratuitous or decorative graphics.

The Personalization Principle: Use Conversational Style.

Many presenters believe that the conversational style (use of “I,” “you,” contractions, etc.) detracts from the seriousness of the material, and that the formal style is more appropriate. This view is predicated on the assumption that it is the presenter’s job to convey information as efficiently as possible and that the formal style is more efficient than the conversational. But compare the following two approaches to the introductory portion of text spoken in a botany computer game [Moreno and Mayer, 2000b].

Formal Version: “This program is about what type of plants survives on different planets. For each planet, a plant will be designed. The goal is to learn what type of roots, stem, and leaves allow the plant to survive in each environment. Some hints are provided throughout the program.”

Personalized Version: “You are about to start a journey where you will be visiting different planets. For each planet, you will need to design a plant. Your mission is to learn what type of roots, stem, and leaves will allow your plant to survive in each environment. I will be guiding you through by giving out some hints.”

Research on this issue shows that students work more diligently in trying to understand material when they feel that they are in a conversation with a partner, like the personalized version, rather than when they are simply receiving information [Beck, McKeown, Sandora, Kucan, and Worthy, 1996; Moreno and Mayer, 2001b and 2000a].

The Animation Principle: Use Purposeful Animation Effects.

The thoughtful and deliberate use of animation effects with graphics and text can be very effective in explaining difficult fact patterns, logical progressions, and complex concepts and frameworks. Properly used, animation effects can help make a good story even more engaging, help emphasize key points, and help students see complex relationships. PowerPoint is packed with a wide range of powerful animation effects. Suggested uses for many of these are illustrated in the presentation on international trade theory that accompanies this paper.

USING INTERACTIVE-ASSESSMENT TECHNOLOGY TO PROMOTE COGNITIVE PROGRESSION

A class session often involves developing one or more basic concepts through two or more levels of the cognitive progression. One way to facilitate this process is to repeatedly challenge students, individually and/or collectively, with level-appropriate questions and problems. Interactive assessment technologies make it possible for the instructor to efficiently present collective challenges to the class, capture and evaluate their responses, and assess the significance of those responses—all in real-time.
Multiple challenges and the contemporaneous feedback that these technologies make possible help motivate students to stay focused on and actively engaged in the classroom discussion. They also provide students with an opportunity to gauge personal progress, to compare their progress with that of the class as a whole, to correct misunderstandings and misconceptions before they become too ingrained and before the instructor moves on to more advanced material, and, generally, to build confidence. The instructor benefits from knowing where students are getting “lost” before spending valuable class time moving on to cover material that requires higher cognitive skills. The instructor can analyze the distribution of responses on the spot and correct problems before they hinder the mastery of important session outcomes. Delayed feedback does not provide these advantages. It may uncover the deficiencies, but not until valuable time has been expended on material that the students are not yet ready to absorb.

Classtalk, introduced in 1992, was the first classroom technology to be widely used to electronically capture student responses to questions and problems posed in interactive class sessions. In spite of technical issues related to the installation of the system, it was well received, especially in teaching scientific subjects [Lopez-Herejon, 2004]. Interactive classroom technologies not only make it easier to engage students in learning activities during lecture, but they also enhance communication between the students and the instructor, and allow the instructor the opportunity to address problem areas that show up as the class session progresses [Dufresne, 1996].

Since Classtalk, other systems with similar capability have been developed. The Personal Response System (PRS) by GTCO CalComp, provides a hand-held 12-key pad similar to a television remote that allows the student to answer multiple choice questions and questions with numeric answers. Recently the Classroom Performance System (CPS) by Pearson NCS has announced a similar 12-key device. A much more sophisticated interactive tool is available through Texas Instruments. TI-Navigator uses a graphing calculator, and responses can include graphs, equations, even spreadsheet lists. This tool, provides more flexibility, but is also much more expensive. While it can be used in any classroom setting, it has been developed to have more applicability to the math and science fields.

The authors of this paper are familiar with an earlier version of the CPS system, which was has an 8-key pad and accommodates only multiple choice or true/false, yes/no types of questions. While the more recent technologies provide more flexibility in creating question content, the general approach to targeting questions to the various levels of the cognitive domain is the same regardless of the specific technology in use.

The CPS system consists of a combination of software and hardware that permits the instructor to present questions to the class from a PC computer display. There is a reasonably short learning curve for the instructor to learn how to set up the questions in advance. Instructors also have the option of quickly creating ad-hoc questions during the class session. Once the question is posed, students use their hand-held devices to key in their individual answers. A receiver plugged into the PC detects the signals. Software installed on the PC processes the responses in real-time, and can display response summaries in the form of pie charts or histograms. The correct answer can be disclosed or not, at the instructor’s discretion. The display can be used to encourage a class-wide discussion of the ideas and methods used by the students in their responses. Another active learning approach is to allow students to work in small groups before responding. The instructor can also use the system to help hold students responsible for reading factual material before coming to class—a task students might be more willing to do if they know responses to questions on this material will be recorded during the class session [Dufresne, 1996].

Once the instructor understands the process of setting up the questions, the real work begins. Questions must be devised that are sufficiently robust to challenge the students, and to provide insight into what kinds of issues and problems may be interfering with the learning progression. Woods and Chiu [2003] identify three major categories of questions that can be used effectively with the type of interactive technology under discussion:

1. **Fact or process questions** assess basic understanding of a concept. The possible multiple-choice answers should be worded with fine distinctions, so that students have to think carefully before they respond. These types of questions are most relevant to assess mastery at the Knowledge level of cognitive thinking. Using responses that incorporate different terminology, phrasing or examples than those used to present the basic facts allows the student to also demonstrate accurate understanding of the concepts at the Comprehension level.
2. **Problem-solving questions** require students to apply their knowledge to new problems. This reflects the abilities expected at the Application level. More complex problems can involve decomposing a problem into parts, or comparing different concepts to determine which ones apply to the problem space. This type of problem requires skills at the Analysis level. Other questions may require the use of a chain or group of concepts used together (Synthesis).

3. **Opinion or belief questions** provide insight into the students’ ability to operate at the Evaluation level. With these questions, there is not necessarily a “right” or “wrong” answer. These questions can be used to generate classroom discussions about how students are thinking and feeling about an issue or concept.

It can take up to 30 seconds to recognize and record all of the responses in a large class. Displaying the chart of student responses helps re-focus student attention to the front of the room. Projecting the results also provides direction for the class-wide discussion of the answer. Students can be asked to share the reasoning behind incorrect as well as correct responses. Knowing the distribution of class responses can help students see how they were doing in relation to others. When in the majority, personal accomplishment is reinforced. Those in the minority can be consoled by the fact that others made the same selection [Dufresne, 1996]. This may help them to “open up” and share how they arrived at the minority answer.

TECHNOLOGY-ENHANCED TEACHING AND LEARNING: ILLUSTRATIONS

To illustrate the concepts, techniques, and technologies discussed above, the authors have prepared several short animated slide shows that use “storytelling” and the multi-media techniques described in this paper to explain and illustrate the underlying concepts in ways that our experiences have shown help clarify meaning, enhance retention, and capture and maintain students’ attention and interest. These files can be downloaded from either [http://web.isy.vcu.edu/lhodgson](http://web.isy.vcu.edu/lhodgson) or from [http://www.commerce.virginia.edu/faculty_research/faculty_homepages/larue/larue_homepage.htm](http://www.commerce.virginia.edu/faculty_research/faculty_homepages/larue/larue_homepage.htm).

ENDNOTES

1. Verbs that describe the *Knowledge* level of intellectual activity include: arrange, define, describe duplicate, enumerate, identify, label, list, match memorize, name, order, recognize, relate, quote, recall, recite, recollect, repeat, reproduce, select, show, state, tell, who, what, when, and where.

2. Verbs that describe the *Comprehension* level of intellectual activity include: associate, classify, contrast decode, define, describe, discuss, distinguish, differentiate, discriminate explain, express, generalize, give example, identify, illustrate, indicate, interpret, locate, paraphrase, predict, recognize, report, restate, review, select, summarize, translate.

3. Verbs that describe the *Application* level of intellectual activity include: apply, choose, change, classify, compute, demonstrate, determine, develop, discover, dramatize, calculate, chart, complete, employ, estimate, examine, experiment, illustrate, implement, interpret, manipulate, modify, operate, organize, practice, prepare, produce, relate, schedule, sketch, solve, show, transfer, use, and write.

4. Verbs that describe the *Analysis* level of intellectual activity include: analyze, appraise, arrange, break down, calculate, categorize, classify, compare, conclude, connect, contrast, deduce, diagram, differentiate, discriminate, distinguish, divide, examine, experiment, explain, illustrate, infer, order, outline, point out, question, relate, separate, select, subdivide, and test.

5. Verbs that describe the *Synthesis* level of intellectual activity include: arrange, assemble, categorize, collect, combine, compile, compose, conceive, construct, create, design, develop, devise, establish, explain, formulate, generalize, generate, integrate, invent, make, manage, modify, organize, originate, plan, prepare, propose, rearrange, reconstruct, relate, reorganize, revise, rewrite set up, substitute, what if, and write.
6. Verbs that describe the Evaluation level of intellectual activity include: appraise, argue, assess, attach, choose, compare, conclude, contrast, convince, critique, criticize, decide, defend, describe, discriminate, estimate, evaluate, explain, grade, interpret, judge, justify, measure, predict, rank, rate, recommend, relate, resolve select, summarize, support, validate, value, weigh, write (a review).

7. Some recent research has suggested that the last two levels in the Taxonomy should be revised. Anderson and Krathwohl, [2001] suggest that Evaluation precedes the highest level of thinking, Creation. In this version of the model, Creation implies a level at which synthesis and creativity combine to create with entirely new ideas. Huit [2004] suggests that Synthesis and Evaluation are the appropriate nomenclature, but that these concepts occur at the same “level”. Synthesis (or Creation) requires using the concepts in an original way, while Evaluation requires a comparison to a standard with a judgment as to good, better or best. He compares the distinction to the concepts of creative thinking and critical thinking: both require analysis skills as a foundation and both are equally valuable. Rather than building one on the other, high level problem solving requires concurrent application of both to make the most effective decisions [Huit, 1992]. Whichever of these alternative models is used, the initial stages of the learning process are essentially the same.

8. The English word "story" and the related words "narrate" and "narrative" all have etymological roots in Latin and Greek words for knowing, knowledge, and wisdom.

9. Perhaps one reason stories are such an effective form of knowledge transfer is that people tend to hear stories in a receptive mode rather than in the reactive mode that other forms of communication might create. When listening to stories, people lower their defenses to absorb what they're hearing, rather than of concentrating on preparing responses and questions.

10. Three fundamental theories have been advanced to explain how the learning brain works. The left-brain/right-brain theory was developed by Dr. Roger Sperry of the University of California in the early 1970s. Our brains are divided into halves. Dr. Sperry discovered that the left brain is the logical, linear half. It collects facts and data. The right brain is the emotional half. It is nonlinear and deals with feelings and creativity. It is the right-brain that interprets the speaker’s body language, vocal tone and inflection, and energy to decide whether to believe and trust the speaker.

The “triune brain” model was developed in the 1950s by Dr. Paul MacLean, chief of the Laboratory of Brain Evolution and Behavior at the National Institute of Mental Health in Bethesda, Maryland. According to MacLean, the brain evolved through three primary stages: (1) reptilian (initiates and monitors all autonomic functions), (2) limbic (houses the primary centers of emotion), and (3) neocortex (responsible for genius and uniqueness).

11. In the field of tax law, which is the discipline most familiar to one of the authors, published opinions in the more than 30,000 court cases that have resolved tax disputes over the years are rich in facts and most of them can be easily condensed or adapted to make excellent stories. Outside the area of tax law, there are thousands of court cases that deal with marketing, management, finance, accounting, and business ethics issues. Most of these opinions begin with a headnote that contains a condensed summary of the facts and holdings of the case. The opinion itself generally lays out the facts of the case in considerable detail and then concludes with the court’s ruling and its rational.

12. Properly used, the dozens of high-quality custom animations available in PowerPoint 2003 can make a presentation come alive. Animation effects are broken down into four groups: entrance, emphasis, exit, and path (moving objects along a path). Multiple animations can be used simultaneously.

14. By “words” includes both text printed on the screen for people to read and spoken text.

15. “Graphics” includes charts, graphs, diagrams, flowcharts, drawings, maps, photos, videos, and animated graphics.

16. Research supports the hypothesis that people learn and retain substantially more from words and graphics than from words alone. See, for example, Mayer [1989]; Mayer and Anderson [1991, 1992]; Mayer, Bove, Bryman, Mars, and Tapango [1996].

17. The cognitive theory of multimedia learning assumes that all people have separate channels for processing verbal and visual information, that each channel is limited in the amount of processing that can take place at one time, and that learners actively attempt to build pictorial and verbal models from the information presented and to build connections between them.

18. See, for example, Harp and Mayer [1997] (extraneous graphics); Moreno and Mayer [2000a] (extraneous music and sound); Mayer, Heiser, and Lonn [2001]; Mayer, Bove, Bryman, Mars, and Tapango [1996] (extraneous text messages).
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