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Instructional Message Design: Theory, Research, and Practice

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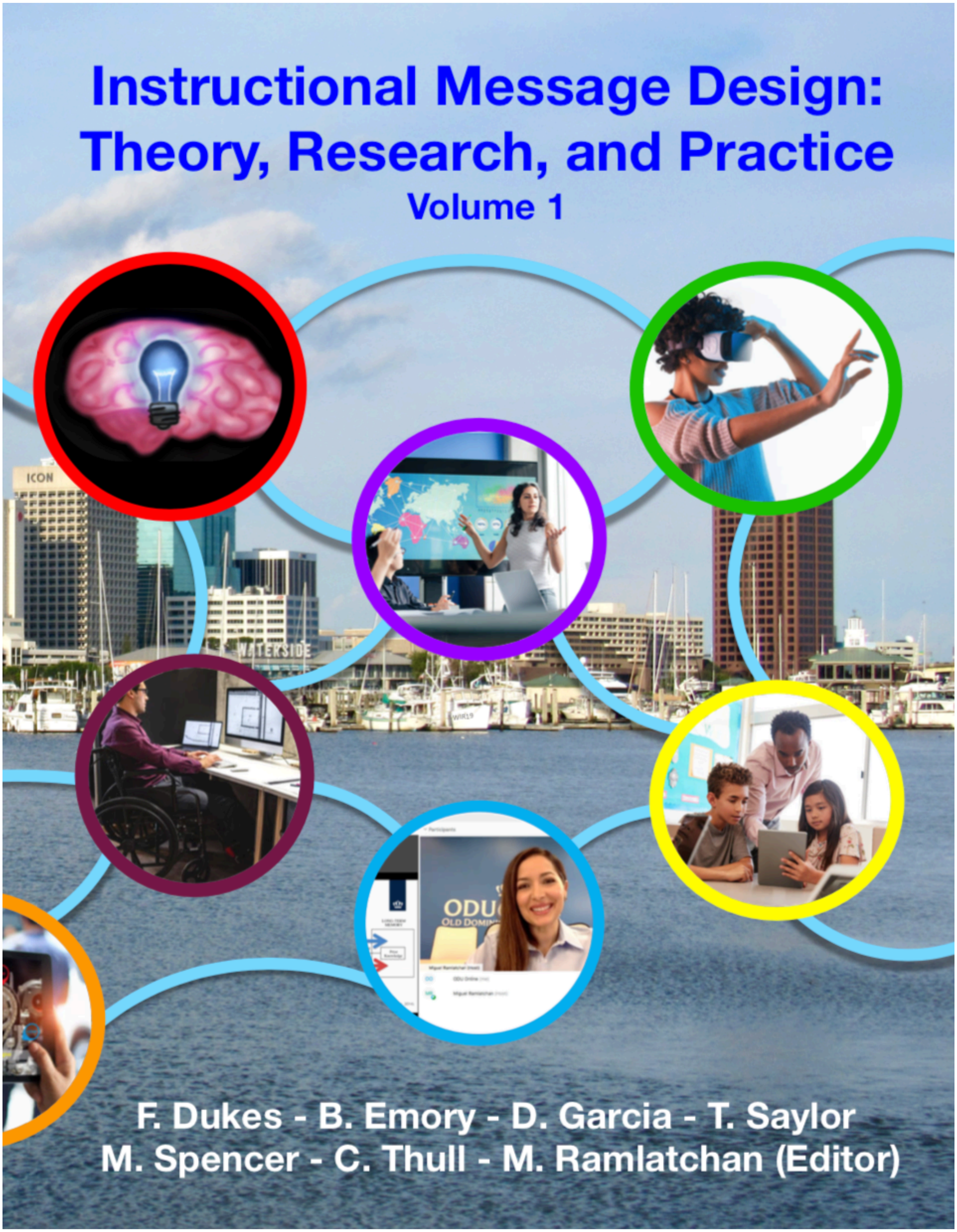
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Instructional Message Design: Theory, Research, and Practice

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Preface

Message design is all around us, from the presentations we see in meetings and classes, to the instructions that come with our latest tech gadgets, to multi-million-dollar training simulations. In short, instructional message design is the real-world application of instructional and learning theories to design the tools and technologies used to communicate and effectively convey information. This field of study pulls from many applied sciences including cognitive psychology, industrial design, graphic design, instructional design, and human performance technology to name just a few. In this book we visit several foundational theories that guide our research, look at different real-world applications, and begin to discuss directions for future best practice. For instance, cognitive load and multimedia learning theories provide best practice, PowerPoint and simulations are only a few of the multitude of applications, and special needs learners and designing for cultural inclusiveness are only two of many areas where effective messages design can improve outcomes. Studying effective instructional message design tools and techniques has and will continue to be a critical aspect of the overall instructional design process. Hopefully, this book will serve as an introduction to these topics and inspire your curiosity to explore further!

Instructional Message Design:
Theory, Research, and Practice

Chapter 1: Message Design for Instructional Designers - An Introduction

Miguel Ramlatchan

Old Dominion University

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Chapter 1: Message Design for Instructional Designers: An Introduction

Miguel Ramlatchan

Key Points:

- Instructional message design is the application of theory and techniques to communicate information to learners.
- Cognitive load and multimedia design theory can be used to help design our instructional message.
- Visual communications can include static art (illustrations, diagrams, photographs) or dynamic art (animation, video, virtual reality, video games and simulations) with or without accompanying audio.

Abstract

Instructional message design is the use of learning theories to effectively communicate information using technology. Theories involving gestalt, cognitive load, multimedia learning, media selection, media attributes, and general communication systems help us guide design. Our communication designs can be based on a wide variety of technologies or a combination of technologies. Technology in the form of tools and techniques includes the study and the use of typography, color, illustrations, photographs, modeled graphics, augmented reality, animation, video, video games, simulations, and virtual reality. This introduction serves as a brief overview of these theories, tools, and techniques while subsequent chapters will dive much deeper into practical applications in instructional design.

Introduction

Message design is all around us. From the logo on the coffee cup beside me here on my desk, to the layout of your car or truck's dashboard, to the street signs you will pass to and from the grocery store, we see hundreds of examples of message design every day. Message design is the use of text, graphics, and/or pictures to communicate and to specifically address a need or solve a problem (Fleming & Levie, 1993). Thinking back to the dashboard on your car, it communicates your speed, fuel level, and general system status, all important pieces of information that are vital for your trip. That dashboard represents the efforts of the engineers (human performance technologists) who wanted to design a system that communicates to you the driver the information you need. That is the essence of message design.

While there are many great references for message design, especially in the context of marketing, advertising, and graphical design, the focus of this book is message design in the context of instruction, learning, and education. Instructional design in a single sentence is the process of determining the need for an instructional solution, assessing and analyzing the learning needs of a user/client/student group, defining learning objectives, and developing a solution to meet those learning objectives (Reigeluth, 1999; Richey, Klein, & Tracey, 2011). The focus of this book is on the latter aspect of this operational definition, the arena of designing, developing, and implementing an instructional solution. **Instructional message design is the real-world application of learning theories to effectively design the tools used to communicate, convey information, and transfer knowledge.** Similar to Fleming and Levie's (1978; 1993) foundational work in instructional message design, this book also assumes the reader has a background and is familiar with instructional needs analysis and the basics of instructional design. An excellent reference for the instructional design process is Morrison, Ross, Morrison, and Kemp's (2019) *Designing Effective Instruction*. The contents and guidance of this book falls within the "Designing the Instructional Message" phase of the Morison, Ross, and Kemp model, or developing how to best present and communicate the information that the learner needs.

Also following Fleming and Levie's original guidance, this book focuses on four key objectives (1978). The authors in this book

present empirical research, from the early foundations of each topic to the latest theory and findings. The chapters of this book also focus on the practical application of theory and research. While each of the talented authors in this book have an applied research background, the authors take a non-technical writing approach in each chapter (with some noticeable deviations from classic, academic APA style). The topics in this book can be applied in a number of learning environments including K-12 general and special education, higher education, military, government, and corporate settings. Additionally, many of these principles apply in traditional and online environments with K-12 and adult learners. The final goal of this book is to present practical examples and real-world best practices in each chapter.

Instructional designers have a wide range of tools and techniques to design instructional messages. Gestalt theory, cognitive load, dual coding, working memory, and multimedia learning theory are among some of the many theories that can be applied as design heuristics. Text, topography, graphics, diagrams, animation, video, multimedia, and simulations are among the many options to present information in our instructional messages.

Instructional Message Design Theory

There are several key theories that guide our instructional message design. These selected theories help describe the cognitive processing of our learners, and thus can be used to define guidelines and best practice.

Gestalt Theory

Gestalt (German for 'shape' or 'form') theory states that individual components of a picture do not communicate much by themselves, it is only when these individual components are combined do they form a picture (Wertheimer, 1944). A complete image is only able to communicate an idea when the components of that image are integrated and presented together.

Gestalt theory has evolved to now include five principles (Lohr, 2008). The first principle is Closure, or humans will see the whole of an image before we will see the individual parts. The second

principle is Contiguity, or the human eye will tend to follow a path when a path is presented in an image. The third principle is Similarity, or the human mind will seek and look for patterns. The fourth principle is Proximity, or we will integrate image components into the complete image based on how close or far those components are displayed. The final principle is Experience, or we will see an image and tend to relate it to something that we are already familiar with. This principle is very similar to schema theory, which states that when presented with new information, humans will tend to look to connect that new information to previously learned ideas, concepts, or patterns (Bartlett, 1936). Gestalt theory helps explain the cognitive processes that are occurring in the working memory of our learners when they are presented with instructional message designs.

Cognitive Load Theory

Our learners have finite short-term or working memory resources for cognitive processing. Cognitive processing, or cognition, is the act of a learner taking available information and adjusting their understanding or behavior based on that information (Izard, Kagan, & Zajonc, 1984). While there may be some debate as to the true quantitative measures of working memory, an early insight put these resources somewhere in the range of seven plus or minus two units of memory (Miller, 1956). This limitation on short term or working memory was supported by research that would eventually evolve into cognitive load. Work to identify the difference between novice learners and expert learners realized that the distinction could be that inexperienced students may be expending their cognitive resources early during problem solving exercises (Sweller, 1988). Expert students have previous schema to pull from long-term memory to help when problem solving. This schema occupies only one of those five to nine working memory units allowing the learner to focus their remaining cognitive resources on solving the problem. Novice students have not developed this schema, and so have to use all their cognitive resources on understanding and solving the problem.

Cognitive load theory continued to develop and is comprised of three basic principles (Pass & Sweller, 2014). Cognitive load theory assumes that learners have limited working memory resources, that the contents of working memory fade after a short time, and humans

have a capacity for nearly infinite long-term memory because of schemata, or the storing of information as patterns). Cognitive load describes the capacity of a learner's working memory resources in terms of germane resources, extraneous load, and intrinsic load (Sweller, Ayers, & Kalyuga, 2011). Extraneous cognitive loads are distracting aspects of instructional message design that divert attention, annoy, or confuse learners. Intrinsic cognitive load is the actual message design and the inherent difficulty of the subject matter. Intrinsic load can be managed and minimized through strategic chunking techniques, development of schema, and scaffolding. Germane resources (often also referred to as germane cognitive load) are the cognitive resources that are available after extraneous load that the learner has available to apply to intrinsic load. The goal of instructional designers is to minimize extraneous cognitive load, minimize intrinsic cognitive load, and to maximize available germane resources to focus on that intrinsic load.

Multimedia Learning Theory

Multimedia learning theory evolved from experiments with random treatment groups and digital multimedia with static illustrations with and without text (Mayer & Gallini, 1990). These early results indicate the unique advantages of using multiple media technologies at the same time in the same presentation. Mayer's cognitive theory of multimedia design evolved from this use of text and illustrations and was first based on the dual-coding findings of Paivio (1991), and then integrated the working memory and cognitive load findings of Baddeley (1992) and Sweller (1991). Dual-coding theory states that humans will process video, slides, or animation separately from audio and narration. Learners cognitively combine that information in working memory, then store that information in long-term memory for future retrieval. Humans also have finite short-term and working memory resources, and these limited germane cognitive resources should be guided to focus on intrinsic content rather than extraneous design distractions.

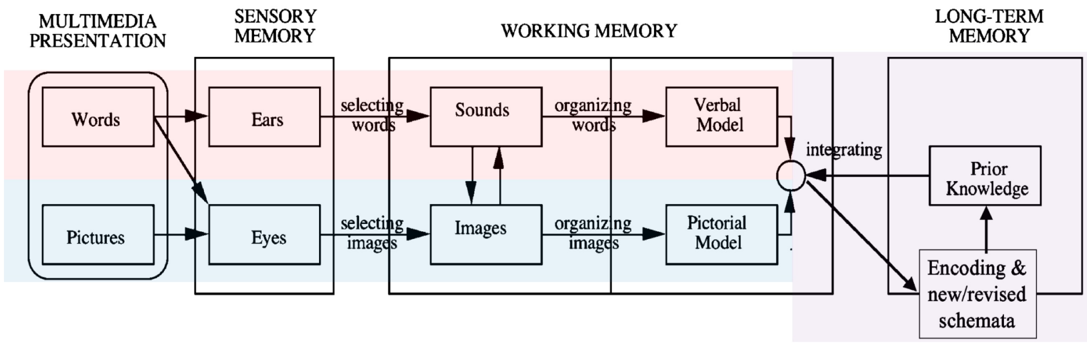

Figure 1. Multimedia learning theory describes that narration and audio information are analyzed and managed by our verbal processing channel while visual information is analyzed and managed by our pictorial processing channel and integrated together in our working memory (modified from Mayer, 2014).

Multimedia learning theory integrates the further explores the dual processing of visual and narrative information, see Figure 1 (Mayer, 2014). The basic guidelines defined by multimedia learning theory can be summarized into three key ideas (Clark & Mayer, 2016). In general, presenting pictures and text together will be more effective than presenting pictures alone or text alone. Next, instructors and instructional designers should look to reduce or eliminate (as much as possible) extraneous and nonessential information or distractions from multimedia presentations. Also, to further aid learning effectiveness multimedia can be personalized, using polite, informal, conversational, and human voices integrated with visuals. Understanding and applying these concepts, especially when looking to effectively deploy multimedia, is a critical aspect of instructional message design.

The Message and the Media

While the affordances of different technology or media allow for different aspects of communication, the instructional message is more important than the media, technology, or vehicle used to deliver that message. For instance, consider a unit of instruction that describes the inner workings of an electric motor. In this context an animation that shows the cross section of the motor and what happens

inside that motor when it is in motion may be more effective than showing a series of still slides. In this example, an animation may be more effective, though we cannot generalize this conclusion to say that animation is a better tool than PowerPoint slides. This would be like saying hammers are better tools than screwdrivers. In practice, both tools can be effective depending on the application and the available resources.

Rather than comparing technologies and tools to each other (as in a media comparison study), it is more important to study the efficient and effective use of each tool in a message design context (Clark, 1983). It is also important to focus on which media or technology has features that differ from other options or earlier versions, such as if the new technology offers immediate feedback, user input, customization, ease of implementation, and/or better technical support (Morrison, 1994). The analysis of what technology to use to deliver our message should now also include the heuristics of multimedia learning theory, implications of cognitive load (especially extraneous load), the equivalency to other options, and cost effectiveness (Clark, 2012). This aspect of cost effectiveness is also important to consider, especially from a human performance technology perspective. In terms of instructional systems, cost effectiveness, student satisfaction, instructor satisfaction, learning effectiveness, and accessibility are among the variables to consider in high quality programs (Moore, 2002). In instructional message design, it is important for us to be sure the vehicle we are using to deliver our message meets the needs of our learners, including accessibility, quality, cost effectiveness, as well as learning effectiveness.

The Cone of Experience

The cone of experience describes the attributes of media and technology in terms of the conceptual involvement of the learner (Dale, 1946). While this model was developed in the context of the technology available in the early 20th century, its concept of engagement is still as relevant today as it was then. The model describes a scale of learning engagement from concrete, cognitively tangible to abstract, intangible experiences. For instance, reading a textbook would be among the most intangible of learning experiences (near the top of the cone). A hands-on cognitive apprenticeship would be among the most tangible of learning experiences (near the bottom of the cone). A cognitive apprenticeship is learning directly from an expert, ideally in a one-to-one setting, in the authentic environment where the lessons learned will be applied (Brown, Collins, & Duguid, 1989). For instance, learning from an experienced auto-mechanic in a professional garage, will be a much more engaging experience than reading about changing an alternator from text in a book. In the context of message design, the affordances of a virtual reality simulation should be able to offer a richer learning experience than a PowerPoint presentation (assuming that the resources are available and that the learning objective will benefit from the use of a simulation). Note, this does not mean that one technology is "better" than another - rather the use of different technology in our message designs will inherently introduce differing levels of direct or abstract engagement (see Figure 2).

Dale's "Cone of Experience":

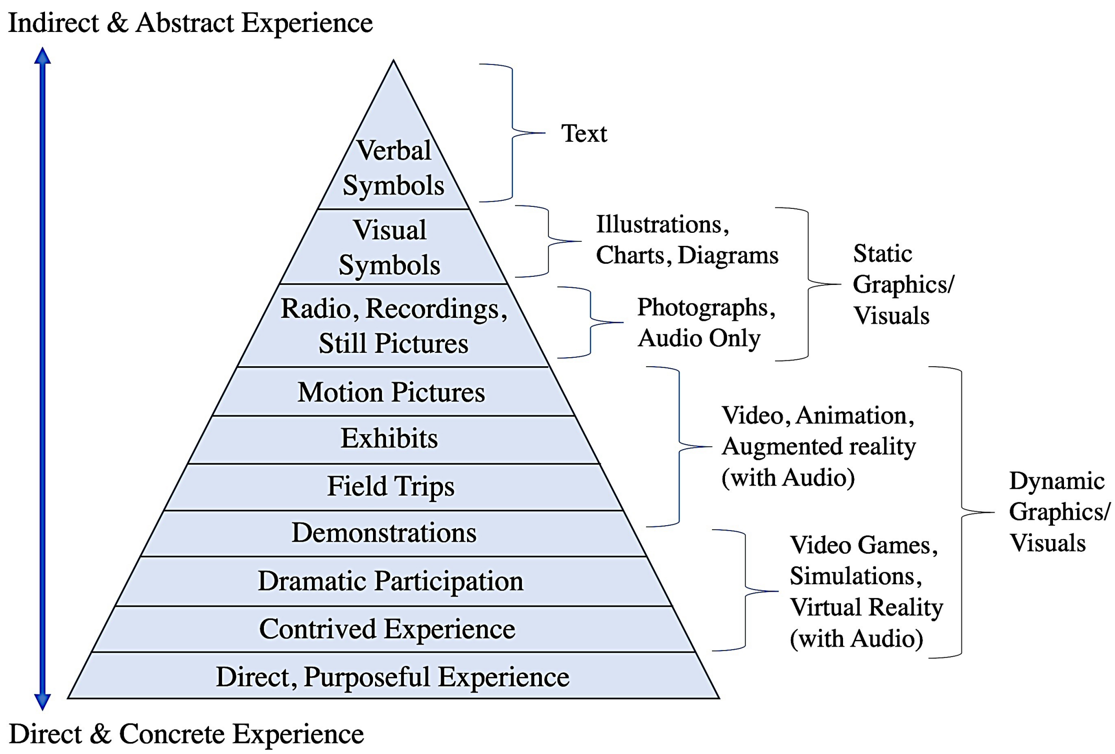

Figure 2. The cone of experience can be used to describe how message design tools and techniques can be used to engage students in terms of indirect and direct experiences.

The General Communication Systems model

Signs and symbols are fundamental aspects of human communication (Bruce-Mitford, 1996). Humans use symbols to make understanding of intangible ideas, for instance, the letters of the alphabet are symbols for sounds. Signs are used to represent an object or idea, such as the physical signs that we see along a highway, or the logos that we see on objects and in marketing ads. A signal can be a method of cueing or gaining attention (Richey, Klein, & Tracey, 2011). Or, in technical telecommunications terms, a signal is the transmitting and receiving of symbols and signs between a sender and receiver, see Figure 3 (Shannon & Weaver, 1949). In either case, in terms of instructional message design, the success of the message depends on the system used to convey signs, symbols, and signals between our instructors and our learners.

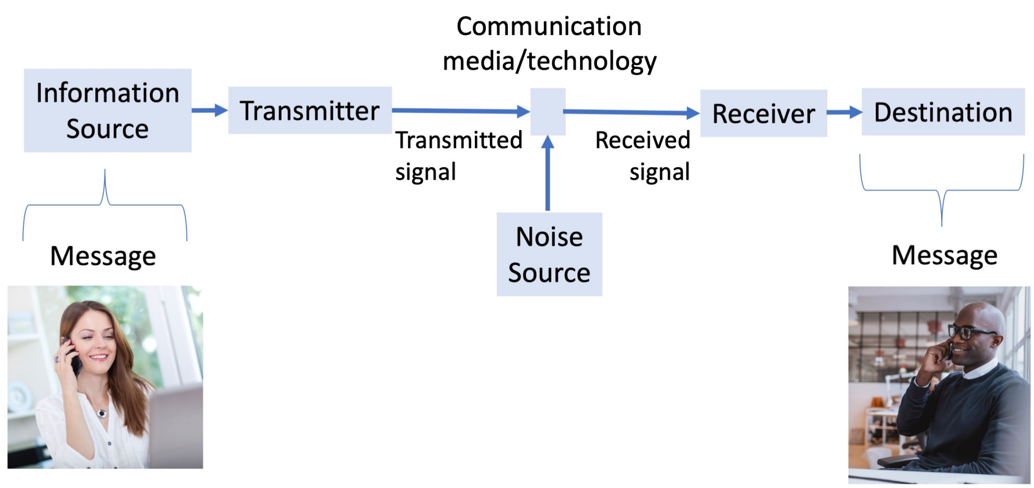

Figure 3. The general communication systems model describes how a message in the form of an information source is sent and received by a destination.

A communication system consists of three components: the accuracy of the symbols being received, the accuracy of the symbols delivering the message, and the understanding of the message (Shannon & Weaver, 1949). The communication process begins with an information source, or a message. The message is encoded, in today's communications systems this encoding takes that message and

converts it into digital 1s and 0s. Those 1s and 0s are carried by a signal to their destination. For instance, our message can be converted into digital 1s and 0s and carried by a signal, over a network to the Internet to another network and to the person that we are sending the message to. There is a receiver at the destination that converts those 1s and 0s back into something that hopefully looks like the original message. Along the way that signal can encounter "noise" or interference than can damage the signal and the message. For example, if there is a network or Internet connection issue, the signal from our transmitter to receiver could be disrupted.

In terms of instructional message design, the general communication model describes how the message is sent and received. In conceptual terms, the "signal" could be a live, interactive web conferencing protocol that is transmitting our audio, video, and PowerPoint slides, or it could be a textbook or research poster we have designed. In either case, the noise encountered by our image could be extraneous cognitive load erroneously introduced by an instructor or instructional designer, or a bad Internet connection, or both. The intended message sent may not be the message received or understood at the destination. A goal in instructional message design is to create, design, and utilize a system that would be robust to both technical and cognitive communication issues.

Instructional Message Design Tools and Techniques

Text and Typology

Text can be operationally defined as the main set of written words in a body of writing, a font is a computer-generated text style, and typography is the study, design, and application of text and fonts (Lohr, 2008). Legibility and readability describe how easy it is to read different types of fonts and a serif font has small strokes at the ends of letters, while a sans serif font does not (Lohr, 2008). Legibility is the ease of reading a short set of text, legibility can be made easier with the use of a more modern, sans serif font like Helvetica. Readability is the ease of reading long sets of text, readability can be improved using a classic serif font like New Times Roman.

There are several other characteristics of a font that contribute to its legibility and readability (Bringhurst, 2004). A font's x-height (the height of the lowercase letter "x"), ascenders and descenders (how much of letters extend above and below the line of text), counter (the filling inside letters), kerning (the amount of space between letters) can all impact the ease of reading that font (see Figure 4). Other common variables in terms of writing for instructional designs include font size, line spacing, and the selections of a serif or sans serif font. In addition to the many serif and sans serif options, there are decorative fonts, resembling elegant and informal handwriting. However, many of these font types lack legibility and readability in instructional applications. Before the inherent resolution of today's devices and displays, we were taught to never use fonts much smaller than 24-point. While we do not want to make our text illegible, high-definition displays offer the affordance to decrease our font sizes to increase the information that we are able to display. For message design for mobile devices, if learners cannot control the amount of text on their screen than it is best to err on the side of lower text density (Ross, Morrison, & O'Dell, 1988).

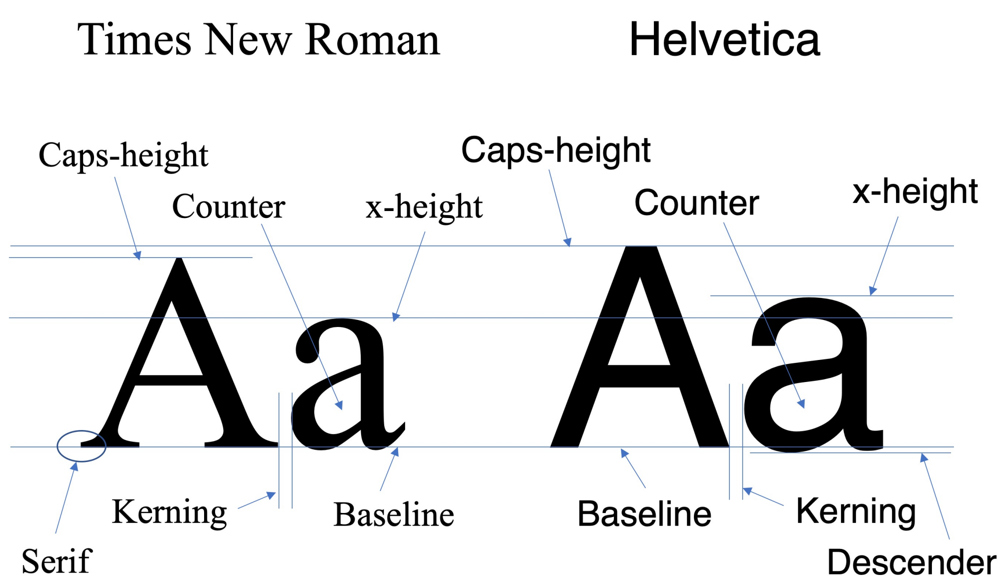

Figure 4. Several aspects of font design can be seen when comparing Times New Roman and Helvetica (note, this figure was made with PowerPoint and a 191-point size for both fonts).

Hierarchy is used to create headings that organize blocks of text into main sections and subsections (Lupton, 2010). White space between headings, bold and italicized text, capitalized letters in words, and indentations can be used to organize bodies of text and cue readers. Hierarchy in short bodies of text can be accomplished with bullets that create a list of ideas, thoughts, or concepts. This typographical signaling aids in browsing, searching, skimming, and gaining the reader's attention (Waller, 1979).

Color

The use of color in message design will have direct and indirect psychological and cognitive implications. For instance, in educational or business contexts I am sure we can all recall the ill-advised use of text color against background color during a presentation. The body of advertisement and marketing knowledge also recognizes the impact of color in message design. Color can be used to gain attention, project professionalism and quality, and induce unconscious decision making (Mohebbi, 2014). Color hue (the color's specific color family) and saturation (the intensity or purity of hue) can enhance positive or negative intentions of message design (Labrecque, Patrick, Milne, 2013). In instructional message design, color can also be used to distinguish different aspects of a diagram, for measurement and quantities as in a chart, for representing reality as in a photograph, and for creating aesthetic appeal (Tufte, 1990).

Another review of the color and psychology research results in a summary of the emotional and potential cognitive implications of different colors in instructional design (Lohr, 2008). Dark greys and black are thought of as somber or elegant shades, while white and light colors signify purity and innocence. It is thought that red signifies passion or power, while orange signifies happiness and warmth, and yellow signifies brightness and idealism. Greens suggest growth and nature, blues represent tranquility and dependability (and sometimes sadness), violets suggest royalty and nobility, and browns represent duty and reliability. Thus, using a light blue background in web design or for slides could elicit a sense of calmness during a presentation.

Graphics

Instructional graphics should communicate and reveal data (Tufte, 2001). This operational definition is especially true in instructional design. Visual elements beyond text can be categorized into two main types: static art or dynamic art (Clark & Lyon, 2011). Static art is graphics that do not move, such as illustrations, photographs, and three-dimensional, computer models. Dynamic art is visuals that move and do not remain static, such as animation, video, and virtual reality. Also, as multimedia learning theory would predict, including narration and sounds in animations, video, and other dynamic visual application will further enhance learning.

Illustrations. Graphics, or visual elements designed or constructed to present data, ideas, or concepts, can take the form of diagrams, charts, and pictures. While there is merit to decorative graphics that aid in the professional appearance of a message or to serve as a cueing aid, care must be taken to avoid distracting extraneous load (Morrison et al., 2019). Along with avoiding "chart junk and PowerPoint Phluff" that unintentionally distracts from the content of the graphics, ethical designers should never manipulate the message and graphic design to mislead (Tufte, 2003). Well-designed charts and illustrations that should show data comparison, causality, multiple variables, integration of multiple data types (words, numbers, images, diagrams), documentation and references, and a faithful focus on the content (Tufte, 2006). Also, diagrams and text should be integrated as much as possible, and diagrams within a text should be positioned as close as possible to the paragraph that describes that diagram (Mayer & Moreno, 2003).

Photographs. Photographic art is still life, realistic images taken with a film or digital camera (Clark & Lyons, 2011). While the same can be true for complex diagrams and digitally constructed models, photographs are inherently comprised of depth, texture, and shade that can be used to direct attention (Lohr, 2008). There may be authenticity implications and benefits of using color photographs in instructional designs as opposed to black and white or greyscale illustrations. However, there could also be cognitive load consequences, especially for novice learners. Photographs also have the fundamental attribute of the instructor or students being able to

zoom in and see subjects or objects in greater detail (Kemp, 1975). Digital photographs can be used to provide learners with a view of the authentic environment they will be performing in or learning about (Lohr, 2008). The authenticity of photographs is in line with other learning theories such as situated learning which focuses on the unintentional aspects of education due to the realism of the learning experience (Lave & Wagner, 1990). Photographs can also provide a cultural and historical context that a diagram or illustration typically could not.

Modeled Graphics and Augmented Reality. Modeled graphics are static visuals that are three-dimensional and have been created digitally (Clark & Lyons, 2011). Augmented reality applications would fall into this category. Computer generated images may be more effective than actual photographs, especially when lighting is poor or when backgrounds behind the subject of the photograph can be distracting (Greitzer, 2002). In an augmented reality application, the learner is typically able to manipulate a three-dimensional, computer generated object against a realistic space or background (Azuma, 1997). Augmented reality allows users to see the unseen, engage in gamification and learning challenges, make connections to other content or previous learning, and compare and contrast content (Dunleavy, 2014; Yoon & Wang, 2014). For instance, in an educational setting, learners can point their mobile devices at an image and be presented with additional information about that object. Other applications of modeled graphics would include contexts where the learning object cannot be easily photographed and when details beyond typical illustrations are required.

Animation. An animation is a series of simulated images that changes over time, such as a rate of 30 images per second, to simulate motion (Ainsworth, 2008). Note, this operational definition is different from video, which is a series of real images that when moving at 24 to 30 frames per second is perceived as motion. Animation is helpful when the instructional objectives require learning about an object, concept, or principle that inherently moves. As compared to trying to learn from a series of static images, learning about an object over time or in motion should be cognitively easier when learning from animation. Also, with all other aspects of

instruction being equal, animation with narration will be more effective than animation on its own (Mayer & Anderson, 1991; 1992).

Video. Similar to the use of static photography for authenticity and realism, video can also be used to record authentic environments especially when audio is also recorded. Video can be used to enhance social presence, for virtual field trips, and to record and collect data (recorded audio and video) from locations that would logistically challenging or inaccessible. Video in instructional applications will be more effective in terms of social presence when students are able to see video of their instructor in online classes (Jayasinghe, Morrison, & Ross, 1997; Ramlatchan & Watson, *in press*). Video can also be useful for novice learners of a process or procedure due to the richness of detail, though video may be less effective with more experienced students (Ganier & de Vries, 2016). Experienced students may not need the details, and so the video may introduce extraneous load from this perspective. Also, the moving images in full motion video are also most effective when that video is also accompanied with its associated audio. Other video applications include tours, portrayals, point of views (such as "how-to" videos), and highlighting (such as the use of digital pens, slow motion, and zooming) (Schwarts & Hartman, 2014).

Video Games, Simulations, and Virtual Reality. Several tools and techniques fall into this generalized category of dynamic, computer generated visuals.

Video games. Successful instructional game play using personal computers, game consoles, or mobile devices involves higher order thinking and learning skills as well as collaboration skills that transfer into real-world situations. Playing, and learning, from early video games involved hand-eye coordination, reflexes, concentration, and visual perception (Heinich, Molenda, & Russell, 1989). As the processing power of devices improved, video games evolved to take advantage of those affordances. Video games soon also included more complex problem-solving challenges and strategic planning (Gee, 2003). Video games that involve problem solving now often require players to analyze situations, synthesize solutions, and test the validity of those solutions to be successful. Digital natives, or learners who have never known a world without mobile devices, the

Internet, and complex video games, may benefit from neuroplasticity (Prensky, 2006). Neuroplasticity describes how the human brain adapts to stimulus, or how digital natives adapt to and learn from video games. In addition to higher order thinking skills, many video games also now include aspects of research, creativity, communication, and collaboration with other players (Qian & Clark, 2016).

Simulations and virtual reality. Simulations do not need to be computer generated (such as in classroom case studies and role plays). However, in the context of this book a simulation is the creation of a virtual environment for the integration of learners into a learning situation. The learner is immersed into an authentic problem, where they have to generate and test a solution, and reach a conclusion (Heinich, Molenda, & Russell, 1982). For instance, learning on simulators is less expensive, and introduces less risk, than initial learning on actual aircraft. The skills learned in high fidelity simulators transfer to more advanced learning on actual aircraft (Hays, Jacobs, Prince & Salas, 1992). Hardware simulators, such as aircraft and motor vehicle systems, use displays, hydraulics, and the physical interiors (control panel or dashboards) of the systems that they are imitating to simulate the actual system (Gawron, Bailey, & Lehman, 1995; Kuhl, Evans, Papelis, Romano, & Watson, 1995).

There is ample evidence for the general effectiveness of simulation and simulators, especially in support of other instructional strategies (Rutten, van Joolingen, & van der Veen, 2012). Additionally, simulations are extremely advantageous when other strategies, such as lab work online and teaching pilots and drivers, are unavailable, logistically challenging, or would otherwise be physically dangerous for the learner. Emerging, cost-effective, high resolution, head-worn technologies promise to be a new arena in immersive simulations and message design (Hupont, Gracia, Sanagustin, & Garcie, 2015). Virtual reality can employ head worn devices to immerse learners in artificial, computer generated environments or worlds (Freina, Bottino, & Tavella, 2016). In an instructional context, virtual reality systems can be designed to simulate real-world environments to prepare learners and allow for practice.

Instructional Message Design Applied: PowerPoint

A discussion on instructional message design would be incomplete without a discussion on Microsoft PowerPoint given its ubiquitous use in academia (and business, and government, and any application where information is shared via presentations). The use of PowerPoint may induce negative opinions and connotations (think the common euphemism "death by PowerPoint" in business meetings), it has even been blamed for the 2003 NASA *Columbia* space shuttle disaster (Tufte, 2003). According to the classic 6x6 rule, a PowerPoint slide should not have more than six words in a line and no more than six lines (Lohr, 2008; Zimmerman, B. & Zimmerman, S. 2009; Zimmerman, B., Zimmerman, S. & Pinard, 2014). However, PowerPoint is a message design tool, and as with any tool there are those who use it well and those who do not use it well (Gabriel, 2008). This philosophy is especially true for modern iterations of PowerPoint that include the ability to apply many of the text, typology, graphics, and multimedia heuristics described in this book.

There is a lot more that can be done with PowerPoint besides extraneous cognitive load inducing templates and bullets. When it is thought of as more about "design, not software" it can be used to guide a lecture, deliver an effective business presentation, or develop engaging, interactive e-learning modules (Bozarth, 2008). However, PowerPoint can also become a crutch for a presenter and distract from substantive content. A presenter should avoid the urge to read verbatim from slides, avoid irrelevant images, and avoid too many decorative "bells and whistles." Deviations from the traditional 6x6 rule can also be made to allow for a focus on content, but care should be taken to avoid extraneous load (such as sounds and overly animated bullets points that do not cue but distract). Chapter five culminates and summarizes the theories and principles discussed in this book and presents evidence based best practice for the optimal use of PowerPoint.

Conclusions and Future Directions

These are only some of the many learning theories and applications of instructional message design and only serves as an introduction to the topic. Subsequent chapters in this book delve much deeper in the theoretical frameworks and evidence-based practices associated with the tools and techniques briefly introduced here. Along with the ability and affordances of newly emerging technologies, there are a number of other aspects of message design that can be explored. Future research directions could continue to explore the social presence implications of message design, applications in online and distance learning, and customizing learning for differing cultures, age groups of learners, and learners with special needs.

Instructional design is an applied science, where theories and models have practical, real-world applications that benefit learners. Instructional message design draws from several areas and fields of study and describes how designers can create systems, programs, and products that effectively communicate information. Readers and researchers are encouraged to follow-up on the studies presented in this book, either to replicate or to extend these formative message design findings with new research on contemporary tools and technology with samples of today's digital natives.

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Instructional Message Design:
Theory, Research, and Practice

Chapter 2: Cognitive Load Theory and Instructional Message Design

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Chapter 2: Cognitive Load Theory and Instructional Message Design

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Key Points

- Cognitive processing is required for all learning tasks, and is separated into components of intrinsic, extraneous and germane cognitive load
- Working memory and long-term memory vary greatly in their functions and capacity
- The effects of all types of cognitive load can vary based on learner expertise
- Message design can significantly decrease the level of extraneous cognitive load in all formats of instructional materials

Abstract

Although theoretical in basis, Cognitive Load Theory (CLT) is pragmatic in nature. Its goal, as it relates to instructional message design, is to present information in a way that enables the learner to process it as efficiently as possible and add it to their brain as learned information. This process relies on the brain for memory, which is separated into two component parts – working memory and long-term memory. Both of these forms of memory are required to connect new information to information that is known – which are essential

elements in the learning process. To do this, information that detracts from processing is discouraged, information that assists in processing is encouraged, and any complexity inherent to the learning is presented at a level that is appropriate (Chandler & Sweller, 1991; Sweller, 2008; Sweller, van Merrienboer, & Paas, 1998).

Introduction

In order to appreciate the effect of cognitive load on message design, we will begin by describing the processes in the brain, which help us to remember, and ultimately to learn. We will then explore the research that went into the development of seven heuristic guidelines useful in designing instruction focused on effective cognitive processing. Finally, we will apply these heuristic ideas to the forms of static media (such as text and images) and animated media (such as audio and video recording and simulations).

You may be asking how this chapter will aid in developing a message design knowledge base. The answer will vary, depending on your level of expertise as you begin this exploration. For those readers who have completed prior study in learning theory or instructional design, you may wish to jump to the final section of the chapter for pragmatic examples prior to moving on to chapters specific to your goals. For those who are new to the arena of learning theory and instructional design (regardless of audience), the theory may provide insight into approaches you have implemented successfully in the past or provide guidance into some new approaches you may choose in the future.

Memory

Memory is the process by which the brain first encodes, stores, then recalls information (Mellanby & Theobald, 2014). Cognitive theory suggests that there are two centers of memory aided through cognitive structures. Long-term memory, whose primary process is organization and storage and working memory, whose primary process is encoding and processing (Mellanby & Theobald, 2014; Sweller, van Merrienboer, & Paas, 1998). Connections between the two areas are supported through organizational structures called

schemas (or schemata) (Sweller, van Merrienboer, & Paas, 1998). These structures of learned patterns aid in organizing information and facilitating its transfer between working and long-term memory.

Long Term Memory

Long-term memory serves as the information store for all results of learning. Although long envisioned as a repository, long-term memory serves equally to organize and recall key pieces of information during the learning process (Baddeley, 1995; Mellanby & Theobald, 2014; Sweller, 2008). Sweller (2008) suggests that it is "…the central structure of human cognitive architecture" (p.371).

Information is transmitted to the long-term memory through encoding and organizing processes of the working memory. These same processes rely on appropriate retrieval of information to categorize new information and is an essential element in learning (Sweller, 2008). Continual cognitive functions, including auditory and visual communication, ensure information remains current, retrievable, and relatable (Sweller, 2008). Long-term memory interacts with the working memory and serves as a support for the association of new knowledge within structures of existing knowledge, commonly referred to as schemas (van Merriënboer & Sweller, 2005). These organizational structures assist the brain in retrieving information and connecting this information in complex ways (Sweller, 2008; van Merriënboer & Sweller, 2005). Schema assist both the long-term storage and retrieval of information, as well as its ability to be encoded (van Merriënboer & Sweller, 2005).

Working Memory

Although sometimes referred to as short-term memory, working memory represents the encoding mainstay of the brain. One of the seminal researchers in the field, Alan Baddeley (2000), defines working memory as "a limited capacity system allowing the temporary storage and manipulation of information necessary for such complex tasks as comprehension, learning and reasoning" (p.418). Baddeley's model has developed over the years, and currently

includes four component parts. Figure 1 illustrates the relationship between these cognitive elements.

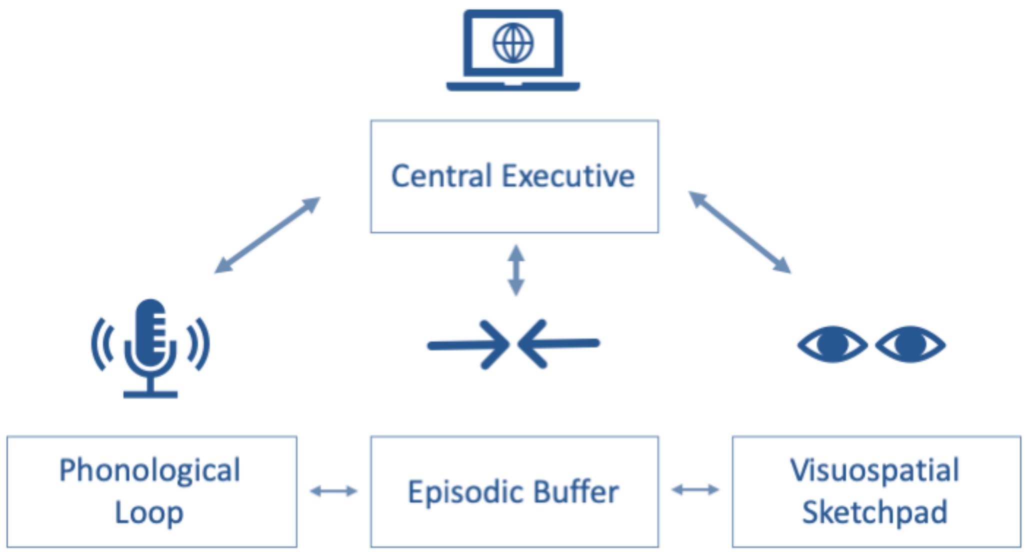

Figure 1. Graphical representation of the components of working memory Adapted from "The episodic buffer: a new component of working memory?" by Alan Baddeley (2000, p. 421).

The central executive serves as the processing core. This component focuses attention and allows for encoding of new information (Baddeley, 1995, 2000; Jonides et al., 2008). The central executive is supported by cognitive areas which aid in the processing of new information. These are the phonological loop, visuospatial sketchpad, and episodic buffer (Baddeley, 1995, 2000, 2003; Jonides et al., 2008).

The phonological loop stores auditory-verbal information for a matter of seconds, unless this time frame is altered by some form of repetition or processing (Baddeley, 1995). The ability to retain information within the phonological loop has been proven to be affected by similarity of the items as well as the item length (Baddeley, 1995, 2000; Sweller, 2008). In addition, memory can be limited by suppression of the auditory processes such as rehearsal, resulting from the repetition of an extraneous word or sound throughout the process of encoding, or allowing external noises to distract (Baddeley, 1995). Consider for example, when watching a

recorded interview, the effect of background music on your processing of the information. This effect can often be the result of an overload within the phonological loop (Baddeley, 1995).

The visuospatial sketchpad is the second reinforcement to the central executive and functions similarly to the phonological loop, however it stores visual information (Baddeley, 1995, 2003). Visual, spatial, and forms of kinesthetic information are stored here throughout the encoding process (Baddeley, 1995; Sweller, 2008). Similar to the suppression effect in the phonological loop, the visuospatial sketchpad can be clogged by unnecessary visual information (Baddeley, 2003). Consider the habit of closing one's eyes when trying to remember, this has been correlated with a reduction of visual interference (Vredeveldt & Vredeveldt, 2011).

The final piece of the Baddeley model of working memory is the episodic buffer. This component is most similar to the central executive as it serves to create a complex memory by integrating contents of the phonological loop and the visuospatial sketchpad (Baddeley, 2000). Baddeley (2000) described this buffer as "… episodic in the sense that it holds episodes whereby information is integrated across space and potentially extended across time" (p. 421). Although this function is temporary, similar to other working memory processes, it has been shown to assist in forming connections to similar information in the long-term memory (Baddeley, 2000).

Early Research Supporting Cognitive Load Theory

In the late 1950s an educational psychologist from Harvard named George Miller began to notice some consistencies in the ability of the working memory to encode information. He began to conduct research into the phenomena and became plagued by the number seven (Miller, 1956). Although the number would vary slightly, in numerous experiments this number would emerge as the amount of information that could be encoded by the working memory – causing Miller (1956) to refer to it as "The Magical Number Seven Plus or Minus Two" (p.81). As his work progressed, he theorized that this number applied to two separate functions within working memory, absolute judgements, and immediate memory (Miller, 1956).

Miller's research built upon works exploring the recall of items such as auditory tones, taste sensations, and colors. Although he

found that the brain could process different topics and stimuli simultaneously, its ability to transfer that information into long-term memory was always limited in quantity to seven units of information, plus or minus two (Miller, 1956). Miller stated simply (1956): "There seems to be some limitation built into us either by learning or by the design of our nervous systems, a limit that keeps our channel capacities in this general range. (p.86)"

In regard to absolute judgments, Miller was referring to the amount of information that a person can transmit correctly after receiving it into their short-term memory. The value is binary, as it is either correct or incorrect (Miller, 1956). Potential for correct transmission increases exponentially as the number of inputs increase (Miller, 1956). For example, if a student hears one word, they can transmit that information correctly or not – resulting in two alternatives per bit of information. Miller proposed that there were two alternatives for one bit of information, where two bits were provided, there were four alternatives, where there were three, eight and so on (Miller, 1956). Miller identified the learner's channel capacity – or highest level of correctly transmitted information before performance waned, at six alternatives (Miller, 1956). He found that increasing the number of inputs failed to increase the correct transmittal (or output) of information (Miller, 1956).

For the realm of immediate memory, the researcher sought to clarify the number of items of information that a person could retain in short term memory. Miller proposed the concepts of bits of information and chunks of information (Miller, 1956). Bits were seen as the component parts of chunks.

In terms of modern instructional design theory, Morrison, Ross, Kalman, and Kemp (2011) describe information as falling into four categories – facts, concepts, principles and rules, and procedures. In relation to bits and chunks, a bit might equate to an individual fact, especially when this fact is not related to other items that had been previously learned. In other words, the learner may not have an initial schema to which a new fact (a bit) can be attached. If, however many facts were described using a concept, this concept (or schema of bits) would represent a chunk of information and may make the bits easier to remember. If again, those concepts were joined to develop a principle or rule of behavior, then the chunk would expand to encompass both the component facts and concepts contained within.

Given this broader definition, the limitation of items which can be processed within working memory becomes far more complex.

As a result, this magic number was revisited in 2010 by a researcher named Nelson Cowan. In his work Cowan proposed that this magical number was in fact closer to four than seven (Cowan, 2010). The difference lies primarily in the ability of working memory to isolate items or chunks, and how this pattern differed in more practical applications versus simpler examples explored in earlier works. For example, although one may be able to remember seven chunks of information, the brain will require part of its processing capacity to form those chunks (Cowan, 2010). How the brain processes this information is explored further in the next section. His work brought to light studies that revealed the effect of instructional strategies, such as rehearsing, and the effects of distractors (Cowan, 2010). However, the limitation can be seen as both a strength and a weakness.

For those who viewed the limitation as a weakness, it was believed that the brain simply functioned most effectively with no more than four concepts due to the number of neurons available. In this view, when too much information was presented, some content was simply not able to be incorporated into schemas and was lost (Cowan, 2010).

When viewing the limitation as a strength, it is believed that when learners are presented information at the optimum level of content items it allows the brain to function at the most efficient processing level. This logical structure allows the brain to discern between what is important and what is not and to apply cognitive resources appropriately (Cowan, 2010).

Cognitive Load Theory

In the late 1980s and early 1990s John Sweller was researching problem solving skills and published a seminal article which introduced the management of cognitive load as a potential means to assist novices to solve problems (Sweller, 1988). He built upon research based on the world of chess that showed that the largest difference between novices and experts when working problems, was that experts could envision successful solution steps based upon experience where novices could not (Sweller, 1988). He used the

word schema to place the problem-solving steps in relation to similar steps in previously encountered problems. Sweller documented that novice students who would often resort to a means-end analysis of a problem, often overwhelmed the capacity of their short-term memory to recognize those important problem-solving steps inherent in schema creation (Sweller, 1988). In many ways they were focusing all of their attention on coming to a solution, rather than developing the skills that could help them apply the same processes in the future. As a result, the findings of this initial research indicate that cognitive processes that are not related to learning (or the acquisition of knowledge) were detrimental.

This research continued, with Sweller and Paul Chandler completing an exploration of unnecessary cognitive processing in relation to static images including charts, graphs, and illustrations (Chandler & Sweller, 1991). The pair completed six experiments within industrial settings to gauge the effects of different placements of text material used in support of these images. The experiments were conducted on varying topics and explored the integration of textual information and its effect on instructional efficiency and student learning. In this early work, the Redundancy and Split Attention Effects began to take form (Chandler & Sweller, 1991). Split attention theory suggests effective placement of text and images when both are necessary to comprehend the concept that they are used to illustrate (Chandler & Sweller, 1991; Kalyuga, Chandler, & Sweller, 1999). Redundancy explores the effect of redundant or overly repetitive information on the learning process (Chandler & Sweller, 1991; Kalyuga et al., 1999). Further discussion follows in the Reducing Cognitive Load through Message Design section.

Sweller, van Merrienboer, and Paas (1998) formed a more concrete definition of the component parts of cognitive load present during instructional processes. Cognitive load was divided into three component parts each with special considerations for instructional design – intrinsic, extraneous, and germane.

Intrinsic cognitive load is contingent upon the number and complexity of required elements to be considered, and the level of interaction that exists between these elements (Kirschner, 2002; Sweller, 2008; Sweller et al., 1998). Things that can be learned in isolation of one another, for example definitions of new vocabulary or individual events on a timeline produce low intrinsic load. However, once the elements begin to require interaction, the cognitive load

increases (Kirschner, 2002; Sweller, 2008; Sweller et al., 1998). The same vocabulary becomes more challenging, when one must also use them in appropriate context, or events need to be expressed in relation to one another. Similar to the work of Miller, the level of intrinsic load is heavily influenced by schema creation (Miller, 1956; Sweller et al., 1998). Although intrinsic cognitive load can be minimized through instructional design (by chunking and sequencing complex content into simpler components and elements), its effect on required overall processing cannot be ignored.

Extraneous cognitive load is commonly defined as load which detracts from the process of learning (Chandler & Sweller, 1991; Sweller, 2008). Extraneous cognitive load was indicated as the one area of cognitive load which can also be directly affected by instructional design, including instructional message design (Beckmann, 2010; Sweller, 2008; Sweller et al., 1998). Consider a simple arithmetic lesson, using an example to illustrate. Should an instructor choose to show examples involving complex calculus functions, that happen to include arithmetic calculations to demonstrate, they would be introducing extraneous load. For someone who has not yet mastered arithmetic, solving calculus equations would most likely serve to confuse rather than explain. Diverting attention from the learning process can be detrimental, especially when the sum of the component cognitive load surpasses the processing ability of the learner (Sweller, 2008; Sweller et al., 1998).

Germane cognitive load encourages effective cognitive processing. Even in cases where intrinsic load is low, and extraneous load is minimized, instruction can be improved through the inclusion of germane cognitive load produced through appropriate instructional design. For example, goal free problem sets, worked examples and completion problems are examples of instructional interventions which have been shown to increase germane load (Baars, Visser, Gog, Bruin, & Paas, 2013; Fernandez-Duque, Baird, & Posner, 2000; van Merrienboer & Sweller, 2010). For message design, reduction in redundant information (to eliminate unnecessary processing) has also been shown to increase germane load (Kalyuga et al., 1999; van Merrienboer & Sweller, 2010).

The intersection and combination of these three component parts result in the overall load on cognitive processes within short-term memory. The levels of each component can be adjusted,

provided that the overall requirement of the short-term memory fits within the capacity of the learner.

Figure 2 below represents varying stages of cognitive capacity. In line A of the chart, capacity exists in the brain to add germane cognitive load through instructional design techniques, but it may not be necessary to facilitate learning. In line B, no additional learning strategies could be added without leading to cognitive overload, unless extraneous or intrinsic load was lessened, however learning can still occur. In line C, learning may not prove effective, regardless of the addition of instructional strategies without a decrease in extraneous or intrinsic load.

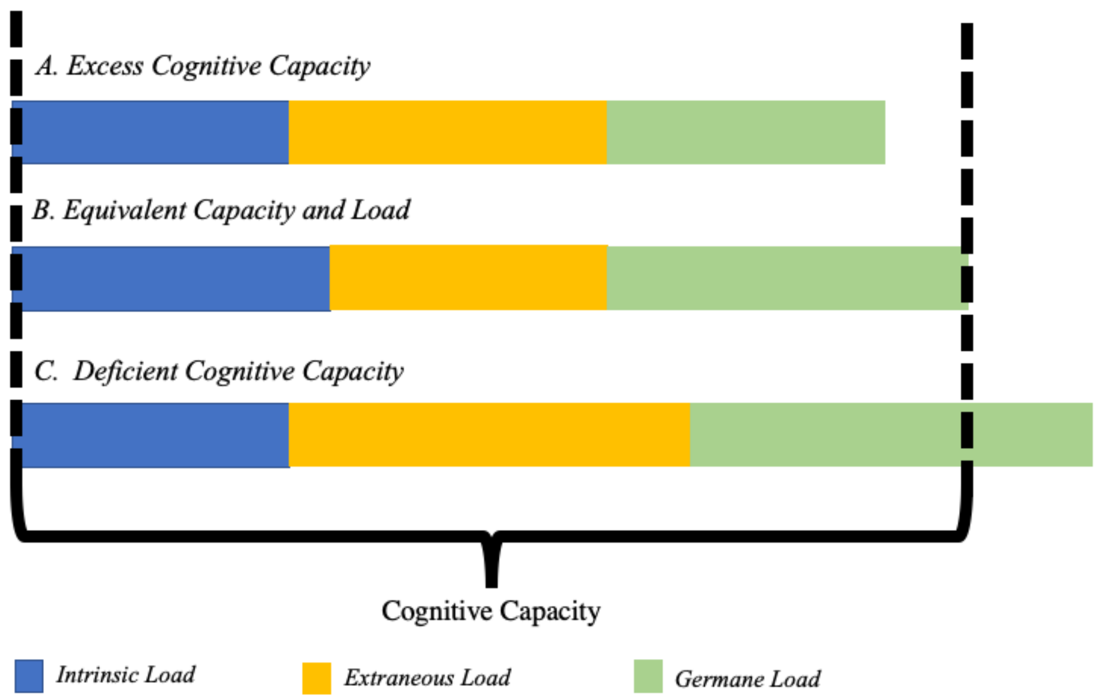

Figure 2. Cognitive capacity by facets of cognitive load Adapted from “Cognitive load theory in health professional education: design principles and strategies” by Jeroen J G van Merrienboer and John Sweller (2010, p. 88).

The goal in both instructional design, and instructional message design, is to ensure that the learner is not taxed beyond their cognitive capacity. In the next section, we will explore methods to reduce this load to an appropriate level through applying heuristic methods of instructional message design.

Reducing Cognitive Load through Message Design

The goal of instructional design is to decrease extraneous and intrinsic load to allow for effective germane load to be added to assist learners. As Morrison et al. (2011) remind us, the goal of effective message design is to "…create an appropriate interface between the instructional materials and the learner" (p. 165). By considering the effects of cognitive load on the presentation of information, extraneous and intrinsic load can be minimized.

Still, no design lives in a vacuum. The ability to decrease extraneous cognitive load through message design, like many other instructional interventions, is contingent upon the expertise level of the learner (Kalyuga, Ayres, Chandler, & Sweller, 2003; Sweller, 2008). Many strategies which reduce extraneous cognitive load, have been shown to be more effective on novice learners. In fact, positive results have been minimized or reversed in some learners with developed expertise (Kalyuga et al., 2003). Researchers in the field of cognitive load theory refer to this effect as the expertise reversal effect (Kalyuga et al., 2003; Sweller et al., 1998). Most findings suggest that this effect is caused by a lack of schema development in novices (Amadieu, Tricot, & Mariné, 2009; Ayres & Gog, 2009; Kalyuga, 2007; Kalyuga et al., 2003; Sentz, Stefaniak, Baaki, & Eckhoff, 2019). This is especially true when encoding has moved from an active process within the working memory, to a rote or automatic process as is common in experts (Mellanby & Theobald, 2014; Sweller et al., 1998). In their study, Kalyuga, Ayres, Chandler, & Sweller (2003) found the expertise reversal effect influenced each method of limiting extraneous load mentioned in this chapter.

Split-Attention Effect

Split attention effect can occur when a learner must acquire information from two different sources to master a concept. Split attention effect occurs when these pieces of information are unnecessarily placed at a distance from each other (Mayer & Moreno, 1998; Sweller, 2008). Due to the need to integrate this information,

unnecessary cognitive load is exerted (Kalyuga et al., 1999; Sweller, 2008).

Split attention in static visuals. The quintessential example of split attention effect can be seen in geometry problems. As is often the case, a diagram most clearly represents the problem to be solved. However, additional text information is especially necessary to support novice learners. Consider the two examples provided in Figure 3.

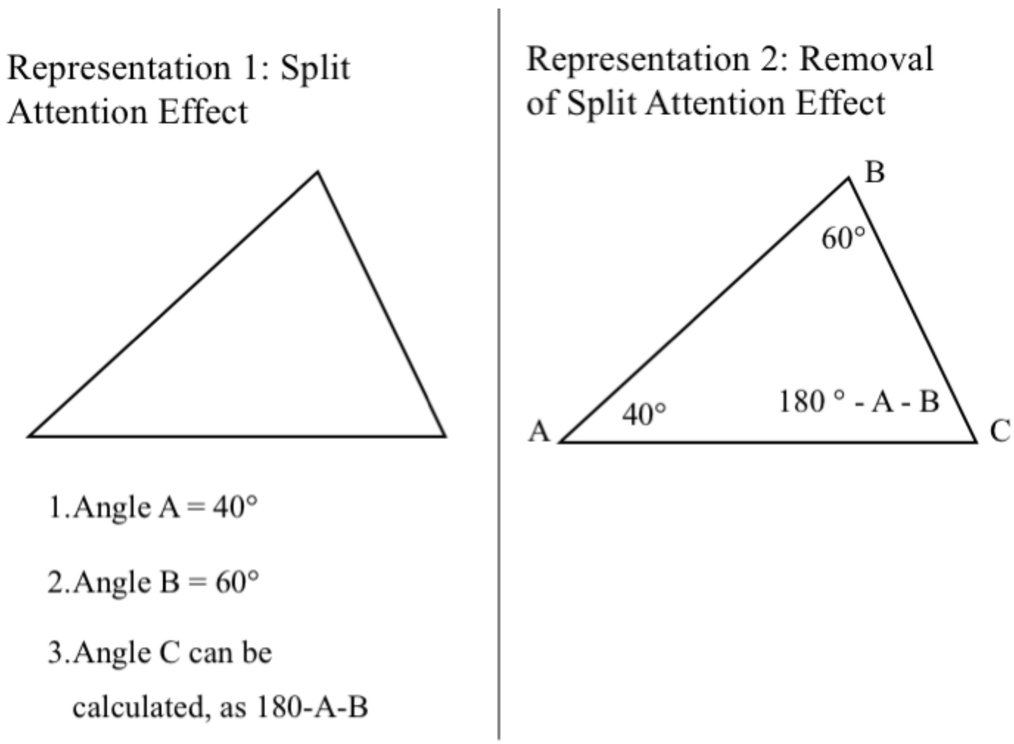

Figure 3: Split attention effect within a geometry problem

For novice learners approaching the problem as displayed in Representation 1, the working memory would be required to split its ability to process between integrating the two disparate presentations of information and solving the problem. Even in this simple example, some cognitive capacity is wasted. By integrating the information, as is done in Representation 2, the designer reduces the amount of extraneous cognitive load through message design.

Split attention in animated media. For animated media, although the concepts remain the same, some applications differ. In relation to simulations which require text information (explanations for example), the included information should again be essential for

understanding, and should be incorporated as closely as possible to the animation or visual representation (Mayer & Moreno, 1998; Sweller, 2008).

When simulation is used to illustrate processes, attention must be paid to the level of detail and scope included. For example, consider the example of a simulation of the parts of a jet engine. Split attention effects could be created if the functions of separate parts of the engine, which relied on one another for comprehension, were presented separately (Sweller, 2008). Animations that focus too specifically on isolated component parts may cause the learner to seek further explanations rather than connecting the information to their long-term memory.

Modality Effect

Similar to the split attention effect, the modality effect is present when the combination of two disparate sources of information are required to comprehend. Where split attention effect is removed by making the integration of information simpler, modality effect seeks to improve the processing ability of working memory (Sweller, 2008; Sweller et al., 1998). You will remember the three processing supports in the working memory, the phonological loop, visuospatial sketchpad, and episodic buffer. Research has strongly suggested that when information includes content that can be processed through both channels, the episodic buffer will assist in its processing (Baddeley, 2000; Sweller, 2008; Sweller et al., 1998). This results in a reduction of extraneous cognitive load.

Modality effect in static visuals. In recent years, the combination of text and imagery, as is suggested through the modality effect, has given birth to a rise in usage of infographics, see Figure 4 (Dunlap & Lowenthal, 2016; Lee & Kim, 2016; Martin et al., 2018). Infographics are defined by Krum as "a larger graphic design that combines data visualizations, illustrations, text, and images together into a format that tells a complete story" (Krum in Dunlap & Lowenthal, 2016, p. 46). Effective infographics include design elements that focus on engaging the learner quickly, flexibility in application to support different learning objectives, and the coherency of the message (Dunlap & Lowenthal, 2016). Given their ability to increase the modality effect in complex subjects, researchers are

beginning to support the use of infographic heuristically in instructional design (Barnes, 2016; Martin et al., 2018; van Merrienboer & Sweller, 2010).

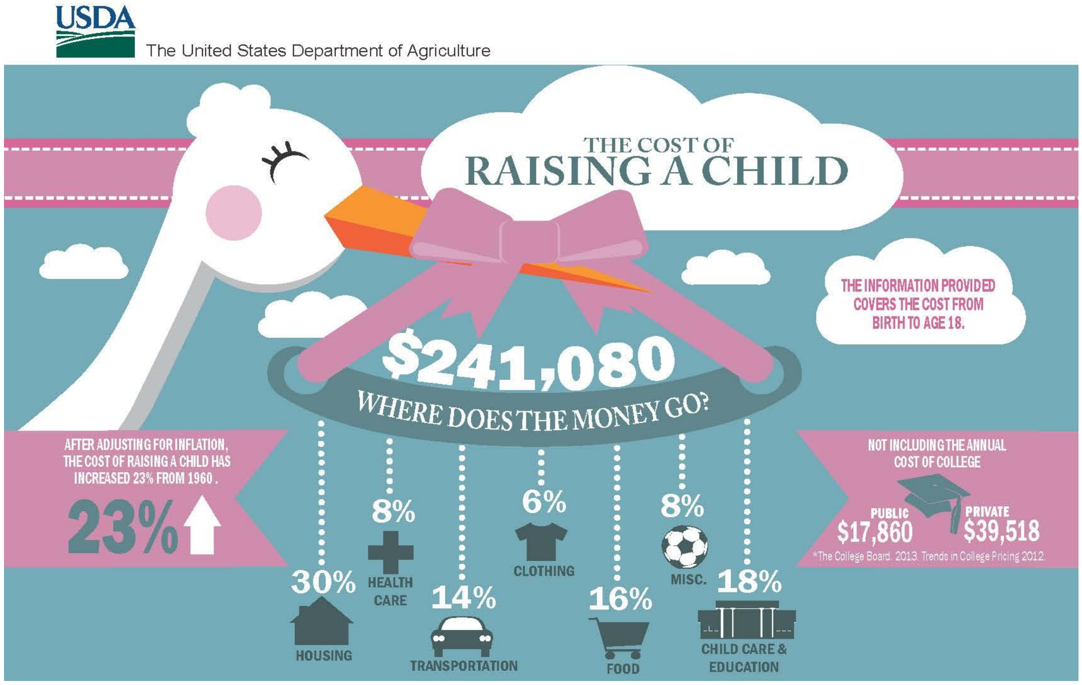

Figure 4: Example of an infographic including Creative Commons Citation Information - "The Cost of Raising a Child" by US Department of Agriculture CC BY 2.0

Modality effect in animated media. Although static images have proven to be useful in limiting extraneous cognitive load, indications also support its effect in animated media as well (Guttormsen Schär & Zimmermann, 2007; Mayer & Moreno, 2003; Moreno, 2006). Heuristic suggestions for reducing cognitive load in animated media include using narration in lieu of text and ensuring that audio tracks appear simultaneously with animation (Mayer & Moreno, 2003).

Redundancy Effect

Where the split attention and modality effects are only felt when multiple sources of information are required for comprehension, the redundancy effect occurs when multiple sources of information

can be processed in isolation of one another yet are presented together (Kalyuga et al., 1999; Sweller, 2008; Sweller et al., 1998). Where the split attention effect asks working memory to integrate information increasing cognitive load, the redundancy effect asks working memory to determine the usefulness of multiple presentations of the same information (Sweller, 1988). For example, when presented the same information in both textual and auditory or narrated form, working memory may occupy itself in first determining if the information differs prior to encoding (Sweller, 1988). As a result, extraneous and overall cognitive load is increased.

Redundancy effect in static visuals. To minimize extraneous load through redundancy, designers of instruction must first ensure that functionally identical information is presented only once, and second must ensure that it is presented through the most cognitively effective manner as possible. A process of curating or weeding instructional materials to remove incidental repetition of information is suggested (Mayer & Moreno, 2003). For instance, presenters should not read their presentation slides verbatim or provide narration of the exact text in dynamic visuals. Alternatively, design methodologies such as universal design for learning suggest providing alternative representations of information to serve the broadest set of learners (Kumar & Wideman, 2014; Navarro, Zervas, Gesa, & Demetrios, 2016; The Center for Applied Special Technology, 2016). In this case a process of signaling learners to the appropriate use of materials may prove more effective.

Redundancy effect in animated visuals. Techniques to minimize cognitive load in animated visuals are similar to those in static media. For example, when presenting a spoken narration, one should not include the same text on screen to avoid redundancy (Kalyuga et al., 1999; Mayer & Moreno, 2003; Sweller, 2008; Sweller et al., 1998). Universal design principles can be accommodated by using tools available in the animated world which are not as easily implemented in the world of static media (The Center for Applied Special Technology, 2016). For example, should a learner need a textual representation of narration due to an auditory impairment, need access to the narration in a foreign language, or for a number of other needs, closed captions should be available. However, to eliminate redundancy these captions should be available but not imposed (Kalyuga et al., 1999; Keeler & Horney, 2007; Navarro et al., 2016). This can be accomplished by using a video player which

allows them to be hidden, see Figure 5. Further discussion of accommodating the needs of diverse learners can be found in the Cultural Aspects and Implications of Instructional Message Design and Instructional Message Design for Learners with Special Needs chapters in this book.

Figure 5: Example of customizable captioning in animated media including Creative Commons Citation Information "Screenshot Closed Captioning using TimedMediaHandler" by Eben Moglen CC BY SA-3.0

Isolated Interacting Elements Effect

High intrinsic load, which can be characterized by a high level of interaction between elements, may require that designers take advantage of the isolated interacting elements effect (Sweller, 2008). This effect decreases the cognitive load necessary to process complex elements by allowing learners to build schema prior to integrating knowledge. This is done by ensuring that learners have an opportunity to master the component elements prior to integrating them (Sweller, 2008).

Isolated interacting elements in static and animated media. To minimize intrinsic load while presenting complex materials, message design and instructional design processes both must be considered. Initially the complex content needs to be specifically divided into manageable chunks of information, that can be isolated and explained independently. In addition, learner analysis is key, as the size of chunks will vary dramatically based on the expertise of the learners.

Once the appropriate learning objectives and procedures have been chosen, message design will become essential. Morrison et al. refer to the size of the instructional steps when considering how to best interact with the complex variables involved in this process (Morrison et al., 2011). Steps are described as the jumps that learners must make to become familiar with the content, and connect it to prior knowledge (Morrison et al., 2011). Message design of both static and animated media can assist in this process through the selection of consistent terminology, and inclusion of explicit connections back to the prior knowledge of the learners.

Secondly, any media should focus on presenting the isolated elements first, to allow schema to be established. This may result in less realistic representations of processes, and limited understanding initially, however gains have been shown in longer term transfer of process understanding (Blayney, Kalyuga, & Sweller, 2015; Pollock, Chandler, & Sweller, 2002). In addition, when animated media was tailored to release content based on learner expertise and performance, learning gain increased even more pronouncedly (Blayney et al., 2015). However, the variables to craft such customized instruction were seen as an area of further research (Blayney et al., 2015).

Worked Example, Guidance Fading and Imagination Effect

The remaining effects of cognitive load, which should be considered when designing effective instruction, have a lesser effect on message design than those discussed previously. Worked example and guidance fading effects are achieved through the use of the worked example generative learning strategy (Baars et al., 2013; Sweller, 2008). This multi-phase process begins by allowing students to progress through a problem using an expert's solution as a guide (Ayres & Gog, 2009; Sentz et al., 2019; Sweller, 2008). This process provides prompts to assist the learner in determining a solution path,

which has proven to be more successful than repeated practice using problems without guidance (Ayres & Gog, 2009; Blayney et al., 2015; Sentz et al., 2019). Guidance fading is implemented as learner expertise increases through worked examples. The design begins to withdraw the expert guidance selectively throughout the process, until a learner is able to solve complex problems based solely upon their own abilities (Sweller, 2008). The imagination effect serves to assist learners in expanding schema prior to integrating new information and decreases cognitive load (Sweller, 2008). It is effective for experienced rather than novice learners (Kalyuga et al., 2003; Sweller, 2008). Experienced learners follow prompts to help to recall prior knowledge and integrate new information. In novice learners however, this technique more often than not causes learners to become overwhelmed (Kalyuga et al., 2003).

Worked examples, guidance fading, and imagination effects work well for both static and animated media. To maximize germane load through these instructional processes, message design should incorporate prompts effectively and be designed to support the generative processes. As always, care should be taken to ensure that the learners' level of expertise is evaluated and taken into account. For example, in an animated presentation of a complex problem, options should be available to allow selective release of content (Sweller, 2008). Novice learners should be able to review demonstrations of processes through completion where expert learners may choose to skip this step (Kalyuga et al., 2003; Sweller, 2008). In addition, for media that is designed solely for the use of seasoned learners, animations may include prompts to pause the content and to imagine results prior to being able to access a solution (Sweller, 2008).

Conclusion & Future Directions - Cognitive Load

In a nutshell, all learning will require memory to process information which leads to cognitive load. As designers we can work to ensure only load that is necessary to assimilate information is placed on learners, as a result, learning becomes more effective and efficient. Considering the impact of cognitive load in instructional message design is a critical aspect of the overall instructional design process.

However, determining the appropriate levels of load is not a simple process. As a result, cognitive load theory continues to be researched with the goal of improving instruction, both through improved message and learning strategy design. Current research includes calls for the study of the intersections between cognitive load and self-regulation of learning and the instruction of complex tasks (Ayres & Gog, 2009; Boekaerts, 2017; Delen, Liew, & Willson, 2014; Efklides, 2011; Sentz et al., 2019). In addition, the design of interactive elements which assist in facilitating these integrations are being explored (Amadieu, Mariné, & Laimay, 2011; Blayney et al., 2015; Delen et al., 2014; Roll, Aleven, McLaren, & Koedinger, 2011). Additional areas for future cognitive load and instructional message design research include direct measurement tools for extraneous, intrinsic, and germane load as well as learning with simulations, asynchronous and synchronous online video, multimedia, and augmented and virtual reality.

Key Terms

Channel capacity
Chunking
Episodic buffer
Extraneous cognitive load
Germane cognitive load
Intrinsic cognitive load
Long-term memory
Phonological loop
Schema
Visuospatial sketchpad
Working memory

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Instructional Message Design:
Theory, Research, and Practice

Chapter 3: Multimedia Learning Theory and Instructional Message Design

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Chapter 3: Multimedia Learning Theory and Instructional Message Design

Miguel Ramlatchan

Key Points:

- Multimedia learning theory describes the use of multiple simultaneous techniques in instructional message design, such as combining narration and visuals in a presentation.
- 1) Dual coding, 2) limited working memory capacity, and 3) the need to maximize cognitive resources for learning are fundamental principles.
- The key to effective multimedia design is to minimize extraneous processing, manage essential processing, and maximizing working memory resources available for generative processing.

Abstract

Multimedia learning theory describes how the designers of instructional messages, systems, and learning environments can optimize learning. The principles and heuristics of multimedia learning theory have application in traditional and online environments, with young and adult learners, in K-12, higher education, military, corporate, government, and informal learning environments. This diversity of application is based on the foundational premise that all learners can independently process auditory and visual information, have limited working memory resources, and require cognitive resources to process new information and to learn. This chapter describes the basic tenets of multimedia learning theory, best practices that can improve our message design

and communication, and exciting future directions that we can take new research.

Introduction

When teaching students, what is better, textbooks or iPads? (iPads right?). When developing my PowerPoint slides for class, I should include a lot of color and animations and sound effects to keep my learners' attention, right? As an instructional designer, should I work to include animation or video in my project, and do those visuals require the added time and expense of narration? Designers and instructors have access to an ever increasing multitude of software functionality, online resources, and ever evolving toolsets. Though where are the research-based best practices that can guide instructional message design with these resources? Subscribing to the heuristics and principles of multimedia learning theory is one option. Multimedia learning theory provides evidence-based guidelines for creating and fostering effective communication and learning using technology. The results of nearly three decades of research can be used to help guide and inform instructors and instructional designers as they navigate the many available tools, techniques, and technologies in the search to enhance learning effectiveness.

Multimedia is the use of multiple presentation tools or techniques to deliver information. Audio and visual presentation technologies provide an effective set of tools for instructors and instructional designers to communicate with learners. Mayer's multimedia learning theory provides an informative set of principles that can be used to create effective instructional message design. It is helpful to understand the origins of multimedia learning from the original sources to also understand how to best apply the theory in practice and plan for future research. Several other theories, models, and many other research studies influenced the evolution of multimedia learning theory. However, the main contributions come from Paivio's dual coding theory, Baddeley's working memory model, and Sweller's cognitive load theory (Mayer & Moreno, 2003).

Dual Coding Theory

Paivio's dual coding theory evolved from Paivio's research on noun-adjective pairs, noun-noun pairs, and how these aspects of language appeared to evoke mental images (Paivio, 1963, 1965). In several of these early experiments, images were evoked by 'peg' words (or words intended to be used to recall other words). The general findings of these studies also suggested that concrete nouns appeared to generate related images more reliably than adjectives or abstract nouns. These vocabulary and imagery findings would evolve into Paivio's dual coding theory, which describes specialized cognitive resources used by learners to process verbal and nonverbal information (Paivio, 1969, 1971, 1986). Humans appear to have independent systems for the processing of verbal and nonverbal information. Interconnections between verbal and nonverbal information are also made and aid in knowledge recall. For instance, images can be given verbal names, and names can be associated with images. Also, single images can be associated with multiple names, and a name can be associated with multiple images (Paivio, 1991). The theory also describes what can be considered units of working memory resources called "logogens" in the verbal processing system and "imogens" in the nonverbal processing system, see Figure 1 (Clark & Paivio, 1991).

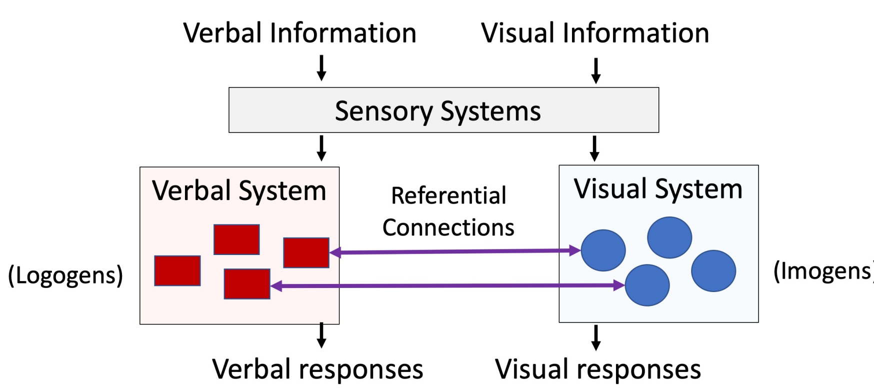

Figure 1. Paivio's dual coding theory describes logogens and imogens in verbal and visual information processing channels (modified from Paivio, 1986)

Logogens are specialized for linguistic information and imogens are specialized for nonverbal or imagery information. For

instance, the spoken word "telephone" would be processed by linguistic logogens in the verbal processing system (Clark & Paivio, 1991). This processing would suggest associated imagery of telephones as well as associated sounds of telephones; this recalled nonverbal information would be processed by imogens. The two systems are able to create referential connections between logogen and imogen processed information. The result can be described as a verbal stimuli trigger to recall an entire telephone schema from long-term memory into working memory. This schema is a pattern of related ideas, words, sounds, and images that have been stored and modified over time in long-term memory. The idea that images and spoken words can be processed separately but associated together by a learner had a significant influence on multimedia learning theory (Mayer & Anderson, 1991, 1992, Mayer & Sims, 1994).

Short-term and Working Memory

Baddeley's working memory model evolved out of research into words, word length, general recall, and visual recall. It was found in a series of ten experiments that participant understanding and recall of verbally presented information was negatively affected by also having to remember six other items, but not as affected when having to recall lists of fewer than three items (Baddeley & Hitch, 1974). Baddeley & Hitch also suggested that short term memory was in actuality doing more than storing information; these cognitive resources were also being used for information processing. Thus, Baddeley and Hitch (1974) began to use the more accurate "working memory" description for cognitive resources that are apparently allocated for both short-term recall and processing. It was also found that if experiment participants rehearsed the words for themselves then they could retain those words in short term memory for an even longer length of time (as compared to not rehearsing). This result suggested a cognitive "loop." Baddeley would describe this as a phonological loop, or cognitive resources that appeared to be reserved for processing of verbal information (Baddeley, 1986).

Research into the visual aspects of working memory also began to yield similar insight into another subsystem of working memory (Baddeley, Grant, Wright, & Thomson, 1975). It was found during this set of experiments that visual memory processing tasks did not

detrimentally interfere with phonemic based recall. These early studies also suggested the potential for a "common central processor" (Baddeley and Hitch, 1974, p. 80). This central processing could be an aspect of working memory that synthesized processed information from the visual and phonologic subsystems into chunks or relationships for storage into long-term memory. Further research from these early findings continued to strongly suggest that learners could independently process both visual and phonological information and supported the existence of a central processing function (Baddeley, 1992). By the mid-90s, Baddeley's working memory model had evolved to describe two independent subsystems and central integration of these subsystems (Baddeley & Hitch, 1994). The model included a phonological loop subsystem that processes audio, a visuospatial sketchpad subsystem that processes visuals, and a central processing system for control of attention and subsystem integration.

Baddeley would specifically recall the work of Miller's seven plus or minus two units of working memory, and the use of 'chunks' to describe units of working memory (Baddeley, 1994; Miller 1956). The 'episodic buffer' aspect of central processing was later added to the model to more specifically describe the processing of visual and auditory information into chunks or 'episodes' for storage in long-term memory, see Figure 2 (Baddeley, 2000). The model that humans have limited working memory resources, used for both short term storage of information and used for actively and independently processing that information, had a substantial impact on the development of multimedia learning theory (Mayer & Moreno, 1998, 1999, 2001, 2003, Mayer, Heiser, & Lonn, 2001).

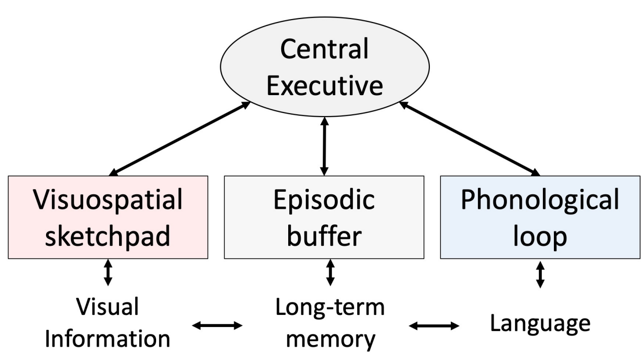

Figure 2. Baddeley's working memory model also considers the independent processing of visual and narrative information (modified from Baddeley, 2000).

Cognitive Load Theory

Sweller's cognitive load theory began with work on trigonometry word problems and the realization that students appeared less cognitively overwhelmed when they were given an example to follow during the problem-solving process (Sweller, 1988). To describe what Sweller called "cognitive processing load," Sweller notes numerous problem-solving experiments when students were more successful as the goals of the problems were simplified (Sweller, 1988, p. 263). Using a variety of physics, geometry, and maze problems, Sweller found that eliminating the implicitly stated end-goal resulted in students exploring the problem and finding the solution on their own. It appeared that not having to store problem-solving rules in working memory freed cognitive resources for working on the problems. It also appeared that the reduction of cognitive load could describe earlier experiments when learning effectiveness appeared to improve when students were given worked examples during their learning (Sweller & Cooper, 1985). Learners in these experiments did not have to store problem-solving rules in working memory (as they referred to the given example) while occupied with problem-solving. An expert has schemata stored in long-term memory that they can recall when problem-solving, novices do not and thus have to rely on inefficient "means-ends" analysis, or they focus more on the end goal (Sweller, 1989). It appeared that when students only focused on the step-by-step rules to solve the problem with only the solution as the end goal, they tended not to form the intrinsic schemata required to become experts.

Bartlett's classic experiments indicated that humans develop schema or patterns of ideas that are stored together in long-term memory as a single unit (Bartlett, 1932). It was found that when given new or unfamiliar information, such as when asked to comprehend the story the "War of the Ghosts," listeners compared the new information to their existing schemata or patterns of existing memory. British students (circa early 1930s) in this experiment did not have a schema for the Native American concept of "canoe" and so the participants translated this term as "boat" in the experiment. The unfamiliar schema was integrated into a pre-existing schema by novice learners.

Schema is a single pattern of memories that can be recalled and stored in working memory and will only occupy a single unit of

working memory resources. This is analogous to Miller's also classic description of a 'chunk' or unit of working memory that is also a pattern of related memories or elements also stored together as a single unit of long-term memory (Miller, 1956). Sweller uses both 'chunks' and 'schema' to describe and further an important aspect of his developing cognitive load theory, specifically that schemata storage renders human long-term storage virtually limitless (Sweller, 1994a; Mousavi, Low, & Sweller, 1995).

Sweller's work in the early 1990s focused on what would become extraneous cognitive load, and the need for instructional designers to reduce the split attention effect and the redundancy effect (Sweller, 1991). The aspect of eliminating split attention effect would become an especially important component in what would eventually become multimedia learning theory. Split attention is the creation of extraneous cognitive load by separating relevant content in an instructional design, forcing learners to use cognitive resources to actively combine or recombine these elements in working memory. An example of reducing split attention and extraneous cognitive load would be to integrate worked examples with problems to be solved. Another classic example of the split attention effect is having a diagram on one page of a book and the text describing that diagram on another page, requiring the learner to flip back and forth between pages. This misguided instructional message design practice forces the learner to utilize cognitive resources as they flip between pages in text, thus adding extraneous cognitive load.

The term "intrinsic load" was soon added to the theory to describe the inherent difficulty of content, especially content where elements interact with each other (Sweller, 1994b). An example of high intrinsic load would be complex math problems where learners have to arrange, organize, and interact with multiple variables, and relationships between those variables, to arrive at a solution. By the late 1990s, cognitive load theory included all three of the now familiar major components of cognitive activity including extraneous load, intrinsic load, and now germane load which described the resources remaining to process relevant information (Sweller, van Merrienboer, & Paas, 1998). This revision to cognitive load theory described a learner's working memory resources as a function and combination of extraneous, intrinsic, and germane cognitive load. For instance, an instructional designer could work to reduce split-attention effects and redundancy in instructional designs and thus reduce extraneous load.

At the same time, the designer could also chunk difficult content into simpler elements in an effort to also manage intrinsic cognitive load. The result of minimizing both extraneous and intrinsic load would maximize resources for germane load, or processing of relevant information.

Sweller would continue to revise cognitive load theory, specifically revising and renaming the idea of germane cognitive "load" into germane cognitive "resources" (Sweller, Ayers, & Kalyuga, 2011, p.57). This subtle change more effectively communicates that intrinsic and extraneous processing inflicts an actual load on working memory in the form of accessible resources available for germane or relevant processing. In other words, available germane resources are a function of intrinsic and extraneous load. The theory that learners have germane resources used to process both intrinsic and extraneous information, and that a split attention effect will increase extraneous load, would be incorporated into the evolving theory of multimedia learning (Mayer, Bove, Bryman, Mars, & Tapangeo, 1996, Mayer & Moreno, 1998, 1999, Mayer, Moreno, Boire, & Vagge, 1999).

The Evolution of Multimedia Learning

Mayer's multimedia learning theory developed from research into text and illustrations and experiments that suggested that illustrations with integrated text improved learning effectiveness (Mayer, 1989). In the early 1990s, Paivio's work on dual coding theory began to inform Mayer's research with narration and animation. Mayer's results indicated that learning was most effective during treatments where the participants were able to see the animation visuals as well as hear the integrated audio narration of those visuals at the same time (Mayer & Anderson, 1991). Animation without narration and narration without animation treatments were not as effective. A further set of experiments yielded similar results when narrated animation was compared to trials of animation then narration, narration then animation, only animation, and only narration (Meyer & Anderson, 1992; Mayer, & Sims, 1994). As dual coding describes, the learners' audio system processed the narration while the learners' visual system independently processed the animation, and central working memory resources integrated visual and narrated information

into schemata. These findings were similar to the independent phonological loop and visuospatial sketchpad described by Baddeley.

Sweller and his colleagues found similar results when comparing audio integrated with visuals, as compared to the visuals alone or the audio alone (Mousavi, Low, & Sweller, 1995). Meyer integrated these findings, along with the implications of split-attention effect into another series of experiments. In a series of experimental trials, participants who viewed and listened to animation and narration outperformed participants who viewed the same animation with the text equivalent of the narration also on the screen (Mayer & Moreno, 1998). These findings were further supported by Paivio's dual coding theory and Baddeley's working memory model. Learners appeared to use dual sensory channels to process animation and available narration, though only used their visual channel when processing animation and on-screen text.

Similar findings also resulted when using different animated content, and trials with narration, integrated text, and separated text (Mayer & Moreno, 1999). This study specifically looked for results predicted by Sweller's split attention effect, or a temporal example described as a contiguity principle. The contiguity principle states that learning will be more effective when narration and visuals are timed and presented together, thus reducing or eliminating extraneous load caused by the split attention effect. The results provided further examples that narrated animation was processed more efficiently than animation with integrated text and animation with separated text.

Mayer, Baddeley, and Paivio all provide strong evidence that learners are able to process visual and audio information independently (Baddeley, 1994; Mayer & Moreno, 1999; Paivio, 1991). Mayer, Baddeley, and Sweller all provide empirical results that suggest that learners, even with independent processing, still have limited working memory resources (Baddeley, 1994; Mayer & Moreno, 1999; Sweller, van Merrienboer, & Paas, 1998). Mayer and Sweller provide evidence that presenting information with both visuals and narration can be more effective and efficient in schema creation than the same content presented with just visuals or just audio (Mayer & Moreno, 1999; Sweller, van Merrienboer, & Paas, 1998). Taken together, these theories, experiments, and models provide the background and basis for multimedia learning theory.

Multimedia learning theory describes a series of processes that are taking place as a student is creating a new schema (Mayer, Heiser, & Lonn, 2001). The first step in the learning process is the initial viewing and listening to instructional content and the immediate storage of that information in short term memory. In this step, text is essentially visual words that when presented with diagrams then both the diagrams and the text are processed by the visual processing channel. When words are presented via audio, the narration is instead processed by the audio processing channel, while visuals are processed by the visual channel. The intrinsic content is separated from the extraneous content in the first phase of working memory. Next, the remaining germane resources in working memory create relationships between the visual and verbal information and recalls associated previous knowledge from long-term memory. Recalled schema is then compared to new information where the learner creates understanding. Finally, new schema can be created, or existing schema modified, and stored in long-term memory (see Figure 3).

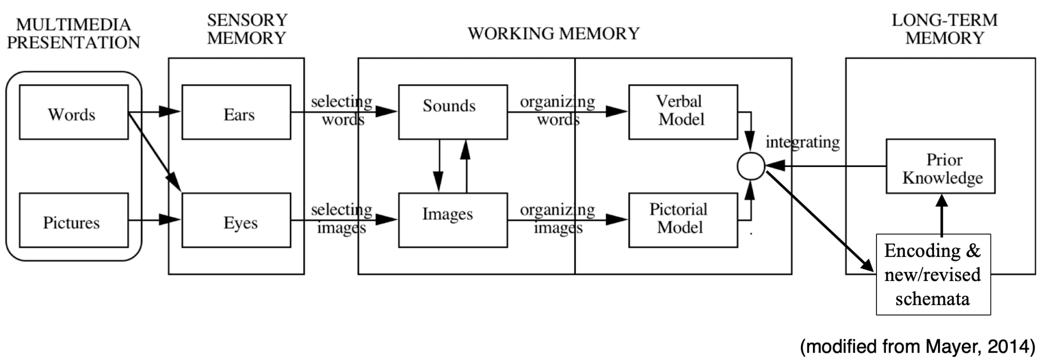

Figure 3. Multimedia learning theory describes two cognitive processing channels available to our learners, one for processing auditory information and one for processing visual information, and the result is the modification or development of new schemata in long-term memory, or learning (modified from Mayer, 2014).

By the early 2000s, Mayer's cognitive theory of multimedia learning had solidified into three main principles (Mayer & Moreno, 2003). The first principle is the assumption that learners have independent channels for verbal and visual information and using both channels simultaneously is more efficient than using either channel

alone. The second principle is that the two processing channels in working memory have limited capacity for both short-term storage and active processing. The third principle is that for learning to occur, working memory must actively process, pull previous information, and create and store new or modified schema into long-term memory (see Table 1 for a summary).

Foundational Principles:
1. The **Dual Channels principle**, states that our learners have two independent cognitive systems for processing visual and auditory information, 2. The **Limited Capacity principle**, states that our learners have limited working memory resources, and 3. The **Active Processing principle**, which states that to learn students need to focus on relevant information, organize that information for themselves, and relate that information to previous schemata.

Table 1, The three foundational principles of multimedia learning theory (Clark & Mayer, 2016; Mayer & Moreno, 2003)

As with early work with new animation technology in the 1990s, Mayer continued to explore new instructional message design tools and early virtual reality applications using new multimedia learning predictions (Moreno & Mayer, 2002). Treatments using desktop monitors were compared to groups using head-mounted displays; the narrated presentations resulted in greater learning outcomes than groups viewing animations with text. These findings continued the dual coding assumptions of multimedia learning theory, and also showed that the specific technology or media used is less important than the instructional techniques and how the affordances of technology and media are used. Desktop monitors produced comparable or slightly superior results as compared to the new

wearable technology, and the use of visuals and narration together were still more important in these experiments.

Media and Methodology

As in early research studies, multimedia learning theory can also apply to the use of text and diagrams (Mayer, 1989). A series of media comparison studies found that good instructional design was applicable independently of the media or the technology used to deliver that message (Mayer, 2003). Dual channel processing, limited working memory, and the need to actively create schema applies to the use of computer or paper-based message designs. In another study, it was found that when both the media and the design methodology are varied, user-controlled text with diagrams can be more effective than narrated animation without user controls (Mayer R., Hagerty, Mayer, S., Campbell, 2005). The ability for participants to review and re-review the diagrams with text was compared to treatments where participants were not able to control the playback of the narrated animation. Both the media and the design methodology were different in these experiments. However, when the media is held constant, the methodology can be adjusted to find the optimal learning effectiveness of the media.

Multimedia learning theory and the use of both audio and video can inform and predict the successful application of multimodal interactive learning environments. Results from asynchronous narrated animation or presentations should be generalizable to synchronous conferencing and online distance learning applications where audio and video is shared to and from all participants (Moreno & Mayer, 2007). The use of web conferencing would be the media being adjusted, the method of presentation is unchanged, and thus learners should benefit from the efficiency of dual coding. All things being equal, the learning effectiveness of an online synchronous presentation should be the same as an online asynchronous presentation, unless the instructor takes advantage of the real-time technology and fosters dialog and discussion with learners. Similarly, if the method remains constant, the use of different media such as comparing desktop and mobile device screens should not matter as long as students can see and hear the presentation. For instance, a specific comparison between electronic textbooks on mobile devices

and traditional hardcopy, paper textbooks found no significant difference in learning effectiveness (Rockinson-Szapkiw, Courduff, Carter, & Bennett, 2013).

Multimedia learning theory provides results supporting instructional methodology being more important than instructional media. For instance, adding chapters and headings to a presentation improved learning effectiveness for both desktop and mobile device treatments groups, and both groups performed equivalently (Sung & Mayer, 2013). This study found that while students may have different preferences, learning effectiveness should not be impacted by device type but can be impacted by methodology and message design changes. Interestingly, the cultural context of instructional methodology or message also has a significant impact on the effectiveness of instructional media or technology (Sung & Mayer, 2012). The common thread through these studies is that multimedia learning theory can be successfully applied using a variety of technologies. The specific technology used to deliver an instructional message is less important than the message being communicated unless that technology allows for an affordance that the instructor can use to improve the message (Fiorella & Mayer, 2016; Mayer, 2018). For instance, consider a classroom of students with iPads. Simply reading an e-textbook on an Apple iPad should not yield any learning differences as compared to reading a physical paper and ink textbook. However, the iPad can connect to the Internet for additional learning resources. If the classroom teacher harnesses the affordances of the iPad by guiding students beyond the e-textbook to additional resources, then the iPad could improve learning effectiveness as compared to the physical textbook.

Processes, Principles, and Instructional Methods

The current iteration of multimedia learning theory advises heuristics beyond its foundational principles with three base processes and several guiding best practices. Multimedia learning theory is based in part on cognitive load theory, though while cognitive load can be described by extraneous load, intrinsic load, and germane resources, multimedia learning theory can be described by analogous cognitive processing. These processes are described as extraneous, essential, and generative processing (Clark & Mayer, 2016).

Extraneous processing is the active use of cognitive resources to process and filter redundancy or distractions from multimedia designs. Essential processing is the utilization of cognitive resources that are used to process and simplify the complexity of a multimedia design. Generative processing is the process of analyzing, synthesizing, and organizing relevant information into schemata. In practice, all three forms of processing are occurring during learning. However, the goal of good instructional message design using multimedia is to minimize the resources consumed by extraneous and essential processing and to maximize the resources available for generative processing.

In addition to foundational dual channel, limited capacity, and active processing principles, an additional series of principles can be thought of as evidence-based instructional methods or design best practices (Clark & Mayer, 2016; Mayer, 2018).

To minimize extraneous processing:

1. The **Coherence principle** advises designers to avoid the use of unnecessary words, sounds, or graphics. Superfluous or irrelevant text, sound, and graphics will require unnecessary processing and use of cognitive resources.

2. The **Spatial Contiguity principle** advises designers to put text and graphics related to that text near each other in instructional message designs. The classic example of text on one page of a book and the figure being described by that text on a different page of that book causes unnecessary extraneous processing.

3. The **Temporal Contiguity principle** advocates synchronizing audio and video in presentations. Presenting audio before video or video before audio, or video and audio that are not in sync confuses and distracts learners.

4. The **Redundancy principle** states that on-screen text is distracting when audio and graphics are also used. Learners can be distracted by the redundancy of focusing and refocusing between the text and narrations when graphics are presented with text, and that text is read verbatim by a narrator. It is less distracting for a narrator not to read the on-screen text word-for-word.

5. The **Signaling principle** states that essential content can be highlighted to draw the learner's attention to it. Signaling can be used to cue learners to important content and can be highlighted text, the use of bold or italics, or visuals of an instructor pointing to specific content on a whiteboard.

To optimize essential processing:

6. The **Worked Example principle** states that a step-by-step demonstration can help reduce complexity when problem-solving. Giving students an example to follow when working through similar problems gives them guidance to refer to and focuses their essential processing.

7. The **Segmenting principle** states that a continuous complex presentation should instead be broken down into shorter more manageable chunks. Complex content can be simplified by breaking that complexity down into easier components.

8. The **Pretraining principle** suggests that key, unfamiliar terminology and definitions be given and discussed before an instructional unit. Similar to segmenting, students can be prepared for learning by first presenting them with and discussing key concepts and definitions.

9. The **Modality principle** suggests the use of audio rather than on-screen text during video, animations, or presentations. Presenting on-screen text with graphics only utilizes the visual processing capabilities of learners while using graphics with narration is more efficient as it utilizes both the learner's visual and auditory processing capabilities.

To increase resources for generative processing:

10. The **Personalization or Voice principle** advocates the use of a more conversational tone when narrating visuals as opposed to a formal, academic tone. A friendly narrative tone fosters social presence which enhances motivation for learning.

11. The **Embodiment principle** suggests the use of human-like gestures when including on-screen agents in multimedia designs. The human-like gestures and personifications enhance the perception of virtual social presence and also increases learner motivation.

12. The **Multimedia principle** suggests presenting relevant graphics with text rather than just text. Static or dynamic graphics combined with text can often communicate more effectively and efficiently than just text alone by presenting concepts and principles as a visual schema.

13. The **Engagement principle** suggests that instructors and teachers actively involve students by asking them questions during presentations. Students will learn better when actively involved in a discussion vice passively listening to a lecture.

Emerging Technologies and Applications

While multimedia learning theory was born of experiments with text and graphics, the principles can likely apply to a number of new and emerging technologies. Emerging instructional message design technologies include mobile devices, virtual reality, e-learning, online education, and digital whiteboards. Building on the philosophy of instructional methods being more important than instruction media, comparing learning on a PC workstation and learning from an Apple iPad should not make a difference. As expected, experiments with iPads have shown motivational differences over workstations, likely because learning with mobile devices means students do not have to be confined to computer labs (Sung & Mayer, 2013). However, learning effectiveness was statistically equivalent. Similar results were found in research with virtual reality headsets; the use of immersive virtual reality enhanced motivation though did not enhance learning effectiveness (Parong & Mayer, 2019). The novelty of the headsets and hand controllers could have increased motivation as compared to the more common use of PowerPoint.

E-learning and online education are now commonplace in K-12, higher education, and government, military, and corporate training. Multimedia learning theory can be used to guide and improve these

learning environments through effective instructional message design (Clark & Mayer, 2016; Mayer, 2019; Sung & Mayer, 2013). These guidelines can also be used to effectively use drawings on traditional and digital whiteboards (Fiorella, Stull, Kuhlmann, & Mayer, 2018). In addition to enhancing social presence, especially in online environments, handwritten drawings appear to foster generative learning by building on the signaling and embodiment principles, or the use of human gestures to highlight content. The use of a transparent whiteboard that allows the instructor to look into the camera while drawing, enhances social presence, though does not appear to impact learning effectiveness as compared to the use of a traditional whiteboard (Stull, Fiorella, & Mayer, 2018).

Future research directions

Multimedia learning theory can be used to guide and predict the usefulness and learning effectiveness of visual and verbal presentations. It is critical that instructional message design is based on research and applied science and not fads, marketing, hype, opinion, and intuition (Mayer, 2018). As seen in previous multimedia studies, the technology or delivery media used by instructors or instructional designers is less important than what the technology conveys. As a result, paper illustrations with audio narration, animation with audio narration, static slides with narration, video with audio, or virtual reality with narration should all be effective ways to communicate and trigger efficient dual coding. The use of simultaneous verbal and visual information in a presentation is an effective communication technique regardless of the specific technology used. Thus, the principles of multimedia learning theory should be applicable to video with audio, and video with slides and audio.

Future research studies could use multimedia learning to guide the design of treatment groups in quantitative experiments that could extend the findings and applications of the theory. For instance, versions of multimedia presentations can be compared to each other to inform the use of audio and video in distance learning courses delivered online, to mobile devices. A version of an online presentation with narrated slides can be compared to a version with the instructor's video in a window with the narrated slides in a larger

window on the screen, the narration and just the instructor video, and a narrated version where visuals switch between instructor video and slides. Potentially, these four treatments can be compared to a group who only listens to the narration without the visuals of the slides and a group who only has access to the slides without narration. Mayer's multimedia learning theory would predict that the narrated visual groups will perform best on comprehension post-tests, but which of the four versions will perform best? Other potential experiments could add real-time engagement with the instructor, variations of visuals of the instructor and visuals of presentation content, and study the social presence implications of longer presentations at digital and traditional whiteboards, writing tablets, and document cameras with and without a view of the instructor. These future study variations could serve to fill gaps in the multimedia knowledge base or to specifically test the potential benefits and optimal variations of integrating audio with both video and presentation content. The results of this series of studies could be used to guide and inform future instructional design techniques intended for augmented reality, virtual reality, and mobile applications.

Future multimedia studies will also benefit from new ways to measure load and processing in experiments. Self-reporting surveys and questionnaires offer an indirect means to measure load and processing. While it is possible to individually measure extraneous, intrinsic, and germane loads and resources (and thus potentially extraneous, essential, and generative processing), these measures remain indirect (Deleeuw & Mayer, 2008). The emergence, affordability, and accuracy of eye-tracking systems offer an emerging and direct means to measure cognitive load and extraneous, essential, and generative processing (Li, Wang, Mayer, & Liu, 2019; Stull, Fiorella, & Mayer, 2018; Xie, Mayer, Wang, & Zhou, 2019). In addition to potential direct measures of load and processing, eye-tracking can also inform designers on the effectiveness of signaling and the potential distractions of design decisions.

Conclusions

Multimedia learning theory builds on a number of previous theories and applies best practice heuristics that can be used to create successful instructional message design. Dual coding, working memory, and cognitive load theories, as well as early experiments comparing text and graphics, have developed into the foundation of multimedia learning theory. These foundational principles include the concept that humans have dual processing capabilities for auditory and visual information, have limited working memory resources, and require working memory resources for the processing of information and for learning. Working memory is also allocated to three cognitive processes when learning: extraneous, essential, and generative processing. Extraneous processing is the resources required to filter distractions, essential processing is required to analyze and sift through the complexity of a presentation, and remaining cognitive resources are allocated to generative processing or the creation of new schemata and learning. These multimedia learning processes are analogous to the extraneous load, intrinsic load, and germane resources described by cognitive load theory. The goal in instructional message design is to reduce the need for extraneous processing, manage essential processing, and maximize generative processing. Multimedia designs can be optimized by evidence-based best practices such as maintaining contiguity in design elements, avoiding redundancy, signaling learners, segmenting complex content, combining and using both audio and visual design elements, using a conversational tone in narrations, and engaging learners by involving them in the presentation.

The principles of multimedia learning theory can be used to enhance and improve the ways that instructional message design is used to provide learning opportunities and communication. We know that the message being conveyed to our learners by technology is more important than the technology itself. For instance, reading from a textbook should be just as effective as reading from an iPad. Only when the instructor or designer uses the affordances and advantages of the technology, do the choice and use of one technology over another become significant. Or, when the iPad users are able to take advantage of different online resources not available in the textbook, does the use of different technologies become effective. Comparing different technologies to each other when teaching the same way is

futile. However, learning how different technologies can afford new and more effective ways to teach and communicate is much more beneficial and relevant. It is hard to estimate the number of instructional message designs in K-12, higher education, military, corporate, government, and informal learning environments that have benefited from the results of nearly 30 years of multimedia learning research. However, given the multitude of poor examples of design in these same environments, and the continued advance of technology, there are still many opportunities for designers to apply multimedia learning principles to help learners learn.

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Chapter 4: Message Design for Instructional Designers - Human Performance Technology

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Chapter 4: Message Design for Instructional Designers - Human Performance Technology

Dana Garcia

Key Points:

- **Human Performance Technology** is the use of principles and models to systematically improve changes in human behavior.
- **Interventions** are performance improvement efforts.
- **Instructional interventions** are the most popular choice to change human performance, but they are often the most expensive.

Abstract

"We cannot teach people anything, we can only help people discover it within themselves." (Galileo)

How often do you take on an assignment or responsibility and reflect I knew how to do it better, but I didn't? I'll do better next time. Do you really do better next time? Maybe? Honestly, probably not but why is that? Human Performance Technology is focused on answering those questions. It gets to the root cause of why we don't meet desired performance levels. The value of finding foundational causes for performance deficiencies is maximizing human capital because the largest expense of most companies is payroll. The most common investment in their employees is providing more opportunities for instruction and training; but more knowledge does not necessarily yield more productivity. Understanding the principles

and models of human performance present a strategic advantage to steer human behavior with instructional message design investments and solutions.

Introduction

Human Performance Technology (HPT) is a systematic approach to improving human performance (Pershing, 2006). HPT is a flexible, interdisciplinary approach combining products behavioral psychology, systems theory, management science, and even neuroscience (Gilley, Dean, & Bierema, 2009). Broken down by each term (Rothwell, Hohne, & King, 2007):

Human – An individual or an organization.

Performance – The results of an activity or behavior

Technology – The practical application of knowledge.

The goal of HPT is to bridge the gap between 'what people are doing' and 'what they should be doing.' Effective instructional message design concentrates and adapts to these performance gaps. Often an instructional intervention is warranted to pass on information that the user would need to use to improve their performance on a given task or activity. Effective instructional message design is an important factor in instructional solutions, especially in the context of training and on-demand job aids. After lesson implementation, instructional interventions are evaluated on whether they increase or decrease human performance. Was the training worth the time and money?

Human Performance Theory Principles

The four principles of HPT provide a framework to pursue human performance changes in organized, prescribed ways (Tosti, 2010). The combination of these principles is applied into an intervention; an instrument of change. Instructional interventions are often the most popular performance intervention.

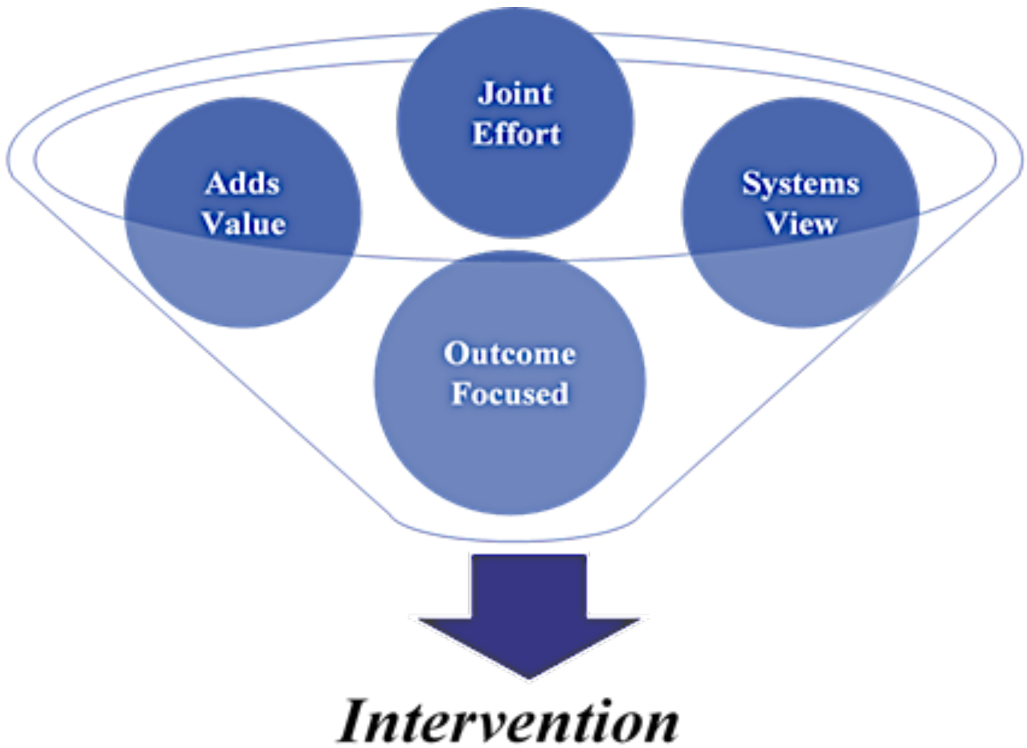


Figure 1. Performance Principles

Value Added

HPT seeks to align instructional goals with actual human performance to achieve results. Training should engage the intended audience at their level of expertise.

Joint Effort

Collaboration is essential to remove barriers for change; instructional designers work in partnership with instructors, students, and managers. There is no task isolation within the HPT model and all resources are considered.

Systems View

HPT uses a holistic approach to problem solving. Instructional analysis is focused on how everything works together instead of on the sum of individual parts.

Outcome Focused

Instructional designers use HPT to concentrate design on the desired results first, then work backwards to connect the human behavior that will produce those results.

Intervention

An intervention is a course of action to improve human performance. Instructional interventions seek to establish new schema or improve existing schema (other interventions could include organizational, management, or technological change).

Figure 2. For pilots trained on the Boeing 737 (an existing schema), could an online course presented on an Apple iPad be enough training to be able to fly the new Boeing 737 MAX? (to create a new schema?)

Intervention gone wrong

The Boeing 737 MAX was the fastest selling aircraft in the company's history. In 2019, the United States' Federal Aviation Administration (FAA) grounded the 737 MAX after two tragic crashes within five months that killed 346 people. Boeing's choice of a 737 derivative over a new aircraft meant cheaper production because derivatives were grandfathered in from the FAA's newer design requirements (Vartabedian, 2019). Instructional design followed the same easy and fast style of 737 MAX production; human performance principles were not followed and the instructional interventions were terrible. The instructional interventions provided to pilots were:

- A two hour training video on an iPad
- A 13-page manual on differences between the 737 MAX and earlier models (AppleInsider, 2019).

That's it. No value added instruction with simulators; instead, pilots were given 45 minutes to familiarize themselves with the aircraft before they flew a 737 MAX full of passengers. There was no joint effort for aviation excellence; instead, pilots were reprimanded for voicing safety concerns and requesting additional training. Only parts not the entire system of instrumentation changes were included in the training. The Maneuvering Characteristic Augmentation System (MCAS), which was the critical failure in both crashes when it took over flight control, was not mentioned in the iPad training (Gates, 2019). The outcome focused on cheap not effective training.

Traditional HPT Model

There are five features to the basic working model of Human Performance Technology by the International Society for Performance Improvement (ISPI) (Dessinger, Moseley, & Tiem, 2012). The ISPI HPT model is used for development of interventions that improve an issue or discover a new opportunity.

If you get a sense of déjà vu with the HPT model, you are not imagining things! The HPT model is very close to Instructional Design's ADDIE (Analysis, Design, Development, Implementation,

and Evaluation) conceptual process model. The biggest difference is the HPT model has more focus on analysis. Because each situation is unique, the HPT model is flexible and does not require all five features.

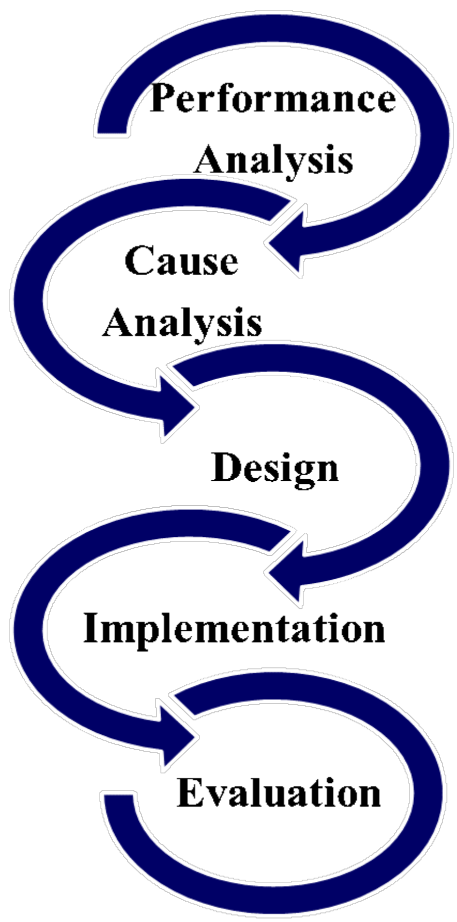


Figure 3. The HPT Process Model

Performance Analysis

Performance analysis uses data collection to identify the performance issue or improvement opportunity. It is important for instructional designers to understand the circumstantial dynamics contributing to the subject. Common tools are observation, interviews, surveys, and document review. Performance analysis is further broken down into three analyses (Kang, 2016):

1. Organizational analysis is used to determine the desired performance. What are the goals of this instructional platform? Are goals too broad? What are the critical issues? Describe the mission, policies, and values.

2. Environmental analysis is used to identify and prioritize what knowledge, tools and skills exist. Who is the audience? Are learners experts or novices? What is the culture around this process? What is actually getting done?

3. Gap analysis is used to determine the difference between the desired performance and current performance. Identifying the root cause of performance gaps is critical to developing viable instructional interventions (Stefaniack, 2018).

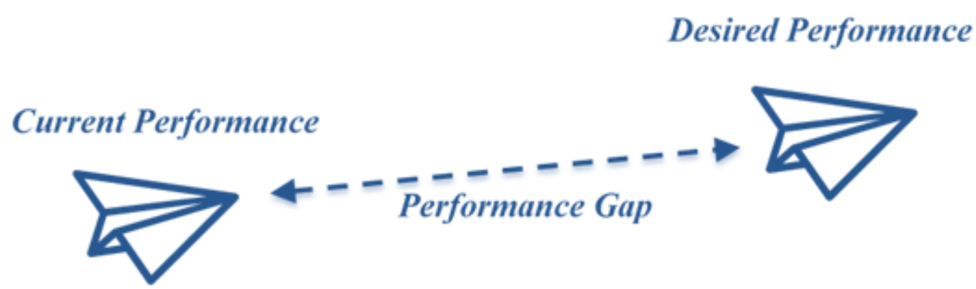


Figure 4. A Performance Gap is the difference between the existing status of a system and the desired status.

Ever sit in an exit row on an airplane? Organizational analysis provides the goal that, as a passenger, you are able and willing to assist in an emergency. Environmental analysis identifies resources provided to achieve those goals such as video instruction, airplane safety placards, human demonstrations, and verbal acknowledgments. It also includes the performance history of passengers assisting with emergencies. Gap analysis addresses the question: could you really help in an emergency? Any doubts or abilities indicate a performance gap; How heavy are the exit doors? Can I drink alcohol on this flight? If weight and alcohol questions were addressed, would passengers actually ask to be reseated?

Cause Analysis

Cause analysis is used to identify the root cause of the performance gap. The Behavior Engineering Model (BEM) identifies six sectors influencing behavior that can be re-engineered to change performance (Gilbert, 2007). It considers the individual capabilities and the environmental support in which they function. Instructional interventions are the most popular choice of how to improve human performance (BCODN, 2012).

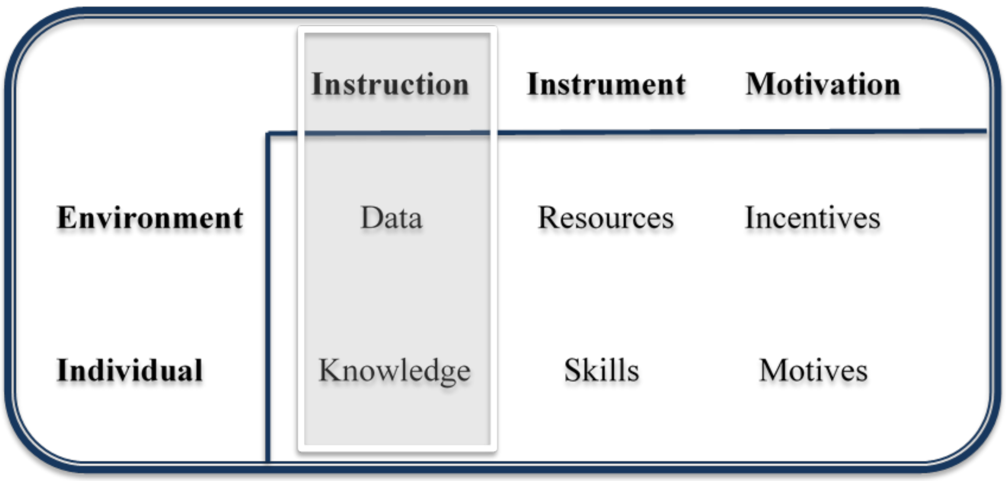


Figure 5. The Behavior Engineering Model

Examples of causes for the performance gap of airplane passengers:

Environmental options:

- Are passenger expectations clearly defined? (Data)
- Are passenger screening tools adequate? (Resources)
- Does legroom motivate passengers to help? (Incentives)

Individual options:

- Do passengers know when to help? (Knowledge)
- Are passengers strong enough? (Skills)
- Are passengers willing to help others? (Motives)

Design

Design is a busy feature in the HPT model, as development happens here as well. It includes the following tasks:

- Translate the performance gap into performance objectives.
- Select the intervention.
- Assess audience needs and capabilities.
- Construct an intervention blueprint.
- Develop and test a prototype.
- Refine and produce the intervention.

The performance objectives are highly dependent on the results of the cause analysis; instructional designers need to have a comprehensive understanding of the situation. Continuing the airplane situation, performance objectives can be matched to possible interventions (Rossett, 2006):

Cause	Possible intervention methods
Instructional	Training Job aids
Instrumentation	Task redesign New tools
Motivation	Revise policies Incentives

The Visual, Auditory, and Kinesthetic (VAK) model offers a simple way to breakdown the way humans learn (McMillian, 2017). This insight allows alignment of instruction delivery with the audience needs and capabilities. For the airplane example, developing a product for each learning style would maximize informational effectiveness for the wide variety of passengers.

Learning Style	**Learning formats**
Visual	Diagrams Pictures Video
Auditory	Verbal instructions Catchy tunes
Kinesthetic	Mockups (or partially functional prototypes) Movement (hands on) simulations

A design blueprint is formulated from performance objectives, intervention methods, and learning formats. The final piece to the design blueprint is determining the skill level of the audience. Is the intervention being provided to expert or novice learners? The intervention needs to be presented at the appropriate knowledge level.

Development produces prototypes of instructional products which are devised from the design blueprint. Testing prototypes provides feedback to refine the instructional intervention. The development cycle continues until the performance objectives are satisfied. Once the final version approval is received, the content is prepared for execution.

Implementation

Whether the instructional intervention is new concepts or improvements, change happens with implementation. Implementation is where the design plan meets the learner, and the instructional intervention is delivered (Hodell, 2016). The ADKAR model helps

individuals process change, since change is more about people's reaction to it than the change itself (Prosci, n.d.). The model breaks down change management into a sequential process.

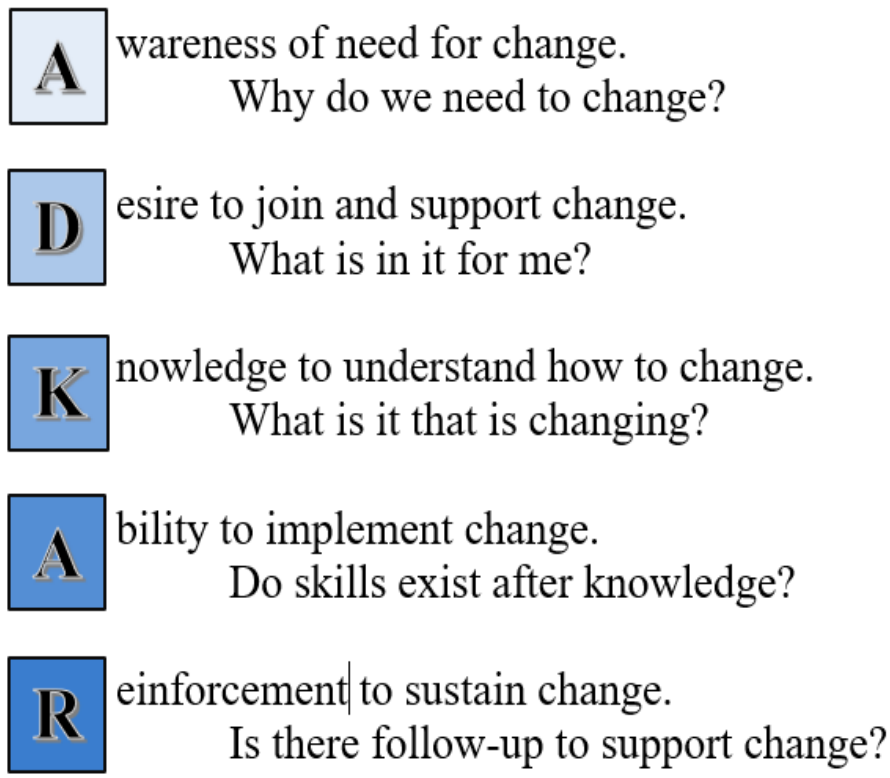


Figure 6. The ADKAR human performance technology development model

A popular change movement is the elimination of plastic straws due to environmental concerns (Ellefson, 2018). News stories about the amount of plastic ingested by sea life generated awareness of the need for change. Usage of straws was portrayed as selfish and inconsiderate to sea life; peer pressure produced a desire to change. Knowledge of how to change is the instructional intervention of the movement; infographics provide impact information and plastic straw alternatives. Ability is adapting to an alternative such as metal straws; how do you carry it around and clean it? As a result of the movement's success, laws were enacted to ban plastic straws and reinforce progress. What HPT message does a restaurant transitioning to paper straws mean to you?

Figure 7. A seemingly simple human performance technology tool (a design that requires no instructions) is now possibly an unintended aspect of the impact of technology on climate change

Evaluation

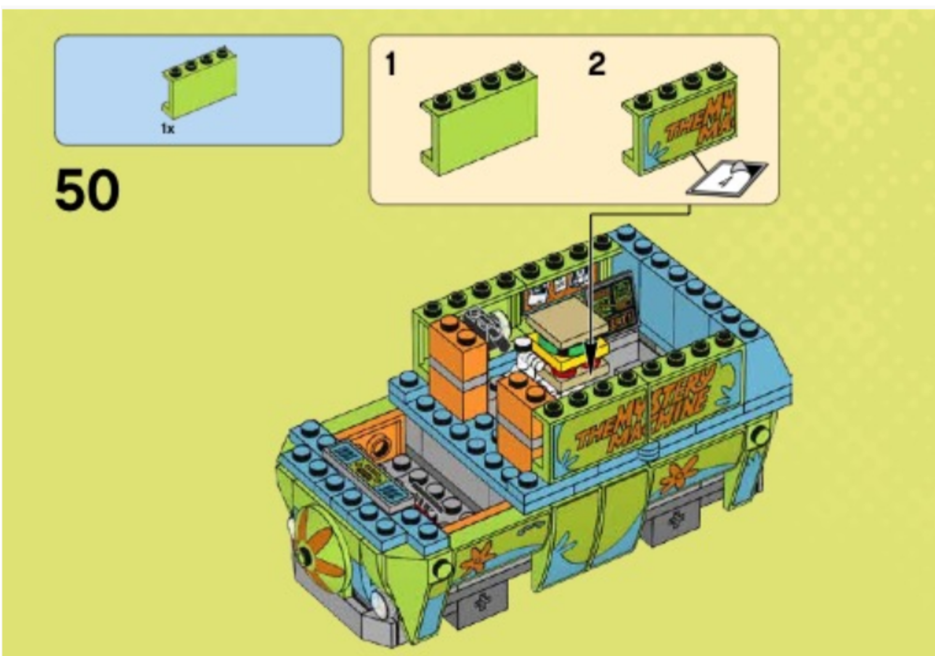
The goal of evaluation is to provide a means for continuous improvement and identify the impact of the instructional intervention (Wilmoth, Prigmore, & Bray, 2014).

- Formative evaluation is a continuous assessment of the value of instructional interventions while they are designed, developed, and implemented. The purpose is to identify instructional deficiencies in meeting performance objectives.

- Summative evaluation measures effectiveness of the instructional intervention. Surveys and questionnaires are often used to determine the impact of the instructional intervention.

HPT and Message Design Examples

Analyzing instructional message designs is useful to identify good and bad applications of HPT principles and models. Job aids are instructional message designs that help learners perform a task. Is text necessary? A job aid is intended to be a cost effective, easy to use tool, with minimized use of text that is used to help a learner perform a specific series of tasks. A job aid can take many forms, such as checklists, quick start guides that accompany a larger more complex manual, reminder notes and control surface labels, or 3D replicas. Job aids are inherently instructional in nature in that they are used to communicate information from a subject matter expert to a learner to improve performance. The job aid message design in Figure 7 is an example of a text minimalist approach, which also reduces costs by relying almost solely on graphics (and avoiding text that would have to be translated to sell the toy or collectible in international markets).



https://www.lego.com/en-us/service/buildinginstructions/search?initialsearch=75902#?text=75902

Figure 7. A LEGO job aid, would text be helpful? Or is the imagery enough to describe how to assemble this project (in step 2, would you know that a sticker is supposed to be applied to this part)? (https://www.lego.com/biassets/bi/6135001.pdf p. 35

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Passenger safety onboard airlines is a serious matter. When and why is humor appropriate? Getting the attention of learners is an important message design consideration, especially given the probability of passengers not preforming procedures correctly during an emergency. For instance, a tragic engine failure in 2017 required Southwest passengers on to put on their oxygen masks. News media reports after the incident included video of passengers incorrectly wearing the masks, even after the safety presentation given at the start of every flight (Cummings, 2018). Meyer's personalization and voice principle of multimedia learning theory suggests teaching in an informal conversational style and adding humor (Clark & Mayer, 2016; Mayer, 2018). Does this departure from the traditional, forgettable pre-flight safety presentation change the message design impact learning of airline seat buckle, exit door, or oxygen mask procedures? Or does the new message approach, as seen in Figure 8, calm and relax nervous passengers, and help serve to get learners/passengers attention?

Figure 8. Two different approaches to airline safety videos, does the humor introduced by a video of the safety presentation being presented in a movie theater relax passengers and break the schema of a normally forgettable presentation.

User interfaces are supposed to be simple and easy to use. Does change translate to improvement? Not always, unless a very thorough and systematic approach is taken during the analysis phase of a human performance technology project. For instance, Apple iPhone users have had to create and learn a new message design schema when the familiar home button was removed (see Figure 8). The home button had been a standard feature of the iPhone since the original was released in 2007. Now users had to adjust and learn to use the device's new face recognition system and new swipe motions (Stein, 2017). However, the removal of the home button also removed a failure point on the phone, specifically the mechanical home button that could wear down and fail after extended use. The removal of the button probably improves overall device reliability. In terms of message design, do the changes appear to be intrinsically simple and functionally reliable enough to be absorbed into new schema?

Figure 9. The Apple iPhone with and without the home button, the new iPhone X was the first time in the ten years since the device's release that the message design did not include the familiar home button.

Conclusions

HPT represents human performance improvement programs that are systematic and flexible. It seeks to evaluate performance gaps, identify causes of gaps, design corrective interventions, implement change, and evaluate the effectiveness of change throughout the process. Current models focus on individual change at the micro-level or organizational change at the macro-level. Ultimately, societal change at the mega-level is the futuristic modernization that HPT needs (Russell, 2007). Instructional interventions and solutions are often an integral part of a performance improvement process. Effective and efficient message design is a critical aspect of these instructional and information initiatives. As globalization flourishes and technology advances, HPT models that employ instructional message design must evolve as well. Instructional message design is an essential aspect of human performance technology.

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Instructional Message Design:
Theory, Research, and Practice

Chapter 5: Instructional Message Design with PowerPoint

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Chapter 5: Instructional Message Design with PowerPoint

Meredith Spencer

Key Points:

- Given both advantages and disadvantages of PowerPoint technology, scholarly discourse on PowerPoint-aided instruction should focus on maximizing its capabilities rather than debating whether or not to use it.

- Though learners both expect and like the use of PowerPoint in the classroom, research on the tool's impact on cognitive learning is inconclusive.

- Responsibility for effective PowerPoint-aided instruction lies in the hands of instructional designers to create appealing displays conducive to learning, instructors to deliver the presentations engagingly, and learners to actively participate in the learning process.

Abstract

Now a household name, Microsoft PowerPoint software is one of the most commonly used slideware presentation tools in business, scientific conferences, education, and other professional, academic, government, and military settings. As an instructional message design tool, controversy proliferates surrounding its role in the classroom experience and its impact on cognitive learning. After compiling the research, lessons can be garnered on how to best visually display PowerPoint slides, how to most effectively deliver PowerPoint-aided instruction, and how to maximize student learning from PowerPoint-based lessons. This chapter will explore the existing body of literature on the technology's capabilities and limitations; offer best practices for instructional designers, instructors, and learners; and suggest future directions for research on PowerPoint use in higher education.

Introduction

As a tool for visually supporting the communication of information, PowerPoint has stimulated a broad spectrum of criticism and praise. From Edward Tufte's (2003a) vitriolic abhorrence of the tool as "corrupt[ing] absolutely" to Yiannis Gabriel's (2008) celebration of the technology for its performative and spectacle-producing capacities, PowerPoint has garnered an impressive mix of critics and fans alike. From its initial release in 1990 to its ubiquity today in education, business, government, and military settings, discourse on this game-changing software has evolved from curiosity about its capabilities to trepidation around the tool's constraints on bi-directional communication to a heated debate over its impact on how people think to finally a more judiciously scientific approach to quantifying its merits and demerits (Kernbach, Bresciani, & Eppler, 2015). If there is one overarching takeaway from the existing body of research on this technology, it is that there are very few "absolutes" in life (sorry, Tufte), and that the power of PowerPoint lies in the wiles of its user, while its efficacy as an aid to the conveying of content is determined by its beholder.

Within the realm of instructional design specifically, with a focus on postsecondary education (college students and adult learners) though with brief mentions of applications in K-12 environments, we must examine the use of PowerPoint from three perspectives: that of the instructional designer, the instructor, and the learner. Ideally, the goals of the instructional designer and the instructor *are* the goals of the learner, but a myriad of factors come into play for each of these groups of individuals when determining the value of the tool.

This chapter will discuss common perceptions, good and bad, of PowerPoint use in the classroom as well as research that attempts to quantify the tool's efficacy in improving cognitive learning. Based on this research, best practices for instructional designers and instructors will be offered, followed by recommendations for further study of the learner's role in PowerPoint-assisted instruction, a relatively underdeveloped area in the scholarship.

The Debate: Dilution of Thought, or Vehicle of Expression

Yale professor emeritus Edward Tufte's bombasts of PowerPoint are the most frequently cited criticisms of the presentation tool. His attacks – supported by illustrations and thoroughly articulated reasoning – emphasize the risks of PowerPoint in watering down, "disrupt[ing], dominat[ing], and trivializ[ing]" content (2003a, n.p.); "reduc[ing] the analytical quality of presentations" (2003b, p. 24); and enabling audience members to be passive recipients of information rather than active contributors to cognitive learning processes. He argues that "Bullet Outlines" – endemic in PowerPoint presentations – "Dilute Thought" (2003b, p. 5) and asserts that alternative presentation aids like well prepared, printed-on-paper handouts "tell the audience that you are serious and precise; that you seek to leave traces and have consequences. And that you respect your audience" (2003b, p. 24).

While Yiannis Gabriel, professor at the University of London, respectfully acknowledges Tufte's charging of PowerPoint with crimes on communication, theirs would surely be an entertaining conversation to witness given Gabriel's (2008) less frequently cited but similarly passionate exaltation of the tool. Gabriel extols the technology's rarely-tapped potential to facilitate an entertaining multimedia performance made more valuable by (Western) society's proclivity for image, spectacle, and multiplicitous stimulation. To complement this, Levasseur and Sawyer (2006) show that multimedia elements excite arousal in and demand attention from an audience, enhancing recall and improving learning motivation and outcomes. They caveat, though, that too much arousal can become distracting and impede cognition. The need for balance supports widely accepted cognitive load theory (Sweller, Ayres, & Kalyuga, 2011).

Further conversations on the pedagogical risks of PowerPoint usage (or, abusage) reveal concerns that PowerPoint is "*becoming* THE message" (emphasis in original) of instruction rather than an enhancer or supporter of instructional messaging (Craig & Amernic, 2006). Critics equitably concede that the efficacy of a PowerPoint-aided lecture is largely determined by the communicative skills of the lecturer, but even the best presenters fall prey to restrictions on student-instructor relationship-building imposed by interrupted eye contact, a darkened room, and the perceived dominance of the speaker

over the audience (Craig & Amernic, 2006; Kernbach, Bresciani, & Eppler, 2015; Ledbetter & Finn, 2017).

Perhaps the biggest threat to the instructor-learner relationship is the relative rigidity of PowerPoint-led instruction in that premade slideshows essentially program the instructor's line of reasoning throughout the class, discouraging improvisation, and streamlining thought processes into an inflexibly linear path regardless of impromptu student input (Gabriel, 2008). While Gabriel does allow that some presentations and learners benefit from the tidiness and linearity offered via PowerPoint-guided instruction, Craig and Amernic (2006) fear that instructors who become over-reliant on the tool lose their abilities to adapt should unanticipated questions or situations arise, hampering classroom dialogue and stifling organic knowledge-creation because of "an unwritten convention of PowerPoint that 'no matter what, get through all the slides'" (p. 152). That linearity that resists digression can be both a good and a bad thing. An instructor prone to tangents might benefit from the structure of a linear presentation, as might an anxious or struggling learner. However, especially in postsecondary education or when working with adult learners, digressions from the lesson plan can be where some of the most productive and innovative conversations take place.

Looking more specifically at the software itself, Kernbach, Bresciani, and Eppler's (2015) codification of 18 constraining qualities of PowerPoint is especially illuminating of the common pitfalls associated with some of the tool's preformatted features. With the 18 items categorized into cognitively, emotionally, and socially constraining qualities, lessons abound for instructors and instructional designers alike. These lessons include ways to avoid loss of meaning through excessive abbreviation and bullet-pointing, to prevent disengagement from content due to overloading of elements on a slide or number of slides, and to resist over-aestheticizing presentations in a way that privileges appearance over substance, or form over function.

One of the most compelling studies, in my opinion, that lends credence to Tufte's call for the abolishment or at the very least temperance of PowerPoint use comes from Hertz, van Woerkum, and Kerkhof's (2015) interviews of 24 scholars (12 novice PowerPoint users and 12 advanced) regarding why they use the tool the way they do. While recognizing the limitations of purely anecdotal evidence from a non-representative sample, the interviewees' responses to the question of what they would do should PowerPoint *not* be available to

them were especially telling. Some flat-out stated that teaching sans-slides was not an option, suggesting that the prevalence of the tool has turned it into a crutch without which new instructors cannot even walk into the classroom. Others responded they would simply employ a different tool such as a blackboard, though with reservations about the quality of hand-drawn images compared to computer-generated graphics. What becomes most alarming, however, is the responses that they would adjust their rhetorical or communication practices,

> "…present more conclusions, give more examples, more descriptions, tell more anecdotes, invite the audience to think about subjects, and improvise more. Some would adjust their voice to maintain the audience's attention and to emphasize structure, or would adjust their articulation or vocabulary." (pp. 279-80)

To state that these are actions they would take should PowerPoint no longer be available is to imply that these are actions they do not privilege when PowerPoint *is* available. If the convenience of PowerPoint leads instructors to present fewer conclusions with fewer examples, descriptions, and anecdotes, or to modulate their voices in a less attention-maintaining manner that does not emphasize structure, this serves as disturbing evidence that the technology in question is, in part and for some, contributing to a decline in instructional quality.

It is easy to get caught up in negativity, but PowerPoint devotees are just as numerous as its enemies. Chief among PowerPoint disciples are learners. Not only do students simply expect PowerPoint to be used in the classroom (Rickman & Grudzinski, 2000) and appreciate when their expectations are met (Ledbetter & Finn, 2017), but they also believe it to be more interesting, more motivating and beneficial for learning, visually clearer with better emphasis on important concepts, and better structured than traditional overhead- or blackboard-assisted instruction (Szabo & Hastings, 2000). Learner perceptions of instructor credibility and reports of a positive affective experience also increase when the instructor employs technology both inside and outside the classroom, such as sending regular emails and even sharing social media posts with students (Ledbetter & Finn, 2017). How student perceptions align with academic performance will be discussed later, but holistically the

research points to learners looking favorably upon their instructors using PowerPoint as a presentation tool.

Many instructors like using PowerPoint, too. Some reasons are practical; often textbook companies provide ready-made slideshows, reducing the work of lesson-planning (Jordan & Papp, 2014), plus the software is relatively intuitive and easy to learn with minimal training (Hertz et al., 2015). Instructors appreciate the ability of structured slides to jog their memory as well as the advanced updates that enable real-time collaboration, allow users to embed multimedia videos and animations, and offer professional designer recommendations (Baker, Goodboy, Bowman, & Wright, 2018; Hertz et al., 2015). PowerPoint is also widely available, and modern classrooms are equipped to support PowerPoint-aided instruction.

Diverse perceptions of PowerPoint leave this debate in something of a stalemate. Some people like it. Some people don't. There is no question that the merit of the tool lies not exclusively within the tool itself, but instead within its user and its perceiver; in instructional design, this is within the instructor and the learner. As such, the debate is not as simple as whether the tool is beneficial or deleterious to the classroom experience, but rather the debate should (and, thanks to more recent scholarship, does) revolve around methodology, or *how* the tool's capabilities can be maximized by both instructors and learners (Jordan & Papp, 2014).

Before we dive in to some of those specific methodologies, though, we have yet to explore perhaps the most important question regarding this technology in the classroom, which is whether PowerPoint-aided instruction *produces better results* than non-PowerPoint-aided instruction in terms of student learning and academic performance. Let's investigate.

The Bottom Line: Does PowerPoint Actually *Work*?

Well, as with most things, there is no black or white answer to PowerPoint's impact on learner performance (quantifiable through assessments) as differentiated from learner experience (qualitative in preference). This absence of a clear-cut correlation is not due to lack of research on the topic, however. Baker et al. (2018) conducted an impressive meta-analysis of 48 studies on the topic (selected from a pool of 486 identified articles) only to conclude that PowerPoint has no statistically significant effect on cognitive learning, defined as

learning ranging from remembering facts to creating knowledge. This is almost undoubtedly a product of the spectrum of opinions on the tool discussed above, along with inconsistencies in presenter skill levels and variety in student learning styles. There are many other influencing factors to consider, though.

For instance, this meta-analysis reflects on the role of subject matter on PowerPoint's potential to yield results. The authors cite two studies (Rowley-Jolivet, 2002; Shapiro et al., 2006) that demonstrate PowerPoint to be effective in Science, Technology, Engineering, and Mathematics (STEM) disciplines, stemming (pun intended) from dealing with complex, model-based information that benefits from the visual (through graphics) and demonstrative (through animations) capabilities of the computer-based tool. Humanities subjects, on the other hand, dealing more with abstract ideas rather than tangible phenomena, are less conducive to the use of such static and dynamic visuals. Literature courses rely almost exclusively on the reading and analyzing of texts; philosophy seminars primarily entail debate and discussion. Neither subject *requires* imagery to learn, so PowerPoint usage in such classes would likely be unnecessary or text-heavy.

Learner age is another factor when assessing PowerPoint's value in achieving learning outcomes. Kalyuga, Ayres, Chandler, and Sweller (2003) discuss the expertise reversal effect – the principle that instructional techniques that work with inexperienced learners no longer work with advanced learners – in the context of multimedia instruction. Findings suggest that inexperienced learners (for instance, K-12 students) benefit more from PowerPoint's ability to explicitly outline key points and break down complex concepts into small chunks of information, while experienced learners find the additional support redundant, excessive, or reductive, ultimately interfering with their cognitive processing. These environmental factors of subject matter and student expertise merit further research.

Another influencing element coming to light is that of how individual student learning styles inform the relative efficacy of PowerPoint-augmented instruction. Levasseur and Sawyer (2006) synthesize four studies on this topic (Beets & Lobingier, 2001; Butler & Mautz, 1996; Daniels, 1999; Smith & Woody, 2000) and surmise that the best-case scenario for student learning would be to match those with preferences for visual learning with predominantly image-based, computer-generated slide presentations and those with verbal preferences with more text-oriented slides or handouts. These studies

show an overall preference for imagery over verbal representations (77%; Butler & Mautz, 1996) and for computer-generated slides over the use of overheads (54%; Beets & Lobingier, 2001). Daniels' (1999) study of the Myers-Briggs learning style classification system correlated students identified as having a "sensing-judging" style with preferring structured classroom environments and thus performing better with computer-generated slides, while those with "sensing-perceiving" proclivities learned better from hands-on experiences.

Gabriel (2008) offers parallels to the (perhaps over-simplified) dichotomy of verbal vs. visual learners in his discussion of caveats and benefits of using lists, images, and statistics in PowerPoint slides. Lists, consisting mostly of text, may appeal more to verbal learners in how they structure thought processes (likewise appealing to sensing-judging learners) and convey reasoning logic from instructor to student. Lists might turn off visual learners, though, in that contexts are obscured, or too much text is overwhelming. Images, on the other hand, may appeal more to visual learners in that they are engaging, demonstrative, and diagrammatic. Verbal learners, though, may perceive incongruence in exclusively image-based presentations or experience cognitive overload trying to extract meaning without textual explanation. Statistics have potential to be either or both visual and verbal, so as long as their presentation avoids misleading the audience, they could have benefits for both learning styles.

Of course, the idea of instructors catering presentation styles to individual learning styles is idealistic and ultimately impractical to implement at a 100% success rate. It does raise questions, though, of how instructors might pre-determine student learning styles to better design the classroom experience, or if there are other correlations, such as between learning styles and chosen undergraduate majors, that might facilitate lesson planning and decisions of whether or how to employ PowerPoint. With limited research addressing these questions, though, it seems that overall instructors should aim to incorporate a variety of presentation styles – verbal and visual, PowerPoint-aided and non-PowerPoint aided – or PowerPoint presentations that incorporate both verbal and visual elements in order to reach as diverse a population of learners as possible.

The scholarship's inability to pinpoint a clearly positive or negative relationship between PowerPoint and student success on assessments is somewhat contradictory to the overwhelmingly positive trend of student self-reports of *perceived* benefits on their

understanding of class material. For instance, university students in a social psychology class reported believing they learned more from PowerPoint-supported lessons compared to lessons supported by overhead transparencies, despite scoring 10% lower on the quizzes that derived from the PowerPoint-supported lectures compared to those following overhead transparency-based lessons (Bartsch & Cobern, 2003).

Learner and instructor perspectives do not always align on this topic, either. James, Burke, and Hutchins (2006) found that while university students and faculty members alike perceived PowerPoint to positively influence note-taking, fact recall, emphasis on key lecture points, and attention-holding, students were less trusting of the tool's ability to help them to learn more effectively than faculty members were. Results suggest that some instructors (in this study, business professors) may overestimate PowerPoint's value to the point of neglecting student desires for a more personal rapport with the instructor and more class-wide discussions, both social motivations.

In sum, Baker et al.'s (2018) meta-analysis cites over a dozen studies purporting statistically significant positive student perceptions of PowerPoint usage on cognitive learning. However, 23 studies across a range of disciplines and age groups show PowerPoint-supplemented instruction to produce *less* cognitive learning, while 25 studies show more cognitive learning, ultimately averaging out to a wash. James et al.'s (2006) citing of two studies (Lowry, 1999; Szabo & Hastings, 2000) showing a positive correlation between PowerPoint and cognitive recall, one study (Daniels, 1999) showing no correlation, and one study (Amare, 2006) showing a negative correlation reinforces this draw.

It is important not to undervalue student perceptions in favor of performance-based measures of "success" alone, though, as learner enjoyment of the classroom experience has incalculable second- and third-order effects on their long-term educational careers. PowerPoint's positive impact on student affect (Ledbetter & Finn, 2017), motivation and interest (Apperson, Laws, & Scepanksy, 2006; Szabo & Hastings, 2000), and satisfaction (Levasseur & Sawyer, 2006) is not to be belittled.

Now What?

Rather than feeling discouraged at the overall impasse that current scholarship leads us to regarding the virtues and vices of PowerPoint as an instructional message design tool, it is time now to capitalize on the lessons we are able to glean from the healthy debates thus far. I will discuss some of these lessons as they apply to both instructional designers and instructors in the categories of (1) visual display and (2) presentation delivery.

Part 1: Visual Display

How PowerPoint slides appear on the screen can make a world of difference when it comes to student perceptions of instructor professionalism and credibility, enjoyment of and engagement in the classroom experience, and understanding and recall of content. The visual impact of a well- or poorly-constructed slideshow presentation can determine first impressions of how a class will proceed and thus shape student expectations for the duration of the lesson and even the entire course. As such, it is important to be *intentional* (making purposeful message design choices about visual presentation) and *consistent* (clean, accurate, and professional) in crafting text, static graphics, and dynamic multimedia functionalities to achieve the foundational goals of encouraging and facilitating cognitive learning.

Text. PowerPoint designers regularly quote variations of the “6x6” rule for text, meaning a slide should have no more than six lines of text with no more than six words per line. Zimmerman and Zimmerman (1997) were among the earliest to recommend this rule in their manual *New Perspectives on Microsoft PowerPoint 97*, though they revised it for unspecified reasons to the “7x7” rule in their 2014 edition now co-authored with Pinard. This rule seems to me rather outdated, though, and somewhat useless on its own; the words still need to have meaning and significance, and, as with all message design, it comes down to *how* those 36 words are presented, not only in terms of being in a grid-like square, but in terms of the font’s legibility from a distance, the text’s contrast to the background even in poor lighting, the vocabulary’s clarity and accuracy, and the text box’s logical alignment and relationship to other elements on the screen.

Once we graduate from this elementary decree of how many lines of how many words to include on a slide, we can reflect more critically on how text format influences student learning. Five of Kernbach et al.'s (2015) six cognitively constraining qualities reflect shortcomings of text-based listing habits encouraged by PowerPoint's conveniently pre-formatted slide layouts: (1) *Abbreviating* words or concepts sacrifices meaning due to omission or partial-conveyance of content; (2) *bulleting* blurs the "big picture" in its generalizing tendencies; (3) *devaluing knowledge beyond the slide* deludes viewers into believing anything not on the slide isn't worth knowing; (4) *fragmenting* forces a choppy thought structure dictated by the order in which text is projected; and (5) *trivializing* renders content less significant because of its self-evident existence on the slide – it's stated in front of me as black and white fact, so what can I possibly contribute, and why should I bother trying?

Each of these cognitively constraining qualities carries lessons to employ bullet-pointed lists only when appropriate, for instance when the guiding logic behind content is sequential, hierarchical, or classified into groups or sets. Kernbach et al. (2015) also stress that provision of external learning materials as complements to slides (as opposed to letting the slides stand on their own) can help mitigate for the potential loss of meaning that results from abbreviated text or fragmented sentences. They argue the more diversity in instructional strategies, the better.

In a more targeted study on typography in presentation slides, Alley, Schrieber, Ramsdell, and Muffo (2006) discovered that actively resisting the constraints of abbreviation and fragmentation by using a succinct (no more than two lines) but syntactically complete sentence that summarizes the main point of a slide as the slide's headline – rather than the typical one- or two-word title – significantly increases retention of that main point. They maintain that this headline should be left-justified, bold, and in a sans-serif font. Foregrounding the key takeaway of any given slide *in* the title box rather than merely alluding to it in the title and then presenting it somewhere buried in the text body ensures that it is the first thing students read and makes it easy to reference when reviewing slides down the line.

Images and static graphics. While text is arguably indispensable in effective PowerPoint design, students find instruction more interesting when teachers use images instead of purely text-

based slideware (Tangen et al., 2011). The key to using graphics effectively is congruence, meaning visuals must relate to and support the content and associated text, if applicable. Per Mayer's (2001) coherence principle, text or images that do not align with the content are merely distractions that harm student learning and should be eliminated. As support, Bartsch and Cobern (2003) show a decline in both student preference for and performance following PowerPoint presentations displaying graphics that were irrelevant to the content. Tangen et al. (2011) also confirm that PowerPoint slides containing images logically related to the content were most beneficial to student learning. Conversely, purely text-based slides were found to be more beneficial to student learning compared to slides showing unrelated images, driving home that it is not just the presence of images but the images' association with the content that makes them conducive to learning.

There are also certain contexts in which some images are more beneficial than others. Hertz et al. (2015) identified five chief reasons why instructors use pictures in their presentations: to explain concepts like how something functions or to show progression through a flowchart, to support student comprehension of complex ideas, to serve as a mental break in content or a transition into a new topic, to add humor or positivity to the classroom environment, or to help themselves remember what to talk about. Hertz and colleagues also found that advanced presenters used almost twice as many images as novices, suggesting that less confident or experienced instructors rely on text as a crutch and fear the fact that images allow more room for interpretation, opening up both freedom for creativity in the best case and opportunity for *mis*interpretation in the worst case.

Subject matter comes into play, too. Gabriel (2008) points out that scientific fields like "anatomy, geography or physics" benefit most from the use of images, given their "infinite variation of nuance, magnification and colour, immeasurably enhanc[ing] understanding and communication" (p. 265). Less demonstrative subjects, though, like foreign languages or law, are characteristically less visual in nature, so use of graphics or clip-art would be extraneous to the subject matter and could even seem amateur.

Regardless of subject, this notion of images (and text and multimedia elements, for that matter) potentially being extraneous is a danger all instructors and instructional designers should beware. Mayer and Moreno (2003) identify three assumptions associated with

learning that employs both words and images: *dual channel*, meaning humans process verbal and visual information separately; *limited capacity*, meaning humans have limited processing abilities in those channels; and *active processing*, meaning learning requires substantial effort in both channels. Given that PowerPoint presentations using both text and images target both verbal and visual channels, incorporation of graphics must avoid inducing cognitive overload in students by a) not redundantly illustrating what was already communicated through the verbal channel, b) not serving purely decorative functions, and c) not being so intricate or complex that the learner is unable to parse meaning from them.

Multimedia functionality. Over the years, PowerPoint has grown into a surprisingly multifaceted multimedia software tool that enables its users to employ audio, video, animation, special effects, and interactivity in addition to text and graphics. There are competing programs for these advanced features (the entire Adobe Creative Suite being one example), but instructional designers stand to gain from maximizing these oft-overlooked capabilities within PowerPoint given their relative simplicity compared to pricier alternatives.

As motivation to explore these more challenging features, Hallett and Faria (2006) show that students both recalled more and were more interested in instruction when the material was delivered through a combination of the advanced multimedia features of audio, video, animation, and special effects as compared to a traditional lecture. Gabriel (2008) also purports that modern culture not only promotes but necessitates multi-tasking in a way that favors multidimensional experiences over one-directional lectures.

Incorporating animation into a PowerPoint slideshow is another relatively simple way to increase the complexity or sophistication of the presentation. Animation enables the instructor to control when and how text appears to echo their lecture organization and direct learner attention to certain topics at certain times. Doing so keeps the learner on pace with the instructor, preventing them from looking ahead or being distracted by material the presenter has not yet addressed. Animation can also extend to figures, making objects move across the screen, or demonstrating progression (in time, size, or significance). These effects cannot *only* be attention-grabbing, though; they must also aid in the explanation or exposition of the content (Reiber, 1990).

Findings on whether animations influence cognitive learning are murky. Miller and James (2011) found in their research on PowerPoint usage in college-level astronomy courses that students perceived animated slides to be more effective, but in-class exam scores revealed no quantitative benefit from the use of animations. They did find, however, through end-of-semester surveys, that the animations may have improved long-term memory of the material and that animating graphics may be more impactful than simply animating text. More research is needed to conclusively determine the benefits of animation, but arguably student preference for movement on the screen is justification enough to employ it.

Overall, when it comes to piecing together text, graphics, and other multimedia elements, Baker et al. (2018) recommend instructors consult the principles of cognitive theory of multimedia learning. Mayer and Moreno's 2003 article on reducing cognitive load in multimedia instruction offers nine techniques, including conveying words through auditory narration rather than on-screen text (modality principle), offering cues for how to process information (signaling effect), and avoiding visually displaying and orally speaking the same text, again erring on the side of narration over projecting large blocks of text on a slide (redundancy effect). These broad lessons can apply in a multitude of scenarios with PowerPoint-aided instruction, with the general takeaway that, often, less is more.

Despite PowerPoint's multifaceted capabilities, through the piecing together of these visual aspects of a slide-based presentation, instructional designers can quickly recognize the limitations of having to fit sometimes large amounts of information into a finite amount of space, or of imparting intricate or abstract concepts by means of a tangible medium. As such, the visuality of a PowerPoint presentation only takes the learning process so far. Ultimately, the efficacy of PowerPoint-based instruction will come down to how the presenter delivers the visual aid to convey their message.

Part II: Presentation Delivery

The visual display of a PowerPoint presentation is only one piece of the puzzle when it comes to using the technology in the classroom. Yet another of Kernbach et al.'s (2015) insightful constraining qualities is that of *overaestheticizing*, or allowing the visual aspects of a PowerPoint presentation to take precedence over

the content of the presentation itself. They reference Tufte (2006) to accentuate that visuals serving purely ornamental purposes are distracting and counterproductive to learning. So, while aesthetic elements certainly play a role, how instructors use the visual aid to support and facilitate their delivery – rather than allowing it to give the presentation for them – is of greater importance.

Rhetorical skills and lesson facilitation. While it is easy to get caught up in the beautification of a PowerPoint presentation, instructors should also recognize the need to devote just as much, if not more, energy to their own rhetorical skills. Hertz et al. (2015) identify that one reason why novice instructors relied on PowerPoint stemmed from personal insecurities, either because they felt they lacked charisma, were anxious that their pronunciation was difficult to understand, or feared they might forget what to say and thus appear unprepared. I am by no means unsympathetic to these forms of self-doubt, but they cannot be used as excuses to rely on technology to do the teaching in place of the instructor. Instead, they must be used as motivation to discover methods of alleviating these apprehensions.

Holistically, we must recognize, as Schnettler (2006) did, that the presenter and the slides are (or should be) intertwined. Presenters must be able to *translate* bullet point lists and graphical images to the audience. This means speakers should rarely read slide text verbatim or superficially summarize projected images (the audience can do this themselves, given a few moments of silence) but instead should offer their expert interpretations of the text or graphic, elevating it from its mere face value into something of significance.

The speaker's delivery and ability to expound upon what is displayed on-screen is crucial to the effectiveness especially of text-based slides given the frequent pitfall of bullet-pointed lists to "imply certain assumptions that are not always met," for instance, that the items listed are exhaustive or mutually exclusive (Gabriel, 2008, p. 263). Lists can often be reductive, slashing complex ideas down to superficial summaries communicated through truncated sentences. Craig and Amernic (2006) even warn of PowerPoint's "profound impact on literacy", where "[t]he obligation to form full sentences has become optional and the spelling of polysyllabic words has become a lost art in a sea of PowerPoint-induced abbreviations" (p. 157). Two lessons here become, first, resisting temptations to over-simplify slide text to the point where quality is compromised due to limitations in

quantity (the area available on the slide, or the arbitrary 6x6 rule), and, second, to mitigate for the condensed text by using practiced rhetorical skills to clearly articulate the meaning of that text.

Learner-instructor relationship. One of the biggest critiques from students and instructional designers alike of PowerPoint-led instruction is the seeming barrier it emplaces between the learner and the instructor (Jordan & Papp, 2014). Craig and Amernic (2006) assert that PowerPoint can (but does not have to) limit "immediacy behaviors" like maintaining eye contact, reading body language and facial expressions, hearing laughter or side chatter, etc. (p. 152). Kernbach et al. (2015) categorize both emotional and social constraints that result from PowerPoint usage, including lack of personal attachment, dominating (of the presenter over the audience), and sitting in the dark (a physical environment that renders the audience sleepy and thus less likely to engage in lively discussion).

Some instructors actually *like* that PowerPoint presentations interrupt direct eye contact and take attention away from them (Hertz et al., 2015). In cases where one-way communication is the goal, this limitation may in fact not be a problem (Kernbach et al., 2015). However, in most higher education classrooms and adult learning environments, active discussion and interactive group collaboration are considered more engaging and productive (Baker, Jensen, & Kolb, 2005). Instructors insistent on using PowerPoint in these contexts should look for ways to integrate discussion into their slides.

One technique camera-shy instructors can use to help break the ice with students is embedding adjunct questions, defined as questions explicitly incorporated into instructional texts (or, in this case, PowerPoint presentations) to engage learners with the content (Valdez, 2013). Valdez's experiment with anatomy students discovered that the students who were asked open-ended adjunct questions throughout a lesson retained and comprehended the information significantly better than the students who were asked no questions. Students can respond to the questions in writing (as they did in Valdez's study) or through a facilitated class-wide discussion as a method of reinforcing the material and creating memorable experiences.

As a second ice-breaking technique, DenBeste (2003) suggests beginning class projecting an image to spark a conversation about the significance or relevance of that image to the topic of the lesson. She

argues that this sets the tone for the rest of the session, gives students something to recall and build upon, and gets them talking right from the start, increasing the likelihood of speaking again later. This can establish a more conversational rapport between the instructors and learners early in a lesson.

Future Directions: Learner Responsibility

Thus far we have focused predominantly on the instructors' and instructional designers' roles in ensuring a successful PowerPoint-assisted classroom experience. But, are not the learners – especially once they pass the K-12 age group – partially responsible for their own development? A few scholars have alluded to the need to proactively teach students how to get the most out of PowerPoint-led instruction (Baker et al., 2018). For instance, students should receive guidance on where to direct their attention during class, and on how to take useful notes (Raver & Maydosz, 2010). Instructors should also foreground student expectations regarding technology use in their syllabi and ensure that learners recognize PowerPoint in the classroom as a framework of key ideas and not the end-all-be-all of content (James et al., 2006; Ledbetter & Finn, 2017). Each of these ideas merits targeted research to see how active learner engagement could potentially help mitigate for some of the aforementioned limitations or weaknesses associated with PowerPoint itself or its deliverers.

Researchers should then explore how instructors teach learners how to use PowerPoint, as it is the go-to tool for student presentations, again due to its widespread availability and relatively intuitive interface. Hertz et al. (2015) suggest that students should first and foremost be taught rhetorical communication skills (sans-PowerPoint), then how to design aesthetically pleasing and functional slides, and only then how to deliver those slides to an audience. This is just one potential method for training our universities' future PowerPoint-wielding faculty members that deserves further consideration.

Conclusion

In sum, the visual display of PowerPoint slides may receive an "ooh" or an "ahh" on first glance, but PowerPoint-aided instruction

ultimately is only as valuable as the instructor delivering the slides makes it. Instructor preparation needs to focus equally on cultivating rhetorical confidence and classroom facilitation skills as well as fostering meaningful relationships with the learners without hiding behind technology.

Despite development of competitors like Prezi and Google Slides, PowerPoint software does not appear to be going anywhere any time soon. Even with its challenges and drawbacks, there is no denying that PowerPoint *can* be used effectively. It is simply up to instructional designers to craft meaningful, cognitively manageable slides, instructors to present those slides with authority *and* flexibility, and learners to understand the role technology plays in the classroom balanced with their own responsibilities. With this trifecta of skill and awareness, PowerPoint can truly live up to its potential.

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Chapter 6: Designing and Learning from Modeling and Simulations

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Chapter 6: Designing and Learning from Modeling and Simulations

Travis Saylor

Key Points:

- The affordance of technology has made the design of simulations a much more practical application of instructional message design
- Augmented and virtual reality applications have become affordable and practical message design options to enhance learning
- Well designed, high-fidelity simulations allow for the authentic practice of skills that learners will need to perform in the real-world

Figure 1. Modern simulations evolved from early post World War II computer simulators, such as the digital AKAT-1 used for thermodynamic simulations (https://commons.wikimedia.org/wiki/File:AKAT-1.JPG (CC BY-SA 3.0)

Abstract

Instruction message design with simulations is the use of technology to create virtual environments for cost-effective, safe, and authentic learning. This chapter presents a condensed history of simulation learning, an introduction to several approaches to design instructional simulations, and research based best practices that can be used to guide instructional designers. These best practices include the attention to fidelity or realism of the simulation, the removal of extraneous distractions from the design, and the inclusion of sight, sound, and haptic details that the learner will encounter in the real world. Augmented reality, or the blending of virtual and physical environments, as well as virtual reality, or the immersion of learners in synthetic environments, are also two related areas that will allow for innovative message design opportunities. Advances in technology have allowed for the use of simulations in a wider variety of instructional applications including K-12, higher education, and military training. This chapter describes several of these intriguing avenues.

Introduction to Modeling and Simulation Systems: A Historical Perspective

Computer simulations date back to World War II when two mathematicians, Jon von Neumann and Stanislaw Ulam, were asked to solve the simulate and predict the behavior of neutrons (Pritsker, 1986; Shinde, 2000). The previous experimental methods of trial and error were proving to be too ineffective. While mechanized flight simulators had existed since the 1930s, von Neumann and Ulam's worked was among the first to begin virtualizing the physical environment with statistical analysis (National Museum of the US Air Force, 2015). They considered many different options and decided to utilize "the Roulette Wheel" or the "Monte Carlo" method, a technique for finding approximate solutions to problems by means of doing many random samples (Shinde, 2000). Since basic data regarding the regularity of various events were known, the mathematicians merged probabilities of individual events into a step by step analysis to attempt to predict the end result of the complete sequence of events. von Neumann and Ulam's (and others' work at

the Los Alamos National Laboratory) pioneering work using early computers for advanced statistical modeling would influence and inspire a new generation of researchers (Wood, 1985). With the remarkable success of the techniques on the neutron problem, it soon became popular and found many applications in business and industry. Through the use of electronic computers, this method became widespread throughout the sciences. Ulam also improved the flexibility and general utility of computers (Banks, 1998). Ulam worked at Los Alamos, New Mexico, where he used his simulation methods to help design the hydrogen bomb, the fusion bomb, the fission bomb, and the atomic bombs used to stop World War II. In the late 1940s his team used the legendary ENIAC computer system to simulate and create the functional design of the first hydrogen bombs (Haigh, Priestley, & Rope, 2014; Wood 1985).

Post-war world, new technological advances that were being developed for military uses during the war, were emerging in the private sector as new problem-solving tools. The beginning of computer technology was broken into two approaches: analog and digital. Commercially designed digital computers began to see uses during the late 1940s and early 1950s in a number of organizations (Shinde, 2000). During this period programming languages such as FORTRAN and COBOL were being developed for early computer systems and the field was beginning to differentiate between the construction of a simulation and the use of the simulation (Sammet, 1981; Wexelblat, 1978). The interesting part was with new technology came new problems. Who would use these expensive computers and what would they utilize these tools for? Historically, it became the senior engineer's responsibility to figure out how to use these electronic behemoths and utilize them to solve the problems of the day. This period of simulation history also saw the evolution from human computers to specialized computer programmers who used electronic computers for calculations and modeling (Shetterly, 2016).

Computer simulation would not see any major advances for years due to the cost and processing power of technology not advancing far enough to make the technology a widely useful tool. This lack of advancement was due to how long it took to get results, and the requirement of an excessive amount of resources to program, design, and execute the simulations (Shinde, 2000). The lack of sufficient computer power negatively impacted early modeling and simulation programs (Wood, 1985). It was not until 1961 when

IBM's General Purpose Simulation System (GPSS) was created and released to assist in the design of various simulations did results begin to be used to rapidly inform decision making (Thesen, 1978). IBM's GPSS was easier to use than previous systems and was also applied to simulate stock exchange, traffic control, manufacturing, data center, telephone, and airline reservation systems (Gordon, 1978). IBM shortened the time it took to model, simulate the problem, and receive results from months down to weeks. The interesting part was that the system was designed so that the engineers could input information into the program, but engineers commonly preferred to have specialized programmers interact with the system (Reitman, 1988).

Now the world had the beginnings of simulation but how would we move forward from here? The one thing that all programs require is a language to utilize. This programming language is the basis for all of the computer simulation's inner workings and calculations. It was decided in the late 1960s that a group needed to be established to address the standardization of these languages and to suggest how to best move forward (Shinde, 2000). This group was comprised of SHARE, the Joint User's Group of the Association for Computing Machinery (ACM), and the Computer and Systems Science and Cybernetics Groups of the Institute of Electrical and Electronics Engineers (IEEE).

In the 1970s, simulation was taught to industrial engineers in school but unfortunately rarely applied due to practical limitations (Shinde, 2000). Industrial engineering graduates viewed simulation as long hours wasted at a computer terminal with endless runs to discover an obscure bug in a language.

Two main misnomers about simulations in the 1980s was that simulations were expert based and took what felt like forever because of programming and debugging. Also, the simulation software only concentrated on material requirements planning (MRP), this only takes into account the timing and sizing of orders and could not account for capacity limitations. Then the Simulation Language for Alternative Modeling, or SLAMII, was developed in 1983 and was popularly used on the cost effective and widely available IBM PC (Pritsker, 1986). SLAMII provided three different cost effective modeling approaches that were Network, Discrete Event (the simulation state changes at specific times or points), and Continuous (simulation state can change at any time or point during the simulation) and you could utilize any combination together. This

program was the modern predecessor of many of today's simulation software (Knill, 2000; Shinde, 2000).

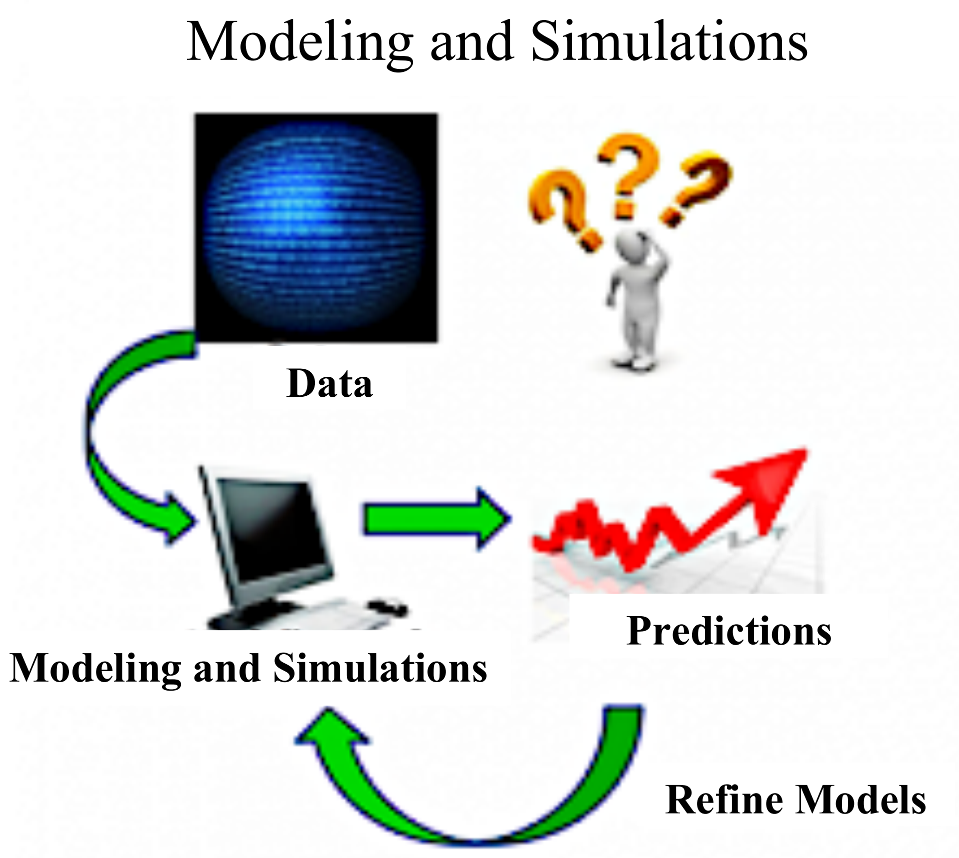
Now jumping forward to 1998, simulation software could provide automatic data collection, optimization, a new user interface, and did not require the user to write in any proprietary programming languages. Today a user is able to model, execute, and animate nearly any manufacturing system in any level of detail in minutes versus weeks. Advanced versions of simulation software in the 2000s now supported the following features (Knill, 2000; Muhammad, 2014; Schank, 1997; Shinde, 2000):

- Uniquely structured environments and graphical user interfaces let the user quickly enter the geometry and production requirements of a model.
- Expert system technology generates details automatically while windows and pop-up menus guide the user through the modeling process.
- Changes can be made quickly and easily with far less chances of errors.
- Built-in material handling templates make the user more productive, so users do not waste time programming.
- The user can verify and test designs, answer "what if" questions, explore more alternatives, and catch system glitches in 3-D animation, all before implementation.
- 3-D graphics are automatically created as the user enters data.
- Results can be communicated in real time or near real time.

Today's modeling and simulation is arguably one of the most multifaceted fields of study to undertake as an instructional systems designer. With the constant advances in technology that occur every day and the cultural change across the planet that welcomes the affordances of technology into their lives, many crave technology in their daily lives and this desire increased the demand for more advances from corporate markets. With this demand driving industry to create faster, stronger, more versatile technology, has made simulation and modeling a much more achievable goal.

The benefits of modeling and simulation are too many to name, regardless of the industry. Quality, safety, productivity, and improvements can all be affected by modeling and simulation, whether the change occurs in the office, or on the industry floor, or in the warehouse (Reitman, 1988). Today, simulation is extensively being used as a tool to increase production capacity in many fields and industries. Visualization and graphics have undoubtedly made an enormous impact on all simulation companies. Easy-to-use modeling has resulted in low-priced packages that would have been unthinkable just a few years ago. The Simulation technology has shot up in value to other related industries. The Simulation industry is coming of age and is no longer just the domain of academics.

Introduction to Modeling and Simulation Systems:
A General Overview



https://www.quora.com/What-is-modeling-and-simulation-1

Figure 2. Data serves as inputs to simulation systems designed to model reality, the systems create predictions based on these models, the accuracy of these predictions are used to further refine the models

Modeling and simulation is a rapidly evolving field that is integral in science, technology, engineering, mathematics, health science, business, education, and numerous other fields of application. With the ever-changing technological advances that occur today, modeling and simulation has immeasurable potential for sparking a student's interest in any science, technology, engineering, and mathematics (STEM) field. Modeling and simulation fields can

include various disciplines that can interest young adults that includes gaming, animation, virtual reality, augmented reality, medical and scientific imaging, engineering drawing, automation and transportation, and architectural drafting.

Today's modeling and simulation is arguably one of the most rapidly expanding fields in an industry that is being extensively utilized as a vital tool to increase industrial production capacity while limiting waste by designing systems in the virtual world. For instance, our military is committing millions of dollars in funding research projects to help augment our troops' abilities and to limit our losses during conflicts. Advances in visualization and graphics have undoubtedly made an enormous impact on all simulation companies.

Simulations have become instrumental in industrial research and development throughout the world. This amazing tool provides the end user the ability to create real world situations without the extreme cost involved in building full scale models, staffing the models with real people, and running the model through several different evolutions to ascertain the effectiveness of the design model. By using this tool, the end user will be able to evaluate how their designs perform in the industry and it will also allow them to collect and review the data that they gather to ascertain its usefulness in industrial applications.

Modeling and Simulation Presentation Methods

Computer-Based Simulations (CS) use computers to predict the fluid responses of a system through the behavior of a system modeled after it (Gould, Tobochnik, & Christian, 2017). Simulations use the mathematical models of a working system in the form of a computer program. The simulation is composed of mathematical equations that recreate the real system. Once the simulation program is run, the output from the simulation will result in mathematical data that represents the behavior of the real system. Not all simulations are programs, some can be in the form of a computer-graphics image which will be a direct representation of a process with an animated sequence. Computer simulations are most useful when it would be difficult or unsafe to study an object or system in real life. Take for example, an asteroid coming straight for earth. How can we find the actual flight path of such an object? By

creating simulations we can create a mathematical model that incorporates such variables as heat, velocity, and gravity to estimate the impact of near earth objects.

Virtual Reality **(**VR**)** implies a complete immersion experience that shuts out the physical world (Merchant, 2014). Using VR devices such as the HTC Vive, Oculus Rift, or Google Cardboard, learners can be transported into a number of real-world and imagined environments such as the middle of a squawking penguin colony or even the back of a dragon. VR open doors to a new realm of instructional message design by immersing learners in artificial environments where they can manipulate objects in 3D spaces.

https://elearningindustry.com/virtual-reality-training-vr-changes-ld-4-ways

Augmented Reality (AR) is the blending of interactive digital elements such as dazzling visual overlays, buzzy haptic feedback, or other sensory projectors which adds digital elements to a live view often by using the camera on a smartphone (Gorman, 2016). This versatile delivery method allows the educator to assign educational locations and virtual field trips to visit during break time and school time to augment the students' educational goals. The additional resources available during physical or virtual field trips ares especially interesting. Examples of augmented reality experiences include Snapchat lenses, Google glass, and the game Pokemon Go (which alerts and encourages players to visit historical locations and sites around them). While Pokemon Go occupies a place in history as the first widely adopted augmented reality experience on mobile devices, there are (and will be) many instructional applications:

Mixed Reality **(**MR**)** combines elements of both AR and VR, real-world and digital objects interact. Mixed reality technology is just now starting to take off with Microsoft's HoloLens as one of the most notable early mixed reality apparatuses. As a result, today's military are including as much technology as possible to better protect our troops. For instance, combinations of mixed reality technologies are being used to remotely pilot drones and to send critical information and communication to soldiers in real-time:

https://www.military.com/video/logistics-and-supplies/field-equipment/us-army-tactical-augmented-reality/5453063309001

Immersive Simulations (IS) are technology supported by VR and allows us to learn skills just like we did when we were children, through observation and emulation (Lateef, 2010). This type of learning plays a huge role in why it is so effective for learning new skills. As you see below, a Naval Research Engineer demonstrates an infantry Immersion Trainer using VR technology:

https://www.navy.mil/view_image.asp?id=48945

Role-Play Simulations (RS) is when an individual portrays a role with other participants, with or without the specific reliance on technology (Joyner & Young, 2006). Best practices include involving all learners, allowing adequate time, providing feedback, and allowing for reflection (and schema creation) at the end of the role play activity. Participants are given a situation plus a task or problem, but they are not acting as themselves but as though they are someone else. The learner assumes the role of the character in the scenario they are provided. An example would be if you are given the role of a manager and you need to discuss a behavioral issue with an employee. Another example would be medical role-play simulations, such as a cardiopulmonary resuscitation (CPR) first-aid learning workshop. Learners are able to practice and refine their new skills on functional models:

How to use Modeling and Simulation Theories

A simulation can be defined as a model of reality reflecting some or all of its properties. Robert Gagne's conditions of learning theory stipulates that there are several different types or levels of learning (Gagne, 1972). The significance of these classifications is

that each different condition type requires several types of instruction. Gagne identifies five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. Different internal and external conditions are necessary for each type of learning. In terms of message design for simulations, Gagne identified the following properties of a simulation as crucial:

- A simulation represents a real situation in which operations are carried out.

- A simulation provides the user with certain controls over the problem or situation.

- A simulation omits certain distracting variables irrelevant or unimportant for the particular instructional goals. Simulation = (Reality) - (Task irrelevant elements)

Simulation-based education today often relies on the usage of computers, programs, and advanced technologies to present a near perfect (or as perfect as possible) representation for the users and enhances the learning environment. There are several tools in use today that can be employed to create effective simulations. Instructional message design using simulations includes five main components that are common despite applications of simulations in different fields (Jefferies, 2005). Characteristics of the students are built into the specifics of the simulation. The message design includes a teacher or facilitator that guides the learner through the activity, provides assistance, and debriefs students after the simulation. Educational practices that are supported by the simulation, including how students work together, should be included in the design. The implementation of the design should consider the authenticity and realism of the design, as well as the exclusion of extraneous content but the inclusion of relevant intrinsic aspects of what the simulation is meant to model. The intended outcomes are also part of the design, including learning effectiveness as well as the instructor and student perceptions and satisfaction with the design. Figure 3 illustrates these instructional message design considerations:

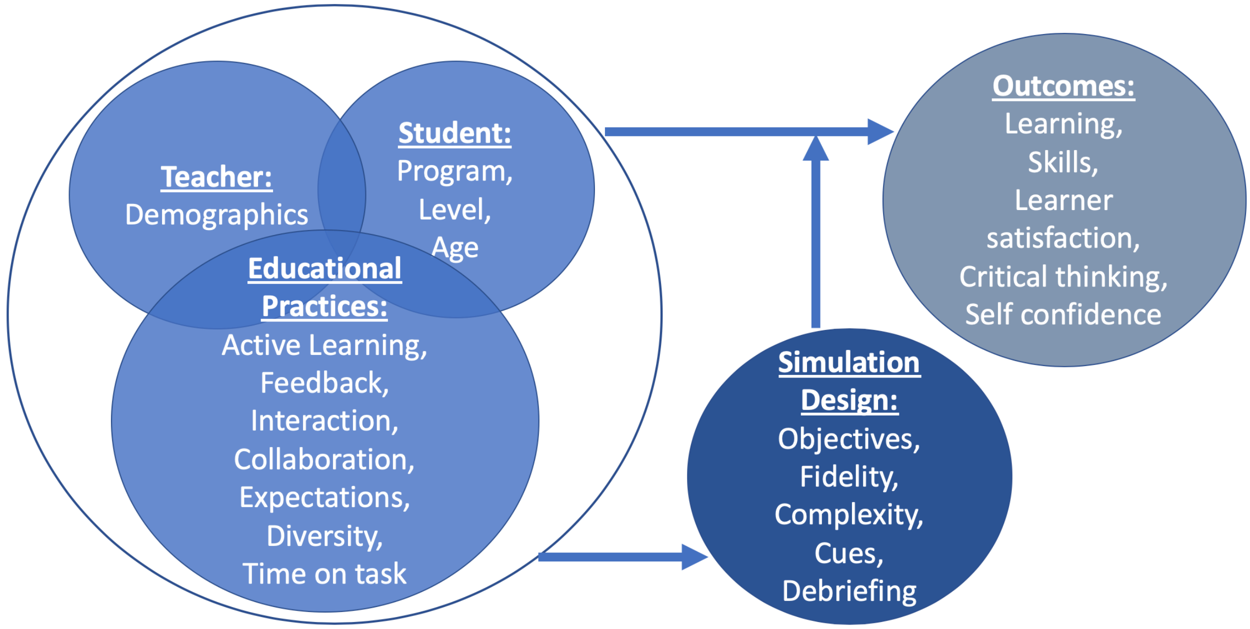


Figure 3. A model for designing simulations starts with the characteristics of the teacher and student and applied educational practices, which informs the design of the simulation, which should result in effective outcomes (Modified from Jefferies, 2005)

Modeling and simulation are effective techniques that can be used to save thousands of hours of work and prevent tragedies. The instruments we have available to use today are improving every day. Where we used to make physical prototypes to represent our processes, which took weeks to create with a large amount of resources exerted, now we can create virtual models in a few short hours with much more accurate results. One of the most important part of an effective virtual simulation process is that it should be continuous in nature (today's technology allows for the cost effective generation of continuous modeling, which in many cases are preferred over discrete models). Once you create a model and place it online you can always improve upon the model and constantly receive data to ascertain the current operating parameters that the system is operating under. For instance, an environment can be simulated during training sessions before the actual facility is built or available and revised during construction of the physical environment:

As will all instructional interventions, the message design of simulations requires a thorough learner and learning objective analysis. Simulation-based learning presents a specific problem in that system designs can be made too complex and difficult for new, novice students. It has been shown that novice learners are routinely unable to retain information from overly complex simulations (Lateef, 2010). The ability for students to understand a simulation is limited by the student's prior knowledge of the topic. Human cognitive structure (i.e., considerations for cognitive load, see chapter two in this book) should be routinely taken into account while designing a simulation. It is also worth noting that the use of simulations is often only part of the over-all learning process. For instance, an instructional program would first consist of online or in-class work with an instructor, then guided learning on a simulator, then learning in the real-world.

Historically, previous research studies have documented that, at least for novice learners, simulation-based learning can be difficult. Learners have problems in establishing goals and results in learning through simulations, or that they have problems with verbalizing results and gained knowledge (Glaser, 1992). The end result is that the more detailed the information, the more chunking is required for the student to retain learning. In a simulation this

chunking involves breaking complex scenarios in simpler modules that comprise the overall larger learning objective. Breaks and debriefing sessions can be designed into the simulation as the simulation progresses from simpler modules to more complex, larger scope challenges.

Instructional Design Best Practice When Designing Simulations

Instructional designers can rely on and apply a set of evidence-based best practice when designing simulations, especially immersive experiences that prepare learners for skills they will need to use to perform in the real-world. For instance, cognitive load theory and multimedia learning theory strongly suggest the reduction of extraneous distractions and a focus on relevant content (Sweller, Ayers, & Kalyuga, 2011; Mayer, 2014). Other best practices include defining clear learning objectives, briefing learners before the simulation, focusing on the fidelity or realism of experience, ensuring practical learner evaluation, and debriefing of learners after the simulation (Sittner, Aebersold, Paige, & Lioce, 2015). The fidelity of the experience is an important point to consider; the simulation must be authentic (ideally as authentic as reasonably possible) such that skills practiced and refined in the simulation can be applied in the real-world (Reigeluth & Schwartz, 1989). For instance, if the control wheel of a vehicle moves in a certain way, then in terms of instructional message design the control wheel in the simulation should move in that exact same way providing that exact same level of feedback to the learner. Several best practice design guidelines can be derived from this previous research:

Simulation Design Best Practice:

1. In terms of instructional message design, focus on the fidelity of the experience
2. The simulated experience should mimic as closely as possible the real-world experience
3. Remove extraneous, unrelated distractions from the design
4. Include the intrinsic details (e.g. sights, sounds, movement, and haptics) that the learner will experience when transferring skills to the real-world

Summary

The effective use of simulation and modeling techniques and technologies is a growing field of educational research and instructional message design. It is an innovative avenue that allows the designer and the user numerous opportunities to lay out their plans and work together to create instructional message designs that transcend previous technology constraints. Simulation technology, including evolving augmented and virtual reality applications, can be used in training applications to increase access, reduce costs, and reduce the danger of training in the physical environment. Simulations and modeling give instructional message designers the power to create virtual worlds to accomplish learning objectives in a very wide variety of industries.

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Instructional Message Design:
Theory, Research, and Practice

Chapter 7: Learners with Disabilities and Video-Based Instructional Message Design

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Chapter 7: Learners with Disabilities and Video-Based Instructional Message Design

Charles Thull

Key Points:

- Individuals with disabilities have education and community access rights and benefit from individualized instruction and supports.
- Individuals with low incidence disabilities often display life-long learning needs, and experience lower employment rates.
- Video-based instruction supports individuals with disabilities and promotes access to workplace and independence.
- All students with disabilities can develop skills and pursue positive outcomes, and benefit from individualized instruction and support.

Abstract

Learners with disabilities are entitled to public education that supports their unique needs, but unfortunately, they experience poor post-secondary outcomes when compared to their peers, including lower rates of post-secondary education engagement and employment. Individuals with low incidence disabilities experience lower employment rates when compared to other individuals with disabilities, due to the impact of difficulties with social/communication, self-determination, and executive functioning skills. Researchers have developed video-based instruction with various message design and technology features to support independence for individuals with disabilities, including basic to

complex vocational task completion. This chapter will provide useful information for designers, educators, state and private service providers, and families of individuals with disabilities.

Introduction

Students with disabilities represent a diverse and dynamic population that display various learning strengths, needs, and outcomes. In public school programs, students with disabilities that participate in the general education curriculum may have high incidence disabilities. High incidence disabilities occur more often, and may include students with specific learning disabilities (weaknesses in academic skills), emotional disabilities, other health impairment (i.e. attention deficits), or mild intellectual disability (lack of some daily living skills). While students with low incidence disabilities may have moderate to severe intellectual disabilities and/or developmental disabilities (i.e. Autism, physical disabilities). Students with low incidence disabilities may participate in adapted education curriculum programs in public schools.

Individuals with disabilities greatly benefit from federal laws which will be discussed in this chapter. These laws are the culmination of decades of advocacy and continue to reaffirm the rights and needs of this unique population. To help the reader build further background knowledge, this chapter will also discuss an overview of the prevalence, characteristics, and outcomes associated with individuals with disabilities. Finally, this chapter will review research about video-based instructional message design for academic and vocational skills, which represents a promising evidenced based approach to supporting the needs of individuals with disabilities. The reader should note that all students with disabilities can develop skills and experience positive individualized outcomes. As such, studies focused on K-12 (elementary school including kindergarten, middle school, and high school) students may also have relevant application for young adults preparing to enter the work force.

Overview of Disability Education and Accessibility Laws

Historically, individuals with disabilities have been underserved or denied access to education and appropriate learning supports and opportunities. With significant advocacy from families and stakeholders, the federal government enacted the Individuals with Disability Education Act (IDEA), which became law in 1975. Originally called the Education for All Handicapped Children Act, IDEA mandates a free and appropriate public education for students with disabilities. Students with disabilities must be educated in the least restrictive environment, including being placed in neighborhood schools with general education peers (Murdick, Gartin, & Crabtree, 2007). Public school systems may not reject any student with a disability and must provide due process when developing and implementing individualized education plans (IEPs) (Heward, 2009; Miller, 2009).

Public K-12 schools are required to identify students with disabilities, which occurs through comprehensive evaluation and school based eligibility committees. When a student is found eligible for special education services, the IEP team develops and proposes an individualized education plan (IEP). IEP teams usually include the student's parents, special education teacher, general education teacher, principal designee, related service providers (i.e. speech teacher, occupational therapist, and physical therapist), and others as needed (i.e. procedural support liaisons, parent provided advocates/lawyers, or school system special program representatives). This plan should define the student's learning strengths, needs, goals, and special education services. An IEP should support the students' access to the general education or adapted curriculum, as appropriate. IDEA also requires public schools and agencies to provide early intervention and preschool services to students with disabilities, aged 3 - 5 years old. Preschool age students with disabilities are often identified by county level child find programs, and are provided with an individualized family service plan (IFSP). This plan supports the child and family's access to therapy and education services (Heward, 2009). With further IDEA reauthorizations, the law has expanded and emphasized the use of evidence-based practices, technology use, and transition instruction and coordination for students with disabilities. Furthermore, students with disabilities are required to receive related

services, including counseling, occupational, physical therapy, speech/language, and/or specialized transportation (Heward, 2009).

Importantly, IDEA grants rights to students with disabilities aged, 5-22 years old. The age references school-aged children K-12, or 5-22 years old. Students with disabilities may stay in public school until they earn a standard diploma and/or when they are 22 years old. In 1986, the law was expanded to include mandatory special education and pre-K services (services available before the start of kindergarten) for students with disabilities, aged 3-5 years old. However, school teams may designate pre-K services to be completed in/out of school settings. Transition services are to include a results-oriented approach that is focused on achievement and a successful transition to post-secondary education (education after high school) and support services. These services must be individualized and should include coordination and related services, and community experiences during secondary education and transition-aged school programs. Students with disabilities at least aged 16 years old must have a transition plan, which should include individualized post-secondary goals and short-term objectives that are based on student interests and abilities, family and school input, and appropriate transition assessments (Heward, 2009).

It is important to note that IDEA requires appropriate education services to be provided to students with disabilities (aged 5 - 22 years old), however after graduating from high school students with disabilities no longer have a right to special education services. Career, education, training, and care services are available through state and local agencies, however an adult with a disability must display a significant barrier to employment and/or significant difficulties across several life skill areas to obtain services (Heward, 2009; Westling & Fox, 2009).

Individuals with disabilities are also entitled to the rights provided by the Americans with Disabilities Act (ADA). The ADA was enacted to comprehensively end discrimination against individuals with disabilities across community services, employment providers, and education and recreation opportunities. The ADA requires access to reasonable accommodations to promote fair and equal access to public and work settings for individuals with disabilities. Importantly, ADA law prohibits disability discrimination with all private entities and state governments, which may be enforced by federal processes (Murdick et al., 2007). To qualify for the

benefits of ADA, an individual must have a record of a mental and/or physical impairment that significantly impacts important life activities and skills (Heward, 2009).

Overview of Learners with Disabilities

Students with disabilities display diverse academic and psychological skill abilities (Heward, 2009; Miller, 2009). During the 2017-18 U.S. public school year, this unique population represented approximately 14% of all school-age students. Of the population of students that receive special education services, 34% have a learning disability. The remaining population of students with disabilities qualify for special education services for various disability categories. These categories include: speech language Impairments, up to 19%; other health impairment, up to 14%; Autism, up to 10%; intellectual disability, up to 6%; emotional disability, up to 5%; multiple disabilities, up to 2%; hearing or orthopedic impairment, up to 1% (National Center for Education Statistics, 2019). A significant population of our learners have some form of a disability, and our instructional message design needs to take them into account to make learning effective.

To qualify for public school special education services and accommodations, students with disabilities must meet eligibility requirements after completing a nondiscriminatory and multifaceted evaluation process (Miller, 2009). Individuals with learning disabilities often display a deficit between skill and ability, which is manifested by difficulties with communication, academic, and cognitive skills. While individuals with emotional disabilities experience academic and behavioral needs due to presumed emotional regulation difficulties (Heward, 2009). Moreover, individuals with intellectual disabilities are also a diverse group that displays mild to severe learning needs, which includes deficits with intellectual and adaptive behaviors. Intellectual disabilities are also associated with co-occurring conditions, including epilepsy, cerebral palsy, and/or physical and mobility needs. Students may also qualify for special education services for deaf/hard of hearing and/or blind/visually impaired, and other health impairment (i.e. conditions that impact alertness to the educational environment). Finally, students with Autism display difficulties with communication, social skills, and

managing personal behaviors. Approximately 30% of all individuals with Autism are non-verbal with communication, and 30% of all individuals with Autism also have an intellectual disability (Westling & Fox, 2009).

Although diverse, students with disabilities benefit from common instructional strategies to promote skill development. Students with disabilities that access the general education curriculum may likely benefit from instructional strategies that support academic and cognitive deficits. These strategies may include information organizers, supportive/organized settings, sequenced/focused instruction, knowledge/background information instruction, and direct/explicit instruction (i.e. modeling, demonstration, and scaffolding) for reading, math, and writing skills (Miller, 2009).

Learners with low incidence disabilities, including students with moderate to severe intellectual disability, Autism, and/or developmental disabilities, may access an adapted education curriculum. Students with low incidence disabilities benefit from strategies to promote skill development, including direct instruction, repeated practice, specific feedback, prompting procedures, behavior management, and task analysis. Educators should utilize concrete objects, examples, and multimedia resources to support content instruction. Furthermore, learners with intellectual disabilities and/or Autism may benefit from instruction that promotes skill acquisition and generalization, as well as individualized supports for communication and sensory needs (Westling & Fox, 2009). Downing (2010) described how students with low incidence disabilities benefit from community and career instruction experiences, and instruction across academic and life skill domains, as appropriate. Prater, Carter, Hitchcock, and Dowrick (2012) described how skill modeling and demonstration support learners with developmental disabilities, including how positive self-modeling is particularly effective. Finally, Van Laarhoven, Winiarski, Blood, and Chan (2012) outlined how educators and programs can support vocational skill development for students with developmental disabilities, including ensuring consistent access to career and work experiences during the middle and high school years.

Students with high and low incidence disabilities may also benefit from accommodations to promote skill development, including extended time, read aloud, assistive technology, reduced assignments, simplified language/plain English, adapted furniture and tools, and

calculator and math aids. IEP teams may provide accommodations during classroom instruction and testing settings, as well as during community and school activities (Heward, 2009). Finally, Students with high incidence disabilities benefit from transition planning, including state rehabilitative agency referral, training/education resources, and post-secondary disability support services (Heward, 2009). Moreover, transition planning and service coordination is crucial for students with low incidence disabilities and may include evaluation and training, along with community, independent living, and employment supports, as appropriate (Westling & Fox, 2009).

Students with disabilities represent a diverse group with a wide variety of learning needs. Many students with disabilities are educated alongside their same-aged peers in general education programs, while others are placed in self-contained classrooms to support more complex learning needs. Furthermore, some students with disabilities may participate in a general education program and graduate high school with a standard diploma, while others will participate in an adaptive education program and will earn a special diploma when they age out of public school at 22 years old. Unfortunately, students with disabilities experience higher rates of high school dropout and reduced enrollment in post-secondary education programs.

Post-Secondary Education and Career Outcomes

As of 2002, students with disabilities had an overall standard diploma high school graduation rate of about 51%. Unfortunately, a significant portion of students with disabilities do not complete secondary education programs, including about 60% of students with emotional disabilities and about 17% of students with Autism (Heward, 2009). Moreover, 66% of all individuals with disabilities are unemployed after leaving school, and about 53% are not enrolled in post-secondary education programs (Kellems & Morningstar, 2010).

Unique challenges for individuals with Autism.

As previously discussed, individuals with developmental disabilities, including Autism, experience poor outcomes when compared to their peers with other disabilities, including higher rates of disengagement from their community and unemployment. Individuals with developmental disabilities, including Autism, experience about a 75% rate of unemployment (Van Laarhoven et al. 2012). These skills may include qualitative deficits in communication (i.e. delayed/atypical language development), social reciprocity (i.e. difficulty understanding/interacting with others), and behavior (i.e. repetitive movements; the need to adhere to strict routines) (Batshaw, Roizen, & Lotrecchian, 2013). Often, individuals with Autism display significant deficits with skills that are primarily needed for successful employment and independence (Wilczynski, Trammell, & Clarke, 2013).

Video-Based Instruction for Individuals with Disabilities

Video-based instruction, including video modeling and prompting, has a relatively large research base for efficacy in supporting skill development for students with developmental disabilities (Bross, Zane, & Kellems, 2018). Video modeling has been traditionally developed with recordings of an individual completing target tasks, which may be then viewed by the learner before completing the same target task. Video self-modeling is developed with edited recordings of learner displayed positive exemplars of work completion, which is also viewed by the learner before initiating and completing the corresponding task. In contrast, video prompting is developed with short duration video clips that the user views in sequence as they complete individuals task steps (Bross et al., 2018).

Individuals with developmental disabilities often benefit from visually cued instruction that relies more heavily on visual information processing than verbal information processing. Moreover, these learners also appear to benefit from a limited area of focus during instruction, which helps support difficulties with managing selective attention and social interactions (Corbett & Abdullah, 2005). Video based instruction enables students with disabilities to directly observe and imitate target behaviors and skills,

which can be further aided by the type of video instruction that is utilized. Furthermore, the necessity for social interaction is diminished with video-based instruction, as the learner attends to technology features for task instruction. Bross et al. (2018) proposed that video modeling may be an appropriate method when teaching short, basic tasks to students with Autism. While video prompting may be a more efficient method when teaching detailed, multi-step complex work tasks (Bross et al. 2018).

Academic Video-Based Instructional Design

Prater et al. (2012) reviewed academic video-based instruction interventions for students with disabilities, which included research based applications of video modeling and video self-modeling. Video self-modeling is developed with edited recordings of the target student completing exemplars of target work tasks. While video modeling is developed with recordings of other individuals completing target tasks. In the reviewed studies, video-based instruction was developed to teach oral and reading fluency, reading comprehension, behavior management, math, writing, and academic task management skills (Prater et al., 2012).

Video self-modeling instruction to teach reading skills.

Bray, Kehle, Spakman, and Hintze (1998) developed video self-modeling instruction to support reading fluency skill development for students with specific learning disabilities and students at risk for academic difficulties in a third-grade general education classroom. The researchers recorded the students reading, and then used editing tools to develop an up to 5-minute video model that displayed only fluent reading. The students then reviewed the video models, and subsequently displayed increased reading fluency, when compared to students with disabilities that did not receive the intervention.

Likewise, Hitchcock, Prater, and Dowrick (2004) developed video self-modeling instruction to support reading comprehension skills for learners with disabilities for first grade with and without specific learning disabilities. Self-model video recordings were developed while the students used a graphic organizer for reading

content to answer factual questions. The students reviewed the video self-modeling before completing reading comprehension work. Students that received the video self-modeling intervention displayed increased comprehension over a sustained period of time. Finally, Marcus and Wilder (2009) developed video self-modeling instruction to letters and symbol identification to students with Autism. Video models were developed that depicted the student or peer successfully identifying the items. After the intervention, the data revealed that the students responded with increased accuracy after viewing the video self-modeling instruction (Prater et al., 2012).

Video self-modeling instruction to teach writing skills.

Delano (2007) developed video self-modeling instruction to support writing skill development for students with Autism (i.e. Asperger Syndrome). The research was completed to identify if video-based instruction could promote the use of self-regulation tasks necessary for independent writing. The researchers created the video self-modeling by recording the students while using effective writing strategies to increase word count and essay organization elements. After reviewing the video self-modeling all of the students displayed increased writing skills. However, it should be noted that not all students maintained the displayed writing skills over time (Prater et al., 2012).

Video self-modeling instruction to teach math skills.

Schunk and Hanson (1998) developed video self-modeling instruction to support basic math skill development for learners with below average math scores. Videos were recorded for peer and self-models for completing math operations with fractions. After implementing the intervention, the students displayed significantly increased accuracy after reviewing the video self-modeling (Prater et al., 2012). Kellems et al. (2016) also developed video prompting instruction to teach functional math application skills to transition aged students with disabilities. Video prompting was developed to depict step by step directions for calculating a tip, determining unit item prices, and adjusting a recipe for different servings. The research

participants displayed increased task accuracy while reviewing the video prompting. In contrast to video modeling (i.e. recording of entire work task), video prompting is developed with recorded segments that are viewed in a step-by-step manner while completing a target work task (Kellems et al., 2016).

Video self-modeling instruction to teach personal management skills.

Hartley, Kehle, and Bray (2002) developed video self-modeling instruction to promote increased classroom participation during language arts instruction for students that displayed difficulties with participation skills. Video self-models were developed by recording the target students while raising hands during instruction and appropriately answering questions. After implementing the intervention, the students displayed increased and sustained appropriate participation during language arts instruction (Prater et al. 2012). Additionally, Clare, Jenson, and Kehle (2000) developed video self-modeling instruction to support independent on task academic work behaviors for students with disabilities. Videos were recorded of the students while they displayed on-task behaviors during independent work. After implementing the intervention (i.e. students viewed video self-modeling of target behaviors), the students displayed significantly increased and sustained on-task academic behaviors while working independently (Prater et al., 2012).

Vocational Video-based Instructional Design

Video-based instruction was identified as an effective, research-based instruction method to teach vocational skills to students with disabilities by Seaman and Cannella-Malone (2016) in their review of vocational interventions for students with Autism. Video-based instruction represented about 62% of the reviewed pre-employment and job maintenance vocational interventions, which included forms of video prompting and video modeling with mobile and computer technology (Seaman & Cannella-Malone, 2016). Video prompting is developed with short duration video clips of specific task steps, while video modeling includes a longer duration video of a chained task-

sequence to depict the overall work task from start to finish. Video prompting instruction has been identified to be more effective when teaching vocational tasks to students with low incidence disabilities than when compared to utilizing video modeling instruction to teach the same tasks without the segmented video prompting (Burke et al., 2013).

Allen, Wallace, Renes, Bowen, and Burke (2010) developed video modeling instruction with video recording technology to teach young adult individuals with Autism to perform work as a department store mascot. The research participants were instructed to view a video model on a television screen that displayed different target body movements to entertain the store customers. After viewing the video modeling instruction for at least two trials, the participants subsequently displayed the mastery criteria of the mascot entertainment tasks. The research participants expressed that they found video instruction to be an acceptable intervention, and enjoyed the mascot work tasks (Allen et al. 2010).

Alexander, Ayres, Smith, Shepley, and Mataras (2013) developed video modeling instruction to teach mail sorting task generalization skills to young adult learners with developmental disabilities. Alexander et al. (2013) developed the video instruction with a task analysis and design features, including zoom angles for detailed task steps, camera recording stops and focuses on text for mailboxes, point of view video angles, and task narration. The participants viewed video modeling instruction on an Apple iPad before completing the target tasks. After the video modeling intervention, most of the research participants consistently displayed mastery criteria accuracy while completing the mail sorting tasks (Alexander et al., 2013).

Burke, Allen, Howard, Downey, Matz, and Bowen (2013) developed video prompting and video modeling instruction to teach an authentic, 102 step shipping and handling task to young adult with developmental disabilities. The researchers developed step-by-step directions for target tasks by collaborating with the shipping and handling company, which resulted in different task analyses with up to 102 steps. Video prompting and modeling instruction was developed with recordings of target tasks with zoom/wide angles, and task narration. Burke et al. (2013) then utilized Video Tote, an app to organize the video based instruction into 36 chapters. The Video Tote app was previously developed with a grant for disability research

funding, which included collaboration to develop the app with universal design features for the target learner population. The app was designed with an easily navigable interface that allowed users to quickly navigate to desired videos and press/pause play by touching the screen anywhere. The participants were instructed to review the video prompting instruction at home and as needed while completing the work tasks. After implementing this intervention, all the participants displayed mastery criteria for task completion (Burke et al., 2013).

English et al. (2017) developed video prompting and modeling instruction with video-based feedback to teach gardening vocational task skills to young adults with developmental disabilities. English et al. (2017) created a task analysis for the target gardening work tasks, recorded video instruction with a digital camera, and then created the video prompting and modeling instruction with an Apple iPad and Apple’s iMovie application. The participants were shown how to review the video prompting and modeling, which was also available to utilize during task completion. The researchers also recorded the participants' work completion and shared video-based feedback. After implementing the video-based instruction and feedback intervention, all the participants displayed significantly increased task completion accuracy (English et al., 2017).

Van Laarhoven et al. (2012) developed video modeling instruction to teach vocational work task maintenance skills to students with developmental disabilities. The researchers created a task analysis for familiar student work tasks, and then developed video modeling instruction with narration, including short recorded segments, zoom/wide angles, and point of view video angles. The research participants were instructed to review the video-based instruction on an Apple iPad while on an extended break from school. After implementing the video-based instruction intervention, all of the research participants displayed increased independence and task completion accuracy, along with skill maintenance and generalization (Van Laarhoven et al., 2012).

Bereznak, Ayres, Mechling, and Alexander (2012) developed video self-prompting instruction to teach basic office work tasks to students with developmental disabilities. The researchers created a task analysis and then recorded the office task steps to create video prompting instruction. The video prompting had embedded text to prompt the student to pause the video before completing the

corresponding task step, which was displayed with an Apple iPhone in horizontal view. Design features also included embedded task narration, zoom angles, and first-person point of view video recording. The participants were provided with training on using the iPhone interface and activating the video prompts. After implementing the intervention, most of the research participants displayed mastery criteria for task completion. Importantly, Bereznak et al. (2012) implemented video prompting instruction with students with more severe developmental disabilities than in previous research studies.

Bross, Zane, and Kellems (2018) described how to develop video modeling instruction to support customer skill development for students with Autism. Students with Autism often have difficulty managing social workplace interactions, so the researchers proposed developing video modeling to help teach routine social communication skills necessary for successful employment. Developing video modeling may be completed with an eight-step process, which includes identifying job expectations and target skills, and developing tasks analyses. Next, the practitioner should plan for video production, which includes selecting appropriate technology and script creation, along with obtaining consent as needed. Next, video modeling is recorded and edited, and the intervention is implemented with fidelity. Finally, the intervention process should be monitored for progress and effectiveness (Bross et al. 2018).

The common thread through these studies is the evidence for the effectiveness of video based instructional message design to help these populations of young adults learn skills and processes to help their employment prospects.

Conclusion

Instructional message design for learning with disabilities has been an under researched area of instructional design. Individuals with disabilities are entitled to PreK-12 educational rights, which are mandated by the federal law, IDEA. IDEA is the result of significant advocacy for individuals with disabilities and has continued to be bolstered and expanded during subsequent congressional reauthorizations since 1975. Public school programs are required to provide appropriate individualized education plans for students with

disabilities. These education plans should promote skill development and access to the school curriculum and must include a transition plan for students aged 16 years or older. Although federal and state laws mandate special education and transition service coordination for students with disabilities, this unique population continues to experience higher rates of post-secondary education disengagement and unemployment, when compared to peers without disabilities.

There appears to be a research gap between studies that focus on developing video-based instruction to teach academic skills and studies with students with developmental disabilities. Although there are several researchers that have utilized video modeling to support independence and academic skill development for students with disabilities, there is a limited research base that describes this approach across content areas and grade levels. Moreover, there are also several researchers that have utilized video modeling and prompting instruction to support vocational skill development. However, there appears to be a gap in research for teaching complex work task skills with this video-centric instructional message design approach. For instance, how do the tenets of cognitive load theory or multimedia learning theory apply to special needs learners? Although previous researchers have used video-based instruction to teach discrete job task skills, it is important to note that successful employment for individuals with disabilities may rely on the consistent demonstration of a variety of employability skills. Further research is needed in several areas of video-based instruction research, including outlining how video-based instruction can support a multitude of employability skills, managing self, work tasks and responsibilities, and social interactions that are necessary for sustained, successful employment and independence. Video modeling appears to be a beneficial application of instructional message design and should be studied further to better refine best practice.

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Instructional Message Design:
Theory, Research, and Practice

Chapter 8: Cultural Aspects and Implications of Instructional Message Design

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Chapter 8: Cultural Aspects and Implications of Instructional Message Design

Frances R. Dukes

Key Points:

- Multiculturalism is a set of beliefs and applications which a group of people use to make sense of themselves and the world to arrange their personal and collective lives
- Multicultural education is an educational movement that gets students to achieve academic success as a reform movement.
- Instructional message design includes applied design, fine arts, visual arts, spatial relationships, color, and secondary messages that clarify or illustrate the real message.
- Training the trainer – Preparing teachers for multicultural education includes the elements of multiculturalism that can be implemented into the educational environment.

Abstract

"There is also widespread agreement that a major priority is the reform of schools and other academic venues so that students from diverse, racial, ethnic, and social class groups can achieve equality." (Roblyer, Dozier-Henry, & Burnette, 1996).

Culture is a major determinant in modern instructional design and instructional message design for a global community of learners. Instructional designers of web-based information for world-wide and cross-culture learners are tasked with developing effective, culture-

sensitive, innovative, and useful instructional tools. "Multicultural teaching must entail reaching students by connecting with their cultural, ethnic, linguistic, social, and other affiliations" (Capuk & Kara, 2015). The tenets of learner needs analysis and instructional message design can be used to enhance learning for our culturally and ethnically diverse future learners. This chapter will examine the various challenges instructional designers are facing based on the changing demographics in America and world-wide, as well as the impact of globalized exchange of information through electronic media. The examination incudes considerations for the growing diversity of K-12 as well as the internationalization of higher education in both face to face and online learning environments.

Introduction

Sharif & Gisbert (2015) examined the quality of online learning through the perspectives of instructional designers in different countries. Their research revealed that designers had similar perspectives on the quality of online courses and the focus on assessment and course overview (see Figure 1).

> "Guidelines and publications developed by a variety of scholars and educators include similar criteria for online education which include strong institutional commitment, adequate curriculum and instruction, peer review, effectiveness, faculty-to-student ratios, attrition rates, student support, sufficient faculty support, instructional design, technology appropriateness, accessibility, and consistent learning outcome." As cited in (Sharif & Gisbert, 2015)

Criteria for Online Instruction

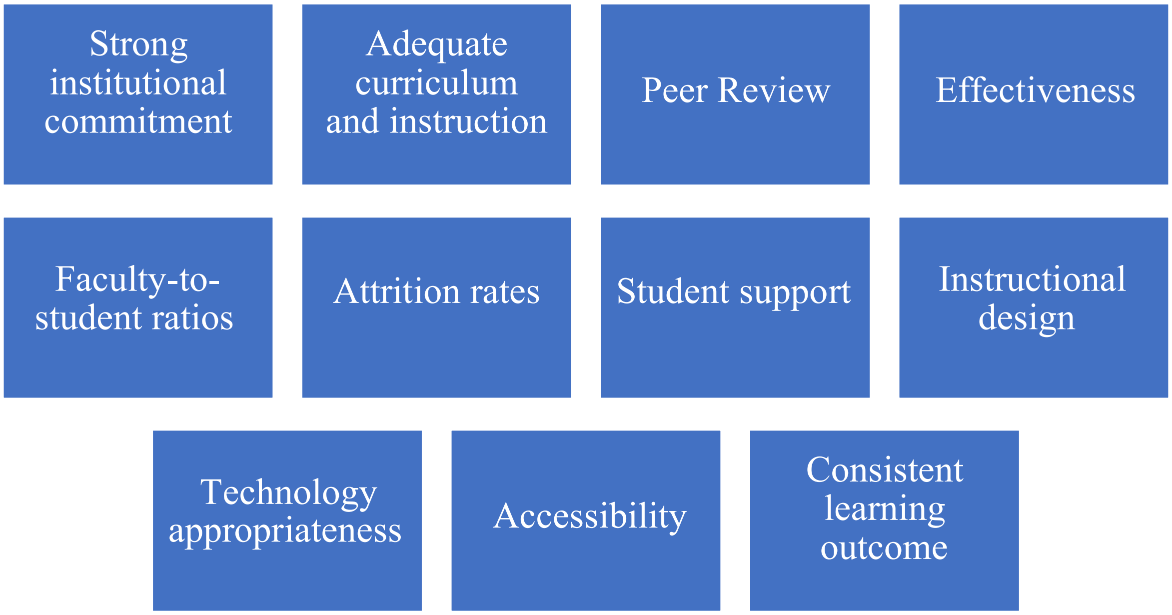


Figure 1. The criteria for online instruction developed by instructional designers.

Changing Demographics in American Schools and Colleges

The demographics in K-12 (elementary, middle, and high school) continues to change which is an aspect of modern education that instructional designers should continue to prepare for (see Figure 2). Recent data showing the changing demographics in America's public schools and colleges indicate that these schools and colleges will be more diverse than in years past, with variations by state. The National Center for Education Statistics (NCES) chart (Table 203.50) additionally included data for students whose ethnicity was two or more races. Another factor to be considered is the increase of international students in American colleges and universities.

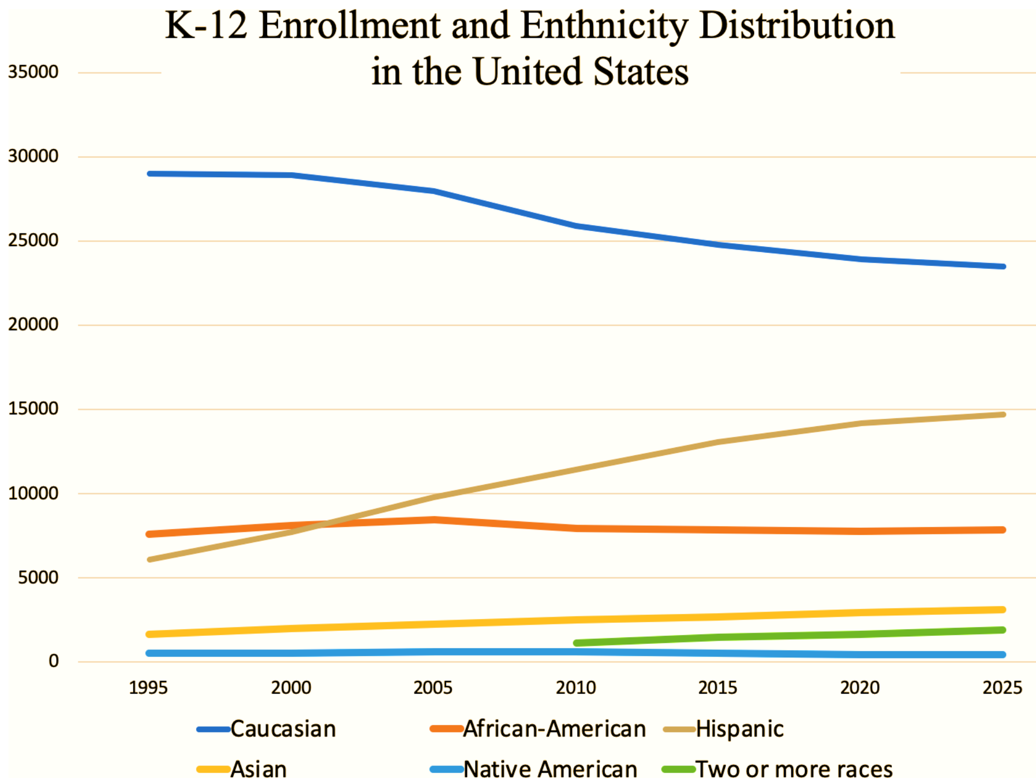


Figure 2. The ethnicity distribution (in thousands) continues to evolve in U.S. schools, as a result, instructors and instructional designers should plan to evolve their message design to consider and design for the diversity of their students (NCES, 2018).

	Percentage distribution						
Region and Year	**Total**	**White**	**Black**	**His-panic**	**Asian/ Pacific Islander**	**American Indian/ Alaska Native**	**Two or more races**
United States							
1995	100.0	64.8	16.8	13.5	3.7	1.1	†
2000	100.0	61.2	17.2	16.4	4.1	1.2	†
2001	100.0	60.3	17.2	17.1	4.3	1.2	†
2002	100.0	59.4	17.2	17.8	4.3	1.2	†
2003	100.0	58.6	17.2	18.6	4.4	1.2	†

2004	100.0	58.0	17.2	19.1	4.5	1.2	†
2005	100.0	57.0	17.2	19.9	4.6	1.2	†
2006	100.0	56.4	17.1	20.6	4.7	1.2	†
2007	100.0	55.7	17.0	21.2	4.9	1.2	†
2007	100.0	54.9	17.0	21.4	5.0	1.2	0.5 \1\
2009	100.0	54.1	16.7	22.3	5.0	1.2	0.7 \1\
2010	100.0	52.4	16.0	23.1	5.0	1.1	2.4
2011	100.0	51.7	15.8	23.7	5.1	1.1	2.6
2012	100.0	51.0	15.7	24.3	5.1	1.1	2.8
2013	100.0	50.3	15.6	24.9	5.2	1.0	3.0
2014	100.0	49.5	15.5	25.4	5.3	1.0	3.2
2015\2\	100.0	48.9	15.4	25.9	5.3	1.0	3.4
2016\3\	100.0	48.5	15.5	26.6	5.4	1.0	2.9
2017\3\	100.0	48.0	15.4	27.1	5.5	1.0	3.0
2018\3\	100.0	47.5	15.3	27.5	5.6	1.0	3.1
2019\3\	100.0	47.1	15.3	27.8	5.7	1.0	3.1
2020\3\	100.0	46.8	15.2	28.1	5.7	1.0	3.2
2021\3\	100.0	46.4	15.2	28.4	5.8	0.9	3.3
2022\3\	100.0	46.0	15.2	28.6	5.8	0.9	3.4
2023\3\	100.0	45.7	15.2	28.8	5.9	0.9	3.5
2024\3\	100.0	45.4	15.2	28.9	6.0	0.9	3.5
2025\3\	100.0	45.2	15.2	29.0	6.1	0.9	3.6
2026\3\	100.0	45.0	15.2	29.1	6.2	0.9	3.7
2027\3\	100.0	44.7	15.2	29.2	6.3	0.9	3.8

\1\For this year, data on students of Two or more races were reported by only a small number of states. Therefore, the data are not comparable to figures for 2010 and later years.
\2\Includes imputations for prekindergarten enrollment in California and Oregon.
\3\Projected.

Table 1. Percentage distribution of multicultural students in the U.S., demographics in schools are becoming more diverse (NCES, 2018).

Changing Demographics in Colleges

The United States hosts international students from numerous countries worldwide. During the school year 2016-2017 the population of international students was over one million or more than 5% of all enrollments (Zong & Batalova, 2018). The highest percentage of students were from China followed by India. Other countries of origin included, but were not limited to, South Korea, Saudi Arabia, Canada, Vietnam, Taiwan, Japan, and Mexico. Forty-eight percent of international students were in STEM (Science, Technology, Engineering, and Math) fields. Engineering, business management, math and computer science were in the top three fields of study for international students in School Year 2016-2017. The number of students decreased during that school year who were enrolled in intensive English, Education, and Humanities fields of study (Zong & Batalova, 2018). The table below lists the top ten states by international student population in American colleges and universities during school year 2016-17.

State	International Students	Share of U.S. Total (%)	Immigrant Population	Share of U.S. Total (%)
United States	1,079,000	100.0	43,739,300	100.0
California	157,000	14.5	10677,700	2.4
New York	118,000	11.0	4,536,100	10.4
Texas	85,000	7.9	4,729,900	10.8
Massachusetts	63,000	5.8	1,123,900	2.6
Illinois	52,000	4.8	1,783,500	4.1
Pennsylvania	51,000	4.7	870,900	2.0
Florida	46,000	4.2	4,236,500	9.7
Ohio	39,000	3.6	513,600	1.2
Michigan	34,000	3.2	662,300	1.5
Indiana	31,000	2.8	349,200	0.8
Other States	403,000	37.3	14,255,700	32.6

Table 2. International student population school year 2016-17, compared to immigrant populations (Zong & Batalova, 2018).

An Overview of Instructional Message Design

Message design is defined as the systemic and purposeful process of making decisions about communication. The concepts of message design include the visual arts and applied design, and draw from education, communication, cognition, and instruction (Dye, 1997). Instructional message design concepts and instructional outcomes are shown in the grid below (Table 3):

Concepts	Definition	"Exemplary" Errors
Grid-based design – provides psychological order.	Major differences are perceived as important	Computer-generated presentations with multiple backgrounds
Perceptibility- essential for communication	Two components: physiological and cognitive	Tiny visual presentation in large rooms, jargon, out- dated handouts
Chunk content into manageable pieces	A chunk is a discrete bit of the message	Squeezing text to make it fit
Spatial Relationships are part of the message	Relationship of size reflects relationship of meaning	Dingbat decorations (extraneous distractions), fonts that are too small
Secondary messages should support primary message	Include metaphors, graphics, models, sounds, illustrations	Dingbat decorations, Mixed metaphors
Color that evokes emotion	Physiological component: how the	Full-color media icons for leader's guide,

	eye perceives color, contrast	pastel screen on computer game

Table 3. Good instructional message design can help students, especially international students who would not have the inherent contextual benefit of domestic students (modified from Dye, 1997).

Cultural Sensitivity in Instructional Message Design

Haynie (2014) highlighted possible challenges for international students in pursuit of online degrees in the United States. Areas that may pose a challenge for international students are time zones, cultural barriers, the demands of reading and writing in English, and international acceptance of online degrees. It was noted that international students may experience challenges understanding American cultural differences and following group conversations during group chats. One of the online students stated, "they start talking in a very American way, so it's very had to follow… sometimes they talk about things that they think everyone knows, but I don't know."

In addition to language barriers, instructional message designers must also be aware of how people from different cultures will respond to the graphical interface layout, images, color, and sound in the online instruction (Chen, Mashhadi, Ang, & Harkrider, 1999). The principles of instructional message design as summarized by Sukmari (2017) include the following:

- Readiness and motivation
- Attention getting devices and directions
- Repetition
- Students' active participation
- Feedback

- Cultural Values

The ADDIE (Analysis, Design, Development, Implementation, and Evaluation) approach to instructional design treats cultural values as assets in the design and development process (Igoche & Branch, 2009). The six phases of the ADDIE conceptual design process are graphically shown below (see Figure 4).

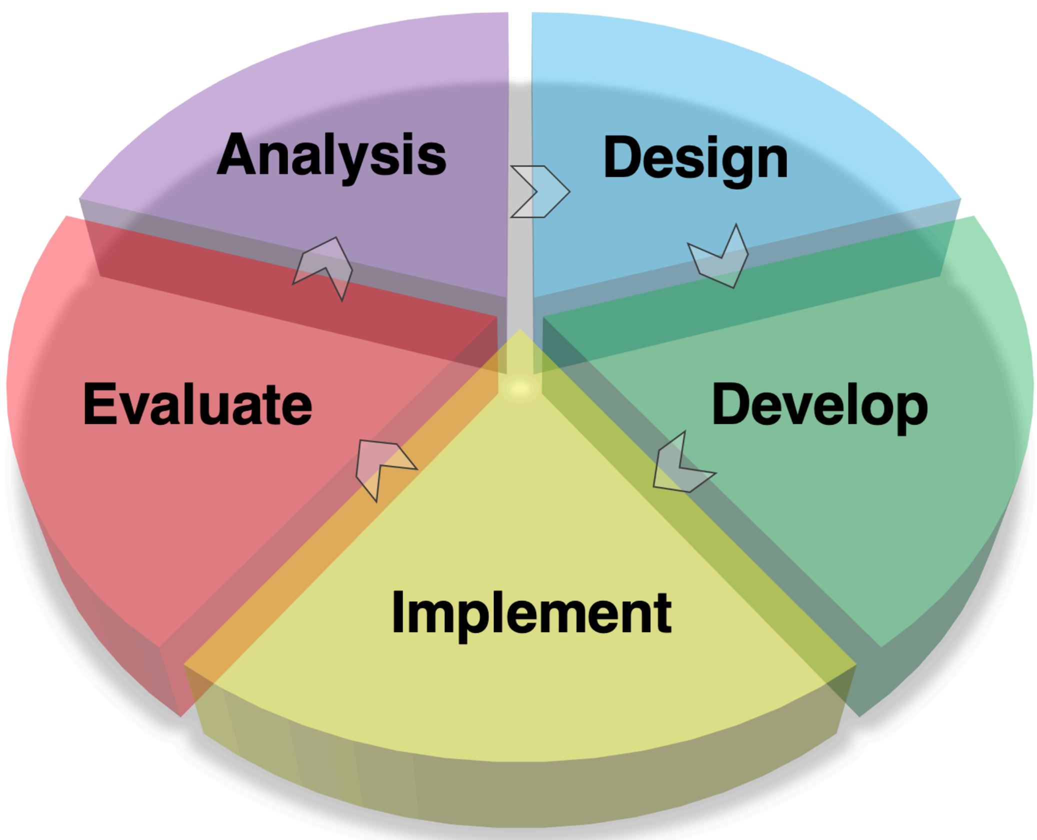


Figure 4. The initial consideration and design for cultural inclusiveness should be integrated into the Analysis phase of the ADDIE process

Similarly, the design for cultural diversity is considered during the analysis of Learner Characteristics phase of Morrison, Ross, and Kemp's instructional design model (Morrison, Ross, Morrison, & Kalman, 2019). During this phase of an instructional design the designer is taking the specific characteristics of their audience into consideration during the formative design of the instructional message.

The design of educational materials is often developed for specific audiences in one country. Ethnocentric instructional design is not suited for all audiences. Researchers determined there was a need to present a framework for instructional design that is culture-neutral for a rehabilitation training program in Haiti by "decreasing cognitive load by removing complex or country specific language, content or examples" (Dunleavy, Audette, Sander, & English, 2015). The redesign was accomplished in three phases. The first phase was an analysis of the learners, tasks, and goals. The second phase involved content reorganization to improve readability and culture specific language. In the third phase further review, formatting, and editing was accomplished.

The conclusion of the study was "global culture-neutral design can be used to facilitate translation and share resources across multiple countries and cultures." The resulting implications were "culture- neutral design or redesign may provide educational materials which are potentially useful for other countries" (Dunleavy, Audette, Sander, & English, 2015).

Issues and Considerations in Multicultural and International Instructional Design

An understanding of how culture has been defined is important to the development of instructional designers (Thomas, Mitchell, & Joseph, 2002). However, Subramony (2004), asserted that "important issues of cultural diversity among learners" have been ignored by mainstream instructional technology research.

Culture is one of the many factors that affect instructional design. Rogers, Graham, and Mayes (2007) posed the following questions about people who are involved in creating online instruction for people of other cultures. "Are they aware of the differences between themselves and the cultural group for whom they are designing instruction? If so, how did they become aware of these

differences? What importance do these differences assume in their thinking? How does understanding cultural differences affect instructional design practice?"

According to Rogers, Graham, and Mayes (2007) three barriers that inhibit designers from being more culturally responsive:

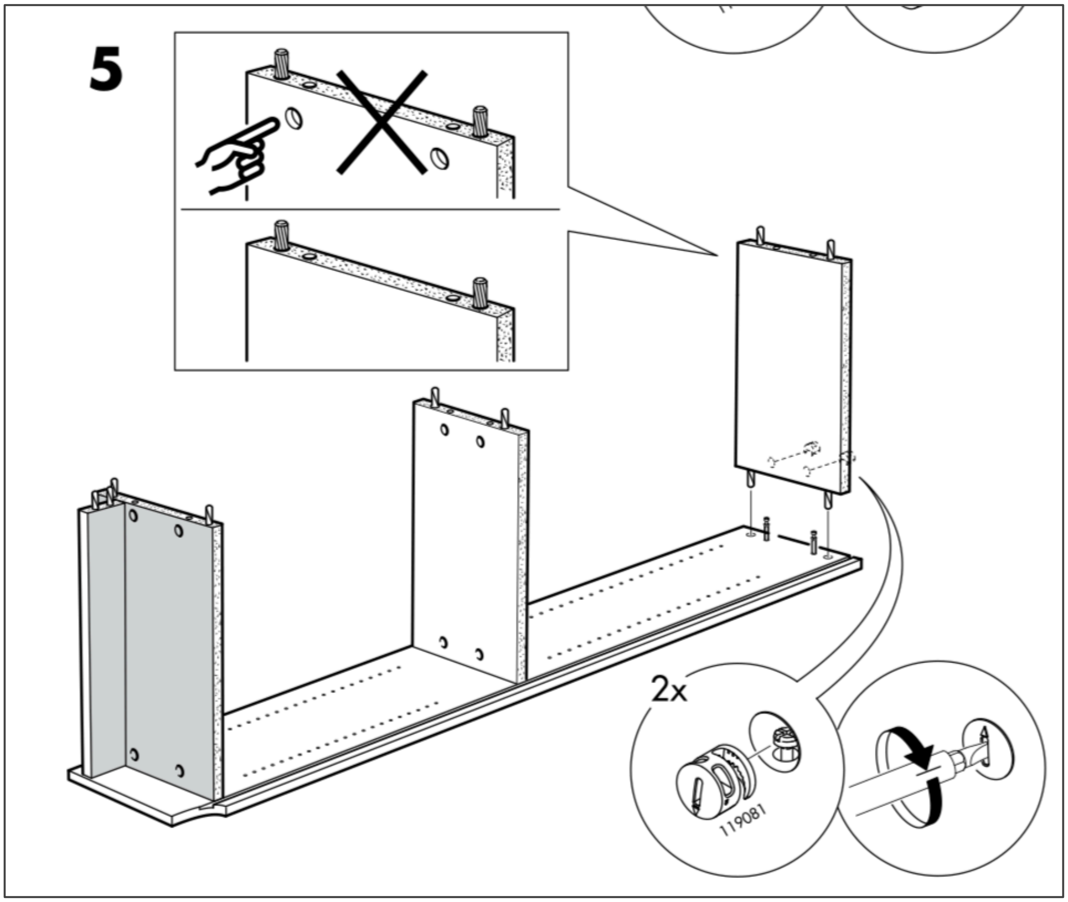
1. An over-emphasis on content development as the center of practice and under emphasis on context, and learner, and the learner's experience.

2. A relative lack of evaluation in real world practice.

3. The creation of less than ideal roles that instructional designers assume in the larger organizational structure.

Instructional designers are instrumental in developing multimedia courseware and material and can be influential in material and symbolic culture (Capuk & Kara, 2015). According to Osguthorpe (2007), "… instructional designers see themselves as those who help others learn" which should include being sensitive to learners' cultural differences, then "they will be ready to contribute more to the development of theory in the discipline" (Osguthorpe, 2007).

To illustrate this point, the furniture and instructional designers at IKEA provide an excellent example of job aids and instructional message designs for international audiences. For instance, while the initial safety warnings appear in 35 languages, the instructional message design of assembly instructions for a common IKEA bookshelf does not include text. Rather, the job aid almost exclusively uses graphics with the intent that these graphics would be universally understood across cultures in international markets (see Figure 5).



https://www.ikea.com/us/en/assembly_instructions/billy-bookcase__AA-982683-7_pub.pdf

Figure 5. Typical furniture assembly instructions from IKEA present an example of simplified yet effective instructional message design intended to be universally understood by international learners through the use of graphics. (© Inter IKEA Systems B.V. 2013)

Training the Trainer

"One of the greatest challenges facing teacher educators is helping future teachers support the learning of our increasingly diverse cultural and linguistic student population who come to school with a range of experiences and abilities." (Boling, 2003). The potential of technology to address the needs of multicultural education continues to grow as technology and online tools are readily available to address the needs and opportunities of multicultural education for teachers. Social network communities are widely popular in

providing opportunities for teacher interaction and collaboration with people from all over the world. Teachers can interact with educators globally and gain cultural insight into societal practices and traditions (Ferdig, Coutts, DiPietro, & Lok, 2007).

There has been an increase in online education in the United States and around the world. Instructional designers have an important role in developing cross-cultural collaborative distance learning frameworks for online instructors. In a study of forty online instructors from two universities in the Northeastern United States consisting of instructors who had taught online/blended courses for at least two years, data was collected through interviews lasting 60 to 90 minutes (Kumi-Yeboah, 2018). Interview questions included cultural responsiveness in online learning and instructional strategies used to facilitate collaborative online learning and activities. The findings revealed that 34 of the 40 participants used computer-supported collaborative learning strategies to aid in interaction with instructors and peers. Other instructors supported using wikis and blogs and other online activities such as social interactions, Google Docs, and GoToMeeting tools. Thirty-two of the participants expressed challenges with cross-cultural learning for students. The participants also expressed that infusion of diverse content and knowledge is not enough to promote diverse students' participation. Instructors also expressed problems with language barriers (Kumi-Yeboah, 2018).

Instructional Message Design for Cultural Inclusiveness

Multicultural curricula design should include the objectives, content, learning situations, and the measurement and evaluation process of curriculum design (Demir & Yurdakul, 2015). Guidelines for effective cross culture design include (Morrison, Ross, Morrison, Kemp, 2019):

- Demonstrate an inclusive mindset; a desire to be genuinely inclusive in message design
- Try to design in a way that reaches all learners
- Engage learners and tie learning objectives to real-world examples that they are familiar with

- Relate learning to cultural contexts
- Encourage team projects with diverse inclusion of learning
- Keep potential language barriers in mind, by including opportunity for praising, modeling, restating, clarifying, and questioning.

Collins (1997) as cited in (Chen, Mashhadi, Ang, & Harkrider, 1999) the interface designer of web-based instruction should be aware of the following when designing for different cultures:

- Response to issues of layout of the graphical interface
- Images
- Color
- Sound

There is a lot to consider in the design of multicultural learning. "New theories can emerge not only from theoreticians but from practitioners themselves" (Osguthorpe, 2007). Existing technology is more advanced and available to a growing global population of learners and a growing number of different devices. Message design principles differ for different devices. The following are suggestions for message design for different devices:

- Design for e-learning, adapt for m-learning (mobile learning)
- Design short and condensed materials for smart phones.
- Students prefer video-based mLearning materials and should be less than 5 minutes (Wang & Shen, 2012).

Conclusion

The cultural aspects of instructional message design have a significant influence on the approach to planning, designing and implementation of the instructional technology used to train global cultures domestically and internationally. The current and projected rise in population growth of individuals and families from countries outside of the United States changes the demographics of communities and schools and requires a paradigm shift in education reform that is more inclusive and less resistant to change. Educators and institutions will depend on the knowledge, skills and abilities of instructional designers, who are tasked with using existing and future technologies to meet the educational needs of a global society that has now become technology dependent. It is also important to note that care must be taken to avoid design stereotyping and to include cultural subject matter experts during formative design evaluation. This instructional message design consideration is especially true as universities develop online courseware for international markets. As technology expands the ability of instructional designers to produce learning material to reach more learners domestically and in other countries, the considerations for cultural diversity have to be included in the instructional message design process.

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