Perception in Designing and Production Instructional Aids: Selection and Organization through Multimedia

Dr. Nidal Zaki Amarin
Faculty of Arts
Al-Zaytoonah University of Jordan
Jordan

Abstract

This article presents a critical review and analysis of key studies that have been done in designing and production instructional aides and other areas on the effects and effectiveness of using multimedia in the learning of scientific-technical content. It also summarizes and reviews those studies that have students design, to express their understandings of the concepts and relationships that are present in the text they read and/or empirical data provided (i.e., student-generated adjunct multimedia productions). In general, the research and theory on instructional aides is fragmented and somewhat unsystematic with several flaws and number of key uncontrolled variables, which actually suppress and mask effects in the studies that have been done. The findings of these studies are compared to relevant literature and empirical research and findings in the areas of cognitive psychology, computer sciences, educational technology, and artificial intelligence that help to clarify many of the inconsistencies, contradictions, and lack of effects found for production instructional aids in educational sciences literature currently and in the past 25 years.

Keywords: Instructional design; instructional technology; multimedia learning theory; perception; visual aids; and cognitive load theory.

Introduction

The purpose of this research paper is to elucidate presentation design. In the presentation design the researcher tried to map the abstraction of conceptual design onto a real multimedia environment. Presentation design has its own problem space. This problem space involves the holistic framing of the multimedia arte fact and the design and integration of the individual media. Key features of human perception are reviewed. These highlight the nature of perception as a highly active, constructive process. Composition principles are discussed that take advantage of the selective, constructive nature of perception. In general, however, both the research and the theory on instructional aides are fragmented and somewhat unsystematic and in most instances functional, pragmatic, and practitioner oriented.

This may reflect to some degree the difficulty and complexities of the research and theory construction problem in this area. Lack of standardized terms and concepts, weak theoretical foundations and, in some cases, questionable research designs have made the literature in this area inconsistent, difficult to evaluate, and particularly difficult to extend and/or operationalize (Levin, Anglin, & Carney, 1987; Ruiz-Primo & Shavelson, 1996). This difficulty has been particularly true in the area of educational sciences and the learning of scientific-technical material, where the nature and kind of empirical research done over the past two decades has been quite diverse (National Research Council – NRC, 2002) to the point where we all now must be “experts in the assessment of [each individual] case,” as Phillips has to eloquently put it (2005, p.959). Many of the most basic elements of instruction, such as what is learning, what type of learning occurring, and which is learning levels are being investigated are not clearly identified. What perception in design – theoretically and in fact – and how is multimedia represented, processed, and then assimilated and integrated into long term memory schemas are also undefined, not addressed, or at best fuzzily addressed in this research literature.

Part of the problem is that instructional aides research, and particularly research on visual aids in educational sciences has not been well designed relative to modern definitions of the term (NRC, 2002) or the more classic views of empirical research (Kerlinger & Lee, 2000).

Further, a great deal of sophisticated and empirically supported progress has been made in the last two decades relative to these instructional elements and questions in the areas of academic cognitive psychology, computer sciences, educational technology, and artificial intelligence. These areas and foundational disciplines, which are not often included and operationalized in the educational sciences literature, are now the real mainstream of the theoretical and empirical work on these instructional elements and questions (Ashcraft, 2002) the important point to be made here is that the educational sciences literature on the multimedia question is extremely "noisy" and not very helpful in making instructional decisions, or not interpreting the results of studies that have been done in educational sciences concerning their efficacy or effects.

In teaching any subject, from the point of view of its efficiency and impact, a considerable role belongs to the use of various digital applications, as they can significantly contribute to didactic principle implementation and education goal achievement (Webb, 2005; Lamanauskas & Vilkonis, 2007; Shi, 2013). Multimedia supported subject matter is still for students very attractive and interest evocating, and moreover it positively influences knowledge duration and correct conception creation (Chen, 2012). Multimedia and virtual realities make the world visible in a way nobody had any idea about not long time ago (McClintock, 2001; Bileck, 2010). A lot of various researches have paid attention to applying the multimedia in educational sciences and to effectiveness of the use of multimedia in production instructional aides.

The effectiveness can result both from the increased motivation or interest in these subjects due to use of different multimedia teaching materials as well as from a higher level of the visualization of the abstract concepts offered by the visual media, what is very important for science, and mainly physics, education (Thube & Shaligram, 2007; Aggul, Yalcin, Acikyildiz & Sonmez, 2008; Ferreira, Baptista & Arroio, 2013).Connecting the use of multimedia instructional aides for the purpose of teaching process efficiency increase and a learner's attitude to a school subject as a predetermining of teaching/learning process efficiency, there is a logical question whether or how multimedia assisted teaching can influence students' attitudes to school subjects. If it was possible to eliminate students' negative attitudes to school subjects in this way (Tomas and Schmid, 2010), the improved attitude of students to a school subject would contribute probably to the students' higher motivation to learn something about the subject, what, consequently, should result in an increased efficiency of the teaching process (Hozinger, Kickmeier-Rust & Albert, 2008). Indeed, the amount of monetary resources invested in educational technology as well as the rhetoric of official publications in support of information and communication technologies (ICT) integration indicates that many schools and governments in the developed and developing countries have confidence in the abilities of ICT to enhance educational processes (Tomas & Schmid, 2010; Yang & Teng, 2014).

Perception in Designing

Deepak Tiwari defines perception as gives the act direction and establishes the external world, which governs the next stage, the manipulation (2008). There is often mismatch between human perceptual capabilities and the way learning materials are presented to students. People are dynamic visual information processors. We are highly efficient movement detectors, and sensitive to subtle changes in the visual field. Traditional media, such as textbooks, are capable of presenting only static visual displays, whereas the Web is well suited for presenting dynamic displays. Reyna et al. report research suggesting interactions among instructional display format, instructional objectives, and characteristics of the learner that should be considered in designing dynamic displays.

Building on work in ecological psychology, Reyna et al. suggest that perception is guided by patterns of information in the environment, rather than sensory elements. J.J. Gibson's theory of affordances suggests that organisms use these patterns of information to direct actions based on perceived opportunities afforded by the environment. Affordances are constrained by the goals, knowledge, and skills of the perceiver, as well as inherent characteristics of the perceptual environment. Obviously, on the Web, designers have a good deal to say about the perceptual environment. Ecological psychology suggests that relationships should lawfully map onto relevant facets of the environment to take advantage of the nature of the perceptual system. Reyna et al. provide evidence that people are able to handle intricacies efficiently when complex relationships clearly map onto the perceptual environment. However, the creators of the websites must deliberately design such lawful relationships onto their visual displays. For example, in a unit for nursing students, Effken and her colleagues varied the size and shape of rectangle to demonstrate how oxygenation is a function of breaths per minute and units of air per breath.

Similarly, on the Draginfly, Web Pages, Wolfe created an interactive exercise where children "designed" a human-powered aircraft after reading a brief expository passage. Participants' decisions about the characteristics of the aircraft, such as weight and wingspan, were systematically tied to pictorial feedback about the aircraft and text describing its success or failure.

Designing is an interaction between the mind and hand (Kimbell, Stables, & Green, 1996). Design thinking is concerned with form as well as function, and includes visual and spatial reasoning. Attempts to understand the process to design through studies with professional designers like architects and engineers have revealed interesting facets of design activity, like the ill-defined nature of design problems, use of primary generators in early designing and the use of shared conventions among designers (Cross, 1984). These studies have broadened the understanding of design process in general, and have given valuable insights for design in school education. Cross (1982) emphasizes that design is analogous to, and distinct from, the two cultures of the "humanities" and the "sciences". He advocates design as coherent academic discipline in general education, which need to be merely a preparation for a career or for the industry, but can enhance and develop students' intrinsic cognitive process, values and abilities (Cross, 1982; Roberts, 1994).

The Perception – Presentation Mismatch

Learning technologies offer new ways to present information to students. For example, instructors can integrate video clips into expository text to create simulations, or mirror the complexity of an intensive care unit or airline control room (e.g., Reinhardt, 1995). However, despite the allure of new technology, there is often a mismatch between human perceptual skills and the way information is typically presented to students.

Basic Processes in Perception

Current applications in learning technologies can benefit from an understanding of basic processes in perception. For example, humans are excellent "movement detectors." A bird in the underbrush can be hard to detect – until the bird moves. Similarly, a perceptually dense display can be better navigated with motion cues. People also easily detect breaks in symmetry, such as pictures hanging crooked on wall or musical dissonance that goes unresolved. Our abilities to detect asymmetries are not so surprising given that much of the information we depend on to survive involves detecting asymmetries. For example, breaks in the usual symmetry of the highway can suddenly arouse drives from daydreaming into heightened state of awareness, although they may not be able to determine immediately what it was that was different. Another human perceptual capability was identified by James J. Gibson (1966, 1986), the founder of ecological psychology. Traditional perceptual theories assumed that our perception of the world (for example, a chair or an old friend) is built by combining a myriad of discrete, atomic sensory impression. Gibson argued instead that the visual information in the environment that supports our ability to get around is the unique patterning of light and textures.

These patterns tell us what opportunities for action the world affords us. Gibson argued that the "affordances" defined by these patterns could be detected by animals that have become attuned to the relevant patterns through evolution or learning. Further investigations in ecological psychology suggest that whether or not an individual detects a particular affordance can be constrained by his or her current goal, his or her prior knowledge and skill (as well as physical development), and the way information is presented. In short, as Koysslyn (1994) notes, the mind is not a camera. We do not view everything at one level of sharpness or acuity. What we focus on, or observe, depend on the task at hand and the salience of the available information for accomplishing that task.

Perception in Designing Instructional Technology

Research on computer display design has focused considerable attention on how to build computer displays that capitalize on human perceptual strengths. One design strategy is to build diagrams that mimic, or model, the physical design of real-world systems. This is very common for engineering display, or for modeling physiology. Another strategy uses abstract objects to show the relationships between specific variables. For example, the size and shape of a rectangle might be used to show how oxygenation is a function of how much air one takes in with each breath and how many breaths one takes per minute. Research shows the at subjects can detect problems more quickly with displays like these, but only if the complex variables or relationships shown map clearly onto the relevant environmental facts. The difference between the designer of the computer display and nature is that the designer has to engineer the lawful relationships into the display. In nature, such relationships are given in the invariance of experience.

Further work has shown that there is a hierarchy of relationships that compose the structure of an affordance. For example, one can define the affordance structure of heart disease at various levels (e.g., cellular, tissue, organ, and system). Each of these levels places some constraints on the others. The way the heart is connected to the arteries and veins constraints the values that vascular pressure can take in any of these areas. Similarly, oxygen needs at the tissue level place constraints on organ and system functioning. Depending on the nature of the observer's task, different levels of information become critical. To support performance optimally, it is necessary to make available the particular level of information that key to the task.

Perception, Drawing and Design

Drawing help mediate and externalize thoughts and ideas. They have been used by psychologists as diagnostic tools and for studying developmental sequence in the early stages of learning (Goodnow, 1977). Drawing is a means of expression, exploration and discovery. It is a multipurpose tool for enquiry, comprehension and communication (Adams, 2002); for organizing and representing ideas; for analogical (Gentner, Holyoak, & Kokinov, 2001), and visuo-spatial (Tversky, 2002) reasoning; and recording medium (Hope, 2000). Drawing as a socio-cultural activity is reflected in symbolic and cultural conversation or resource preferences in productions (Anning, 1997). Drawing, which plays an important role in design; it is the heart of technological activities. Practitioners of technology, modern and pre-modern, "read" drawings because they understand and share symbol conventions (Do & Gross, 1996). Drawing reveal contexts the intentions of design, design drawing is an external representation that helps in a problem solving and generating ideas (Ullman, Wood, & Craig, 1990; Cross, 1984). While advocating an approach to teaching and learning drawings, Edwards (1992) has claimed that drawing can be potent problem-solving aid for both children and adults. Anning (1997) has emphasized the role of graphicacy, the use of drawing in representing ideas or objects, as a tool for learning and recording thinking in classroom. She believes that people are socialized into working within the modes of graphicacy each discipline demands of them. Many designers, engineers and practitioners in technology education have also emphasized the richness of design drawings as the non-verbal language of technology.

Designing is an interaction between the mind and hand (Kimbell, Stables, & Green, 1996). Design thinking with the form as well as function, and includes visual and spatial reasoning. Attempts to understand the process of design through studies with professional designers like architects and engineers have revealed interesting facets of design activity, like the ill-defined nature of design problems, use of primary generations in early designing and the use of shared conventions among designers (Cross, 1984). These studies have broadened the understanding of design process in general and have been valuable insights for design in school education. Cross (1982) emphasize that design is analogous to, and distinct from, the two cultures of the "humanities" and the "sciences". He advocates design as a coherent academic discipline in general education, which need to be merely a preparation for a career or for productive skills for the industry, but can enhance and develop students' intrinsic cognitive process, values, and abilities (Cross, 1982; Roberts, 1994). Students' verbal and non-verbal representations, as they explore and evaluate alternative ideas of conceived artifact, processor system, give us clues about their understanding and its progression.

Instructional Technology and Representational System

One of the central problems with the majority of the literature and studies reviewed concerns the overly simplistic behaviorist view and assumption, present in most of them, that the text and language are strings of words or homogenous units representing homogenous structures that are somehow fundamentally different from visual representational systems such as diagrams and graphs. This view is diametrically opposed to the mainstream research in cognitive and computer assisted instruction and artificial intelligence such recognizes that verbal, mathematical, and visual systems and displays are all forms of representing deep structure information, and *all* have their own but similar language. Further, modern cognitive psychology and cognitive sciences contend, and have vividly demonstrated, that *all visual information and stimuli may be represented propositionally (*as with computer) and at different levels of depth. It is the propositions that define the relationships in a deep knowledge structure – and/or surface display or topology – and provide the semantic meaning and interpretation component in any system (Pitt & McCollough, 1988; Penrose, 1991; Pylyshyn, 1973, 1999, 2003), this *propositional representational view* is in fact the central and core postulate and contention of modern cognitive learning theory (Ashcraft, 2002).

In many of the studies described below, only the surface structure of the text is considered and examined, and only weakly so, while the quality of the conceptual, causal and explanatory deep structure of the text is not addressed at all. Contemporary mainstream models of text processing and reading comprehension have shifted from analyzing surface structure to analyzing deep (macro and micro) structures and their role and function in learning and understanding (Van Dijk, 1980; Dagostino & Carifio, 1994; Kintsch, 1986; Graesser, Swamer, Baggett, & Sell, 1996; Meyer, 1986; Britton & Graesser, 1996).

Gestalt psychology and cognitive theory have convincingly demonstrated that visuals depict, show, and establish *relationships* and that all learning is the learning of relationships (Ashcraft, 2002). However, visuals do not have and do not communicate the key and fine-grained details, specifics, and nuances of relationships. For example, there is no set of simultaneous equations that can represent any knowledge base beyond a simple Euclidean proof and none that can represent knowledge base that is dynamic and generative. Any equation or mathematical algorithm or model must include semantic text to mean anything. Pictures, diagrams, and graphics are also more ambiguous and primitive representations (i.e., the iconic level to Bruner) and cannot really represent cognitive networks and semantic webs. These points are why and how visual are impoverished and limiting, and why contextualizing and rich text and/or dialogue is needed. These points are also the reasons why both text and graphics are always present in something deeply learned in an integrated fashion, as opposed to chunks and categories of fuzzily related information or images, or both simultaneously, if one holds to Paivo's (1986) dual – verbal and spatial – encoding model, or that of DeVega, Intons-Peterson, Johnson-Laird, Denis, & Marschaqrks (1996) multiple encoding model.

All of these letters points are also why items such as concept maps (Ruiz-Primo & Shavelson, 1996; Mintzes, Wandersee, & Novack, 1997), even very elaborate and detailed ones, represent only a very small impoverished amount of the information in the actual knowledge structures that they depict. There are several missing levels of much more detailed representation before one gets to the deep knowledge structure in question. In a word, illustrations, diagrams, charts, tables, graphs, concept maps, and other such as visual displays always have a high degree of excess meaning and ambiguity as well as inherent and latent meaning, even to experts, which cannot be reduced to the level of "noise" except through accompanying text and a knowledge of conventions, language, and semantics of the visual display in question. Visuals, therefore, may convey a great deal of information – particularly relational information – almost instantaneously and more transparently, particularly for relationships, but at the very high price of excess, ambiguous, and latent meanings which need operationally narrowing, defining, and often highly nuanced thick and rich text to reduce the noise level. Textual and visual representations are, then, somewhat like quarks – namely, they naturally come in pairs and to separate (de-contextualize) them significantly is to more than abuse or denture them. Separating texts and visuals is to both seed and fuel a whole host of potential unintended and unwanted consequences through unwarranted and often unconscious inferences, deductions, and interpretations, which are broadly referred to as misunderstandings, misconceptions, or alternative conceptions.

It is often said that one picture, or visual, is worth a thousand words (of text); but visuals without text are most often just pretty pictures, and pretty ambiguous pictures as well. Further, the point that is rarely made – particularly as a counter argument – is that one word (e.g., freedom, democracy, friend) is often worth a million plus pictures, as any poet or novelists knows, and that text is far more powerful and generative than visuals because of the richness and layers of nuanced semantic networks. This is a point that is often forgotten in the current *moving image* and *sound-bite* age (i.e., impoverished text) we live in or in what is now referred to as the *presentation culture* – mostly image and little substance – by current sociologists. The power of the text is even fading from unconscious memory as trade books, magazines, textbooks; educated TV programs are purposefully increasing the amount of space/time occupied by visual compared to text. The stated rationalization is that they are crafting communications for the image and visually conscious generation as this generation is not as textually literate as previously generations, as Hirsch (2006) has documented. Visuals and visual aids in learning, therefore, are even more important in instruction today than they are made out to be by science educators and those doing research on the effects of visuals and visual aids in the learning of scientific-technical content (Carifio & Perla, 2008).

Learning Experience

Three traditional components of the instructional environment vie for the attention of teachers and instructional designers – subject matter, instructional methodology, and the learner. Instructional designers often broaden this traditional view by including the instructor and/or instructional designer and the instructional context to describe the complete instructional system. However, a more holistic approach would also include the idea of “learning experience.” Learning experience describes the transaction that takes place between individual learners and the instructional environment. Learning experience includes the way that the learner feels about, engages with, responds to, influences, and draws from the instructional situation (see Fig.1). Learning experience is different for each learner, depending on the connection made to the other components of the situation and depending on what the leaner brings to the situation and draws from it for future situations. “Experience” in this sense describes more than a passive event. It is a transaction with the environment in which learning is an outcome (witness the saying, “experience is the best teacher”). Viewing learning as experience broadens the concerns of instructional designers because it necessitates consideration of the quality of that experience and not just its goals and mechanics. For example, this viewpoint raises learner engagement in status: only when learners consider the experience worth attending to and reflecting upon will the transaction of experience have its full impact.

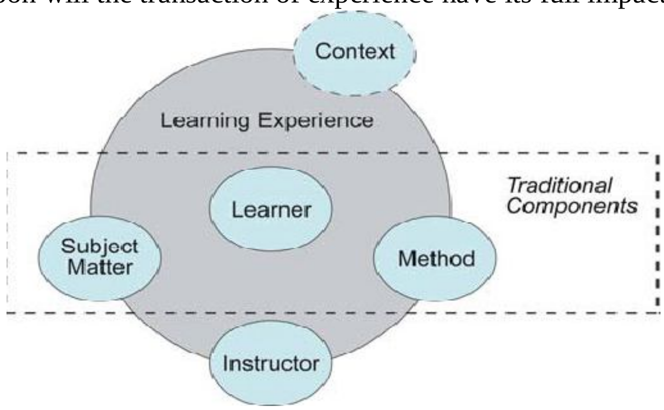

Fig. 1: Components of instructional environments

Learning experiences have many qualities, including cognitive ones of course. But they also have emotional, social, cultural, political, and aesthetic qualities (Wilson, 2005). All these come into play in determining the immediate qualities and enduring meaning of an experience. Aesthetic qualities include the rhythms of instructional activities; methods for creating intellectual and emotional tension and revealing unity within content sequences; strategies for providing memorable closure to learning experience; and the sensory impact of classrooms, computer interfaces, and texts. But these immediate qualities are not attended to simply for their immediate rewards–they are designed to lend the experience lasting resonance. An instrumental view of learning may consider only the immediately measurable outcomes of a learning experience, particularly is impacts on cognition, behavior, or performance. But a more inclusive view, one that values a growing capacity and willingness to engage with and learn from the world, considers the continuity of experience (Dewey, 1916) and is concerned with how the quality of an experience impacts the meaning we attribute to it. A meaningful experience leads us to engage fruitfully not only in the immediate situation but in the future experience to which it points.

Visual Display and Learning

For learning to transfer to other problems, invariants (relationships) must also be shown to be appropriate for the new tasks (Lintern, 1991). Procedures or techniques that accentuate the invariant relationships to be learned will enhance the student’s ability to differentiate the relevant information. For example, providing explanatory illustrations can help students understand the key relationships they are trying to learn (Mayer & Gallini, 1990). Illustrations by themselves are much less effective. In a recent edition on flight, students were asked to invent a plane that would meet particular design goals, but were constrained in choosing their design parameters from a limited set of possible wing length and weights. A picture that mapped easily onto the relevant relationships (weight and wing length) showed the results of their choices. Picture, text, and task goal complemented each other. For visual display to support learning, visual objects shown in the display should be compatible with the properties “more” of a substance, it should be shown as relatively larger, longer, or higher than the object with which it is compared.

Size is relatively easy to map accurately (Although errors still can be made), but other relationships and concepts are not as easily mapped onto a display's geometry. Indeed, this is one of the real challenges of designers of learning environments. A related issue is whether the mapping presented should be based on the learner's native model, which makes the relationships more intuitive for the student, or whether it should be based on the laws or principles (e.g., mathematical physical, or ethical) that support it, which may be quite counterintuitive for the student. Because education is the goal, one might assume that the latter would be the case, but this may not be so. It may be necessary to begin with the native worldview, particularly for initial navigation, and then progress to the more scientifically based view. Instructional technology has the potential to be helpful to be broad range of students. However, ultimately it needs to support the weakest student without frustrating the strongest (cf. Rasmussen, Pejtersen, & Goodstein, 1994).

Cognitive Load Theory and Designing

The human cognitive system consists essentially of limited working memory, a powerful long-term memory, and learning mechanisms which reduce the burden on working memory by utilizing previously known facts. Cognitive load theory proposes that optimum learning occurs when the load on working memory is kept to a minimum to best facilitate the changes in long-term memory (Sweller, 1988). When elements of a task can be learned in isolation, they are described as having low element interactivity. The level of "element interactivity" refers to the extent to which elements of a task can be learned without having to learn the relations between other elements. It is proposed that the amount of interactivity between elements of the material is closely related to the cognitive load that is generated by the activity–for example when learning (the syntax of) a language, it is impossible to learn a single word in isolation as the material is highly interactive and must be learned in conjunction with several other elements with which it is related. This creates a high cognitive load and therefore the material is harder to learn. This effect is seen even when the number of elements to be learned is small, so long as the number of elements that must be learned simultaneously is relatively high (Sweller & Chandler, 1994). Sweller and Chandler describe cognitive load as a belonging to two categories, and the above example refers to intrinsic cognitive load. Intrinsic cognitive load is determined by the element interactivity within the material. High element interactivity results in high cognitive load whether or not the number of elements to be learned is high or not. Cognitive load may also be introduced within instructional media simply by using instructional techniques which unnecessarily increase element interactivity. This second category of cognitive load termed extrinsic cognitive load and it is this cognitive load that may be reduced with the application of design principles to the design of instructional materials. A fundamental principle described in cognitive load literature id the split-attention effect, and several cognitive design principles are built upon this theory (Mayer & Moreno, 1998; Moreno & Mayer, 1990a; Touvinen, 2000).

Cognitive Theory of Multimedia Learning

In the design of multimedia system, issues of layout, transmission, or pure aesthetics are commonly considered – if a system is to be used to facilitate learning then the dimension of human cognition should be factored into the design. In many information technology design projects, trade-offs are routinely made when limitations of the resources become apparent. In an e-learning system, these must be considered very seriously as the cost, in terms of effectiveness, may not be immediately apparent. If the human mind is viewed as an information processing architecture, then as with any automated system, the levels of load imposed upon this architecture will affect its working capacity. Therefore, the application of cognitive load theory (Sweller & Chandler, 1994) is of relevance to those aiming to improve the efficiency of mental process such as integrating and assimilating new knowledge. Those familiar with user interface design will have encountered the work of G. A. Miller (1956) in which he coined the term "the magic number seven plus or minus two," to describe the length of a list of items that a person could hold in a working memory at any given time.

In practice, this number varies based on environmental conditions, age fatigue, and so forth (Tuvinen, 2000), but it is very clear that the actual working capacity of the human memory is very limited. Therefore, the broad goal to be considered when designing a multimedia system is to minimize this cognitive load so that more working memory is available to be devoted to the process of learning new information (Mayer & Moreno, 1998). Mayer utilized cognitive load theory and split-attention effects and applied these to the context of multimedia learning, proposing the cognitive theory of multimedia learning (Mayer, 2001).

Based on a series of experiments by Mayer and colleagues, a number of principles have been derived which provide support for the theories (e.g., Mayer & Anderson, 1992; Mayer & Moreno, 1998). These principles may be considered during the design of a multimedia project to aim to maximize the usefulness of the product. The principles can be broadly categorized into three areas, those of contiguity, modality, and redundancy.

Multimedia and Its Theory

Tannenbaum (2000) defines multimedia as “an interactive computer-mediated presentation that includes at least two of the following elements: text, sound, still graphic images, motion graphics, and animation.” The choice of media is also flexible; this may incorporate audio, video, animations, and text in varying quantities. One particularly relevant and established theory of instructional design is the cognitive theory of multimedia learning (Mayer, 1989, 1997, 2001). At first blush, the name of this theory is somewhat misleading in that it appears computer centric. However, multimedia learning theory is less about the type of media used in educational settings and more about memory and how learners process information. In fact, Mayer’s work has been generalizes to the e-Learning environment, with the vast majority of principles remaining the same (Clark & Mayer, 2003). Essentially, multimedia learning theory posits a dual modality because it emphasize what a learner sees and hears for creating meaningful learning (Mayer, 1997; Mayer & Moreno, 1998). As such, Mayer suggests the theory may be more appropriately referred to as a multimodal (vs. multimedia) learning theory.

Mayer’s theory holds that auditory and visual stimuli processed first in the sensory memory by the student, and then selected words and images are organized into the learner’s working memory. Learners integrate the visual model of what they see with the auditory model of what they hear into their functioning memory; this integrated model becomes part of the students’ long-term memory when it becomes part of their storehouse of knowledge (2001). Ultimately, the multimedia theory claims that *coordinated* presentation of narration and pictures is effective because it guides learners’ cognitive processes in selecting and organizing relevant information to build cause-and-effect relationships (Mayer, 1997). The theory makes a *dual channel* assumption, meaning learning stimuli are processed in either the auditory or visual channel in the brain. Pictures, screen text, and animation are handled in the visual/pictorial channel, and sounds and narration are dealt with in the auditory channel. Important to the original theory are thus the learner’s visuospatial processing and his or her phonological loop, which deals with processing language (Baddeley 1992, 1999). Second, the theory presumes *limited capacity* for the auditory and visual channels. Put simply, each channel is capable of processing only so much material at one time. Working memory theory (Baddeley, 1992) and cognitive load theory (Chandler & Sweller, 1991; Miller, 1956) also support a limited-capacity principle in learning. The most direct design principle that follows from cognitive load theory is that extraneous information should be omitted to preserve learners’ attention resources. The third assumption of multimedia learning theory is a focus on *knowledge construction*, versus knowledge acquisition, meaning it is assumed the learner is trying to understand and make sense of the material rather than acting as a passive receptacle. However, it will be argued later that the findings based on this theory are also likely applicable in more passive instructional scenarios.

Multimedia Principle

The most fundamental principle in this line of research is dubbed the multimedia effect. It suggests that students learn better from screen words and relevant pictures than from the presentation of screen words alone (Mayer, 2001). In all time experiments reported by Mayer (2001), learners who received text and pictures or pictures with narration (i.e., where the instructor is speaking about a visual element) performed better on tests than did those who received text alone, pictures alone, or narration alone. As evident by related research in a college literature class, the combination of text and static pictures creates more holistic learning than print alone (Speaker, 2004). Text requires mental effort to translate into meaning; in contrast, pictures depict material in a more efficient, holistic, nonlinear way. Graphics are interpreted in terms of what viewers already know and what they expect the graphic to mean, and ultimately, help improve understanding (McDaniel & Waddill, 1994; Winn, 1994). As such, each source of learning input – audio and visual – is distinct in its information-providing capacity (Mayer & Anderson, 1991, 1992). In sum, combining words and corresponding pictures to produce a multimedia message in higher education should increase student learning.

Conclusion

Cognitive load theory (Sweller, 1988) states that human cognitive system possesses a finite processing capacity, which is split into channels for various modalities, and that learning, will be inhabited if any of the cognitive channels is overloaded. However, although the amount of e-learning materials is increasing steadily, the design of instructional material is still largely based on intuition rather than cognitive principles (Mayer et al., 2001). Mayer proposed a series of design principles by which multimedia presentation can be designed to maximize learning. Beside this review of multimedia production, effective collaboration could possibly be taught in specific instructional design and technology case studies (e.g., Ertmer & Quinn, 2006) or possibly in informal learning activities as espoused by Schwier (2010). As such, instructors may be better positioned to present course information to their students in a way that enhances understanding and to model effective presentation techniques that their students will likely use in the field. The researcher also encourages additional studies that review and possibly propose new instructional design and technology competencies, such as Leigh and Tracey's (2010) recent investigation, as well as Larson and Lockee's (2004) comparison of relevant competences. Uncovering four primary instructional design paradigms (Visscher-Voerman & Gustafason, 2004), four main roles of an instructional designer (Schwier & Wilson, 2010), and primary instructional activities (Kenny, Zuochen, Schwier, & Campbell, 2005; Villachica et al., 2010) are all worthy endeavors to comprehend the essential competencies and activities that are required of Instructional Design and Technology program graduates.

References

Aschcraft, M. (2002).*Cognition* (3rd ed.). New Jersey: Prentice-Hall.

Anning, A. (1997). Drawing out ideas: Graphicacy and young children. *International Journal of Technology and Design Education,7* , 219-239.

Baddeley, A. D. (1992). Working memory. *Science, 255*, 556-559.

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

Beeland, W. D. (2002). Student engagement, visual learning and technology: Can interactive whiteboards help? *Annual Conference of the Association of information Technology for Teaching Education,* Trinity College, Dublin. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.135.354andrep=rep1andtype=pdf

Britton, B.K. & Graesser, A.C. (1996) (Eds.).*Models of understanding text.* New Jersey: Lawrence Erlbaum.

Carifio, J. &Perla, R. (2008).*An examination and critique of the theoretical and empirical literature of the use of diagrams, graphs, and other visual aids in the learning of scientific-technical content from expository texts and instruction.* (Comprehensive and original version of article). Available at http://gse.uml.edu/carifio

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

Chandler, P., &Sweller, J. (1992). The split attention effect as a factor in the design of instruction. *British Journal of Educational Psychology, 62*, 233-246.

Cross, N. (1982). Designerly ways of knowing. *Design Studies, 3*(4), 221-227.

Cross, N. (Ed.), (1984). *Development in design methodology.* New York: John Wiley & Sons, Inc.

Dagostino, L. & Carifio, J. (1994). *Evaluate reading and literacy: A cognitive view.* Boston, MA: Allyn and Bacon.

DeVega, M., Intons-Peterson, J., Johnson-Laird, P., Denis, M. & Marschark, M. (1996).*Models of visuospatial cognition.* New York: Oxford University Press.

Dewey, J. (1916). *Democracy and education.* New York: The Free Press.

Do Yi-Luen, E., & Gross, M. D. (1996). *Drawing as a means of design reasoning.* In Artificial intelligence in design (AID) '96, Workshop on visual representation reasoning and interaction in design, Palo Alto, CA.

Edwards, B. (1992). *Drawing on the right side of the brain.* London: HarperCollins Publishers.

Effken, J.A., Kim, N-G., & Shaw, R, E. (1997).Making the constraints visible: Testing the ecological approach to interface design. *Ergonomics*, 40 (1), 1-27.

Ertrner, P. A., & Quinn, J. (2006).*The ID Case Book: Case studies in instructional design* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Gentner, D., Holyoak, K., & Kokinov, B. (Eds.), (2001).*The analogical mind: perspectives from cognitive science.* Massachusetts: The MIT Press

Gibson, J. J. (1966). *The senses considered as perceptual systems.* Boston: Houghton Mifflin.
Gibson, J.J. (1986). *The ecological approach to visual perception.* Hillsdale, NJ: Lawrence Erlbaum Associates. (First published in 1979)
Goodnow, J. (1977). *Children's drawing*. London: Fontana/Open books.
Hanfat, A. (2003). More power than point. *Inc., 25*(8), 116.
Hope, G. (2000). Beyond their capability? Drawing, designing and the young child. *The Journal of Design and Technology Education, 5*(2), 106-114.
Kenny, R. F., Zuochen, Z., Schwier, R. A., & Campbell, K. (2005). A review of what instructional designers do: Questions answered and questions not asked. *Canadian Journal of Learning & Technology, 31*(1), 9-26.
Kerlinger, F.N. & Lee, H.B. (2000).*Foundation of behavioral research.* Fort Worth, TX: Harcourt College Publishers.
Kimbell, R., Stables, K., & Green, R. (1996).*Understanding practice in design and technology*. Buckingham: Open University Press.
Kintsch, W. (1986).Learning from text. *Cognition & Instruction,3*, 87-108.
Kosslyn, S.M. (1994). *Elements of graph design.* New York: Freeman.
Larson, M., &Lockee, B. (2009).Preparing instructional designers for different career environment: A case study.*Educational Technology Research & Development*, *57*(1), 1-24.
Leigh, H. N., & Tracy, M. W. (2010). A review and new framework for instructional design practice variation research. *Performance Improvement Quarterly, 23*(2), 33-46.
Levin, J.R., Anglin, G.J., & Carney, R.N. (1987).On empirically validating functions of pictures in prose. In D.W. Willows & H.A. Houghton (Eds.), *The psychology of illustration* (pp. 51-85). New York: Springer-Verlag.
Lintern, G. (1991). An informational perspective on skill transfer in human-machine systems. *Human Factors, 33*(3), 251-266.
Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist, 32,* 1-19.
Mayer, R. E. (2001). *Multimedia learning.* Cambridge, UK: Cambridge University Press.
Mayer, R. E., & Anderson, R. B. (1991).Animations needs narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology, 83*, 484-490.
Mayer, R. E., & Anderson, R. B. (1992).The instructive animation; Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology, 84*(4), 444-452.
Mayer, R. E., & Anderson, R. B. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology, 84*, 444-452.
Mayer, R. E., Heiser, J., & Lonn, S. (2001). Cognitive constrains on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology, 93,* 187-198.
Mayer, R. E., & Gallini, j. K. (1990). When is an illustration worth a thousand words? *Journal of Educational Psychology. 82*, 715-726.
Mayer, R. E., &Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90,* 312-320.
McDaniel, M. A., & Waddill, P.J. (1994). The mnemonic benefits of pictures in text: Selective enrichment for differentially skilled readers. In W. Schnotz& R. W. Kulhavy (Eds.), *Advances in psychology: Comprehension of graphics* (Vol. 108, pp. 165-185). Amsterdam: Elsevier.
Meyer, B.J. (1986). Following the author's top-level organization: An important skill for reading comprehension. In R.J. Tierney, P.L. Anders, & J.N. Mitchell (Eds.), *Understanding readers' understanding: Theory and practice* (pp. 59-76). Hillsdale, NJ: Erlbaum.
Miller, G. A. (1956). The magical number seven, plus or minus two; Some limits on our capacity for processing information. *The* Psychological *Review. 63*, 81-97.
Mintzes, J., Wandersee, J., & Novack, J. (1997).*Teaching science for understanding: A human constructivist view.* New York: Academic Press.
National Research Council. (2002). *Scientific Research in Education.* Committee on Scientific Principles for Education Research. R.J. Shavelson & L. Towne (Eds.).Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.
Pavio, A. (1986).*Mental representation: a dual-coding approach.* New York: Oxford University Press.
Penrose, R. (1991).*The emperor's new mind: Concerning computers, minds, and laws of physics.* New York: Penguin Books.
Phillips, F. (2005).The contested nature of empirical research (and why philosophy of education offers little help). *Journal of Philosophy of Education, 39*(4), 577-597.

Pitt, W. & McCullough, W. (1988). How we know universals: The perception of auditory and visual forms. In E. Feigenbaum & J. Feldman (Eds.), *Computers and thought* (pp. 217-246). Cambridge, MA:MIT Press.

Pylyshyn, Z. (1973). What the mind's eye tells the mind's brain: A critique of mental imagery. *Psychological Bulletin, 80*, 1-24.

Pylyshyn, Z. (1999). Is vision continuous with cognition: The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences, 22*, 341-523.

Pylyshyn, Z. (2003). Return of the mental image: Are there really pictures in the brain. *Trends in Cognitive Science, 7*(3), 113-118.

Rasmussen, J., Pejtersen, A. M., & Goodstein, L. P. (1994).Cognitive systems engineering. New York: Wiley

Roberts, P. (1994). The place of design in technology education. In D. Layton (Ed.), *Innovations in science and technology education* (pp. 171-179, Vil. V). France: UNESCO Publishing.

Ruiz-Primo, M.R. & Shavelson, R.J. (1996).Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching, 33*(6), 596-600.

Schwier, R. A., & Wilson, J. R. (2010). Unconventional roles and activities identified by instructional designers. *Contemporary Educational Technology, 1*(2), 134-147.

Speaker, K. (2004). Student perspectives: Expectations of multimedia technology in college literature class. *Reading Improvement, 41*, 241-254.

Tannenbaum, R. S. (2000). Multimedia developers can learn from history of human communication. *Ubiquity, 1*(34).Retrieved November 2014, from http://www.acm.org/ubiquity/views/r_tannenbaum_3.html

Van Dijk, T.A. (1980). *Text and context: Exportations in the semantics and pragmatics of discourse.* London, UK: Longman.

Villachica, S. W., Marker, A., & Taylor, K. (2010). But what do they really expect? Employer perception of the skills of entry-level instructional designers. *Performance Improvement Quarterly, 22*(4), 33-51.

Visscher-Voerman, I., & Gustafson, K. L. (2004).Paradigms in the theory and practice of education and training design. *Educational Technology Research & Development, 52*(2), 69-89.

Wilson, B. G. (2005). Broadening our foundation for instructional design: Four pillars of practice. *Educational Technology, 45*(2), 10-16.

Winn, W. (1994).Contributions of perceptual and cognitive processes to the comprehension of graphics. In W. Schnotz & R. W. Kulhavy (Eds.).*Advances in psychology: Comprehension of graphics* (Vol. 108, pp. 2-29). Amsterdam: Elsevier.

Wolfe, C. R., Halas, J. W., & Arthur, S. (1999). Scoring procedures manual scientific reasoning scenarios. *Technical report of the Center for Human Development, Learning and Teaching. Miami University. Oxford, Ohio*[Online] (pp. 1-19). Available (October 10, 2014): http://miavxl.muohio.edu/~chdltcwis/wolfchris_instrument.html