Creating Supportive Multimedia Learning Environments

Bobbe Gaines Baggio, Ph.D.
Director of the Graduate Program
Instructional Technology Management
La Salle University
Philadelphia, PA 19141-1199

Abstract

A strategy for developing effective multimedia instruction should be based on evidence presented by cognitive science and backed by research. Unless guided by instructional design principles, multimedia learning products run the risk of being unusual and entertaining but not effective. An effective design strategy at a minimum should embrace; recognizing learner differences, creating good multimedia messages, managing cognitive load, providing opportunities for active cognition, and monitoring learner engagement, intentions and progress. Activity theory, when integrated into multimedia instruction can support the creation of constructivist learning environments. Activities are ways that learners interact with the outside world and cognition is part of the interaction. Using multimedia to develop opportunities for learners to participate in active cognition can enhance the learning environment Active cognitive engagement should include active, interactive and reflective e-learning. The challenge for instructional designers is to position multimedia in an environment that supports the realization of meaningful learning.
Introduction

This chapter presents a strategy for developing effective multimedia instruction based on evidence presented by cognitive science. The strategy is based on research and may guide instructional designers in creating supportive multimedia e-learning environments. The underlying assumptions of this chapter are that learners have individual styles of learning, construct their own meaning and that the learner is at the center of the learning process. Though learning differences exist, environments can be created that provide the learner with effective, functional and appealing places to learn.

The end of the twentieth century has produced changes in technologies and new ways of thinking about how people learn. The new paradigm supports a constructivist view that learners create their own meaning. Learning is seen as an active, intentional and constructive practice. Learners in constructivism are actively engaged in the learning and responsible for creating knowledge. This is a vast departure from traditional didactic pedagogy where the teacher is seen as the purveyor of knowledge. In constructivism, community and environment are relevant aspects of the learning experience. Learning environments must provide authentic activities or ways for learners to interact with the objective world, which support their intention of meeting learning goals. The challenge for instructional designers is to create environments rich with crucial learning attributes that support a cognitive, constructivist paradigm.

Creating effective multimedia instruction means creating environments that adhere to cognitive learning theory, utilize the results of high quality research and apply these to a learning situation. By creating multimedia messages that are grounded in how the human mind works, managing cognitive load, fostering active cognition, and creating
Multimedia and learner engagement, instructional designers can create supportive and effective constructivist learning environments.

Chapter Objectives

The reader will be able to:

- Understand how constructivist theory and cognitive science can aid in the creation of effective instruction for multimedia e-learning.
- Appreciate the importance of creating a supportive learning environment when using multimedia.
- Evaluate several influences on learner centered design when using multimedia in learning environments.
- Identify three different strategies for creating active cognitive engagement.

Background

Understanding the human brain and the complexity of the processes involved in learning is a division of the cognitive science field. The field is relatively young, very dynamic, and expanding. Advances in technologies and computers give scientists the ability to create expert systems, robots, and artificial intelligence. These advances have also given scientists a better picture of how the mind works. Cognitive science is the study of how the mind works (Boring, 2003).

The establishment of this area of study began in the 1940’s and 1950 with developments by computer pioneers like Alan Turing. Turing realized that computers could be programmed to understand language, solve math problems and play chess. This established the theory that the human mind operated much like a computer with inputs and outputs. The theory that minds were programmable and ran on brains with capacities was a shift in paradigms. Other advances in the fields of linguistics and neurophysiology
Multimedia and 4 contributed to the knowledge base of how the human brain processes information. Continuing research in the areas of cognitive psychology and cognitive neuroscience are creating images of the human brain and mapping out the processes. Along with learning about the brain, scientists are learning about how we learn (University of California Berkley, 2005).

Instructional design and development professionals are concerned with the process of recognizing learning needs and goals. Instructional designers must also determine which delivery methods meet these needs. E-learning is a viable and economical alternative for delivering learning materials and creating a learning environment. There are many varieties of e-learning including those targeted at higher education, K-12 education, corporate training and the military. These varieties can be delivered in as many forms including WBT (Web-based learning), CBT (computer based training), learning management systems, virtual classrooms and a wide assortment of other forms. Generally, instruction that is designed for and delivered on a computer system is classified as e-learning (Allen, 2003). Multimedia can be defined as the combination of pictures and word (Mayer, 2001). Interactive multimedia is the combinations of audio, video, text graphics, and animations that are used to deliver the e-learning.

Effective e-learning is learning that facilitates transfer and retention of content to the learner and meets the learners learning goals. In good e-learning understanding or knowledge is enhanced, behavior changes, processes are improved or some other function gets better (Allen, 2003). Over fifty years of research support the findings that it is not the media but the instructional methods that make the difference in learning. Yet each form of multimedia has unique affordances. The challenge for instructional
designers is using these distinctive capabilities to deliver instructional methods and meet learning objectives. (R. Clark, 2003).

Issues, Controversies, Problems

Contemporary Learning Theories

Contemporary learning theories consist of a confusing collection of theories with a distinctive language and a considerable amount of common ground between epistemologies. This is further distinguished by the division into two camps: those that apply to adults and industry and those that apply to children and K-12 education.

Learning theories are concerned with the foundations, scope and validity of acquiring knowledge. Generally, learning theories are classified by dominant traits in the paradigm. Four learning theories are relevant to the discussion of creating cognitively supportive multimedia learning environments because either the theory is currently dominant, has influence reflected in one of the other theories, or because it provides a context or framework for comparison. The four major classifications are: behaviorism, cognitivism, constructivism, and humanism. These are only the general classifications of hundreds of individual learning theories and models (Leonard, 2002).

Behaviorism

Behaviorists consider learning to be a change in observable behavior that results from an experience and lasts over time. This is important because, insights, goals, ideas, and any other change that exists only in the learner’s mind are not considered. B. F. Skinner’s concept that behavior changes because of contiguity or the pairing of stimuli and response is at the heart of behaviorism. Skinner also contributed the concept of operant conditioning which affirms that learners respond to the consequences of an outcome and this can influence future behavior. This sets up a system of rewards and
Multimedia and punishments. Pavlov also contributed to behaviorism with his famous dog experiment. This led to classical conditioning and respondent behavior which greatly influenced learning for the last half century and still plays a strong role in education today (Eggen & Kauchak, 1999, pp. 197-214). Despite distracters, this is still a force in learning and instructional design circles. The reconceptualization of learning challenges this theory by presenting alternative theories that are more learner centered. (Leonard, 2002, p. 16)

**Cognitivism**

Cognitivism is not an uncomplicated or solitary paradigm. Cognitive science is at the root of cognitivism. Learning takes place in cognitivism when a learner processes information that comes from the outside world by building a mental construct of the information. Cognitive information processing (CIP) relies on the analogy of a computer with components for processing, such as input, storage or memory, retrieval or output. Like behaviorism, cognitivism purposes that learning consists of the formation of associations. Inputs in some form are linked to what is already in storage or prior knowledge. In this way, the learner makes cognitive connections, between what is known and what is being learned.

Cognitivism concerns itself with automaticity, pattern recognition, feature analysis and mental models. The concept of chunking developed by Miller (1956) where information is arranged in bits (7+ or – 2) for short term memory recall, is a classic in cognitivism (Driscoll, 2000, p. 88). Situating problems to be practiced and solved in context is also a characteristic of cognitivism. Cognitivists are interested in the influence that context has on input. In the world of e-learning and multimedia, cognitive load has resurfaced as a real concern. Cognitivism is a strong and vital force in the design of e-
Multimedia and learning and in delineating how learners think and learn. Like all the other learning theories, this one too, has distracters (Leonard, 2002, p. 30).

**Constructivism**

The movement in recent years in contemporary learning theory has been toward a constructivist approach. This approach is learner centered and focuses on creating supportive learning environments. Constructivism is not a single vision. The fields of educational psychology, instructional technologies, and sciences contribute many influences and multiple expressions of ideas that constitute the learning theory referred to as constructivism. This view supports the connotation that knowledge comes through an individual’s internalization of events that happen in the outside world. Constructing knowledge is the learners’ attempt to make sense out of their world by interacting with it. Learners are not “empty vessels to be filled” (Driscoll, 2000, p.376) but rather take an active part in the learning process. This idea is central to and universally accepted as an integral part of the theory of constructivism.

Constructivism makes the role of the learner an active one rather than a passive one. The learners must be actively engaged in order to build, understand and decipher the outside world (Eggen & Kauchak, 1999). In Western educational circles this is a revolutionary concept. Traditional instruction is reliant on organizing and categorizing information, independent of the learner (Hein, 1991). These methods that supported the industrialization of western cultures from the agrarian era relied on transmitting information. The emphasis was on information recall. As learners became exposed to increasing amounts of information, the ability to problem solve, retain and transfer knowledge became very important. The old methods were just not very effective. Traditional methods of learning just did not support these critical cognitive processes.
Multimedia and 8 (Mayer & Reigeluth, 1999). With constructivism, the emphasis is on the learner so motivation, autonomy, inquiry and discovery on the part of the learner become paramount to the learning process. Constructivism is the predominant theory embraced today in many traditional and non traditional learning venues (Leonard, 2002, pp. 7-39).

The paradigm shift toward constructivism is centered on the position of the learner. Learners in constructivism are actively engaged in the learning. The instruction or teacher is no longer the center of the creation of knowledge. Constructivists believe reality is relative to the learner. This has also influenced pedagogy because constructivists believe that to come to the truth multiple perspectives or groups of learners working together have a better chance of accomplishing it. A social aspect is introduced with constructivism and so is the concept of learning environment.

**Humanism**

Like constructivism humanism is concerned with the individual learner. Although some skeptics have dismissed this as a true paradigm, humanism and constructivism coincide. Humanism emphasizes that learning and thinking are driven by a desire to be a complete and fulfilled human being capable of making decisions and positively affecting others. Humanistic views of motivation believe that learners seek gratifying experiences. This theory which originated in the mid 1950’s has had resurgence because of the emphasis on learner growth and potential (Eggen & Kauchak, 1999).

Humanism in many ways is a reaction to cognitivism and behaviorism. These theories are diametrically opposed. Humanism does not support the kind of logic that reduces the human learning to either a response to an environmental stimuli or internal inputs and outputs. The emphasis in humanism is on the whole person. This is expressed
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as the interaction of physical, emotional, intellectual and interpersonal elements that are combined to reinforce self actualization (Leonard, 2002, p. 86).

The Big Shift: Cognitive Constructivist Environments

The shift in the underlying assumptions of how learning occurs, from a knowledge transfer paradigm, to an active process learners use to construct knowledge has not been swift nor has it been definitive. The dichotomy centers on the view of learning as information acquisition or as knowledge construction (Mayer, 2001). In the information acquisition model learners are passive and instruction is about transmitting information to the learner. Instruction that relies on lecture and/or audio or video to disseminate the information to the learner follows this pattern. There are many examples of this because it is easiest to prepare, it is common and has a familiarity to learners and many instructors or trainers rely on their own educational experiences to create courses. Many do not understand active learning (R. C. Clark, 2003).

The behavioral model can still be found in many multimedia and computer based course as well as in classrooms. Direct instruction is a program where structure, sequencing and systematic skill development approximate many of the attributes of behaviorism. Direct instruction has been the focus of a vast amount to research and has been shown to be highly effective instruction in certain cases (Marchand-Martella, Slocum & Martella, 2004). Characterized by short lessons, frequent reinforcement and feedback and many small correct responses to build large chains of knowledge behaviorism was a natural for adaptation to the emergent technologies. (R. C. Clark, 2003)

The evolution of the Internet and other instructional delivery mechanisms that make one-on-one learning possible anywhere on the globe has also been characterized by
Multimedia and 10 more learner involvement and responsibility. Learning is now the responsibility of the learner. This learner liberation creates the need for a dynamic environment where learners can actively choose their own involvement in the learning process. Constructivist learning environments are learner centered places where knowledge is constructed by each learner rather than transmitted from a teacher or instruction (Wilson, 1996).

The environment now has an importance in learning that it did not previously occupy. The fundamental requirements are a learner and a space where learning can occur. This new paradigm is a more accommodating concept of learning. The environment is any place “where learning is fostered and supported….a place where learners may work together and support each other as they use a variety of tools and information resources in the guided pursuit of learning goals and problem solving activities” (Wilson, 1998, p. 5).

The challenge to creating these constructivist environments lies in understanding how learners learn. Barriers to learning can be removed and techniques and strategies to promote learning employed (Stage, Muller, Kinzie & Simmons, 1998). This construction requires an integration of new knowledge coming from the environment with prior knowledge existing the learner’s memory. Cognitive input is required to facilitate active construction of new knowledge. Instruction is about promoting this construction by supporting psychological processes that mediate it. The cognitive-constructivist approach to learning positions the learner in an environment that supports the active processes learners use to construct knowledge (R. C. Clark, 2003).

Solutions and Recommendations

*Using Multimedia to Support Cognition and Learning*
Advancements in cognitive sciences have given instructional designers new guidelines for applying the affordances of multimedia delivery to the way that humans learn. Cognitive theories of learning can help the instructional designer achieve a particular goal, using whatever variety of instructional systems design (ISD) an institution or organization chooses. ISD consists of a systematic approach to creating e-learning through the process of analyzing, designing, developing, implementing and evaluating a learning solution. The goal of instructional designers is to create e-learning products that are effective, functional and appealing to learners (Clark, 2002). This section focuses on the general application of advances in cognitive science and the overall aptitude for creating meaningful instruction. It examines the implications of using findings that are based in research on the ability of instructional designers to design and deliver effective instruction. It also covers the implications of learning styles, and investigates creating learning environments, cognitive load, learner presence and the importance of content and context.

Research Based

The literature suggests that e-learning courses should incorporate the results of well documented and high quality research. It also suggests that instructional design professionals use care in interpreting and applying these results. Although designing courses that are based on the results of research is more expedient, designers must be aware of what is practical and applicable to a particular situation. Until recently there was a void in the research base for designing e-learning and multimedia learning. There has been growth in this area and more useful and high quality research is becoming available (Clark & Mayer, 2003).
Three forms of research provide the foundation for the research base available to instructional designers: informal studies, controlled studies and clinical trials. Informal studies take the form of observing learners and or asking them about their learning. Informal studies can be useful but also has a risk attached to them. These types of studies do not adhere to rigorous scientific standards. Even controlled or formal studies can measure different attributes of the learning experience, such as processes and outcomes, and yield a wide variety of results. Empirical research provides the best information for application of cognate learning theory. Clinical trails measure the outcome from e-learning courses compared to some other venue and can be useful but are limited. These studies can be influenced by extraneous variable and there are many in the field of learning. Ruth Clark (2003) presents five questions that are critical to the consideration of the quality of research:

1. How similar are the learners in the research study to your learners?
2. Are the conclusions based on an experimental research design?
3. Are the experimental results replicated?
4. Is learning measured by tests that measure application?
5. Does the data analysis reflect statistical significance as well as practical significance? (Clark & Mayer, 2003, p.45).

These questions must not only be answered but the answers must be applied to the particular learning audience and interpreted with care. Michael Allen (2003) suggests that the results of research are often misinterpreted and applied inappropriately. Instructional designers must resist the temptation to universally apply research finding and must be aware of the context and circumstances surrounding the present learning situation. There
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are also often contradictions that exist in the research. Many universal theories that may be appealing may not be correct in certain situations.

There are many areas that show promise and the collection of high quality studies is continuing to grow. Some of the areas that show promise are learning styles, creating learning environments, prior knowledge, learner presence, cognitive load, and content and context.

Implications of Individual Learning Styles

A great deal of ongoing research supports the conclusion that different people learn differently. Research in cognitive psychology indicates that people show significant individual differences in problem solving and decision making activities. Although it would be impossible to cover all the available research, this review will highlight the work of Howard Gardener on Multiple Intelligences, David Kolb’s Learning Styles Inventory, and VAK. There are many others.

One of the most popular theories of explaining intellectual diversity is Howard Gardner’s Theory of Multiple Intelligences (MI). Gardner’s Theory of Multiple Intelligences has been around for about two decades and has caused more than one debate over validity (Logan 2002). Howard Gardner (1983) published *Frames of Mind*, and in it he argued for the existence of several comparatively independent human intellectual capabilities. Gardner’s theory suggests an entirely new way of thinking about learning. If learners have different kinds of intelligence then there must be different ways to teach them and reach them. Instead of a single intelligence factor, $g$, this theory is multidimensional. Gardner originally reported seven intelligences, which operate independently of each other (Mettetal, 1997). The number of Gardner’s proclaimed
Multimedia and 14 intelligences has changed to ten but the concept of multiple intelligences has been widely accepted throughout the educational and training communities (Snyder, 2000).

The Kolb Learning Styles Inventory is a four stage model that defines learning styles as: concrete experience, observation and reflection, the formation of abstract concepts and generalizations, and hypothesis tested by active experimentation leading to new concrete experience (Ginther, 1999). Kolb’s Learning Styles Inventory and Experimental Learning Theory have interesting connections to other concepts such as the Meyers-Briggs Type Indicator and Carl Jung’s belief that learning styles come from people’s preferred way of functioning in the world. (Chapman, 2005)

The VAK model uses audio, visual and kinesthetic sensory receivers as the main channels of input into the learners’ brain. The theory indicates that for most learners one of these is the dominant channel. The dominant channel can vary by task. These channels can also be combined in a variety of ways. Most importantly, this can and does vary by individual learner and indicates that not every one learns in the same way (D. Clark, 2000).

There is a great deal of research available to substantiate that learners have individual differences. This is significant because a paradigm shift in educational circles places the learner at the center of instructional design. Traditional epistemology assumes that the teacher is the transmitter of information and that better instruction means conveying ideas in a clearer format. The new paradigm assumes that knowledge is constructed and is the process of making meaning, not the transmission of knowledge. This new approach also focuses on the social and communal nature of making meaning.
This shift is known as constructivism and is really a collection of theories many find promising. Instructional pedagogy has embraced the promise of constructivism (Jonassen, 2000).

Creating a Learning Environment

Creating learning environments supportive of individual learners is demanding. One of the most appealing features of e-learning is also one of the greatest challenges. E-learning provides the opportunity to deliver learning on an individual’s desktop. Understanding the delivery environment, the physical environment, the platform, the interface and the level of support available for the learner are critical components in e-learning. Reviewing the multitude of components that make up the learning environment can be a daunting task, yet all of these workings can have an effect on learning.

Designing for the new paradigm means instructional designers are challenged to design constructivist learning environments (CLEs) that support the learning process. This is a formidable task. One of the challenges is to understand of what exactly makes up a CLE. Another difficulty comes from then applying ever evolving technologies to deliver the CLE. Several theoretical frame works have attempted to provide guidelines for creating CLEs.

Jonassen (2001) provides eight characteristics needed to create meaningful learning environments when using technologies. The environment should keep learners: active, constructive, collaborative, intentional, complex, conversational, and reflective. Active assumes the learner is engaged in conscious processing of information and responsible for the outcome. Constructive indicates the learner is able to integrate prior knowledge in order to construct meaning. Collaborative implies the building of communities and social supportive networks. Intentional suggests that learner behavior
be directed toward a cognitive goal. This goal should be learner defined for any given learning circumstance. Complex indicates that the learning should be presented to reflect problems with multiple components and perspectives. This is done to encourage higher order thinking. Contextual implies tasks should be situated in a real world context or problem solving environment. By teaching knowledge framed in a useful context transfer is facilitated. Conversational indicates the environment should foster communication and interaction. Reflective is about including the metacognitive aspects of learning and increasing understanding through internalization.

Honebien (as cited in Wilson, 1998) has established seven goals for CLEs. Many of these concepts coincide with those presented by Jonassen. The seven are: providing experience with the knowledge construction process, providing experience in and appreciation for many different perspectives, a context that is real and relevant to the learning, encourage ownership and voice, provide a social experience, use multiple modes of representation, and encourage self awareness or reflexivity (Wilson, 1996, p.11). There are many other versions of guidelines and rules for successful creating CLEs.

An important breakthrough for the new paradigm came through the concept of situated cognition. This idea says “knowledge is situated, being in part a product of activity, context and culture in which it is developed and used” (Brown, Collins & Duguid, 1989, p.32). Activity and context are regarded as an integral part of learning.

There is no separation between what is learned and how and where it is learned. This is an enormous departure from traditional didactic education which treats knowledge as a separate substance. However, situated cognition integrates the activity and the situation with the learning, there is no separation. Psychological research
supports this principle. In situated cognition, activities and context are an integral part of the learning experience. This also becomes a very important concept in designing CLEs. A great deal of work has been done in this area but much more needs to be researched. This new conceptualization changed representation from something that had to happen before knowledge could be obtained to one that focused on activity and perception. Situated cognition wrestles with the implications of explicit knowledge and implicit understanding. These create dilemmas for designers of CLEs (Brown et al., 1989).

Activity theory is another important concept for instructional designers attempting to design CLE’s. Practical design advice for constructing CLEs, and especially applying the analysis phase of methods like Instructional Systems Development (ISD) to constructivist pedagogy, has not been forthcoming. The needs analysis and task analysis by their nature have the wrong connotations because they assume “relevant knowledge can be embedded in the instruction for transfer to the learner in any context” (Jonassen & Rohrer-Murphy, 1999, p. 62). Activity theory is very consistent with the philosophical underpinning of constructivism, situated cognition, and social cognition and everyday cognition. It focuses on the interaction of human activity and the human mind in a relevant environmental context. In activity theory there is no separating the activity from the context. An activity system involves not only the kinds of activities present but also the people, the goals of the participants, results from the activity, norms and rules that circumscribe the activity, and social and communal circumstances surrounding the activity.

Jonassen (as cited in Reigeluth, 1999) warns against misinterpreting the concept of authentic tasks or problems that is so central to constructivist pedagogy. By insisting
that authentic equates to real world, designers are very narrowly interpreting authentic. Authentic problems can involve the community of learners, the physical setting, goals, constraint, affordances, and tools which intercede with activity. Activity theory provides a framework for designing CLEs. Authentic can also mean personally relevant or meaningful. Authentic for designers of CLEs means activity that engages the learner.

Learning environments are regarded as authentic when similarity exists between learning activity and some meaningful context for that activity. Authenticity is a relative term and varies according to the learner. Evaluating authenticity must include learners’ life-worlds and professional domains. Authenticity is not something that can be mandated by instructional designers, communities of practice or the desires of the learner. Authenticity is found in the learner alleged relationship between the preparation they are carrying out and the use and value of these practices. The “buy in” of the learner is critical to authenticity (Barab, Squire & Dueber, 2000, p.38).

At the center of activity theory is the idea that consciousness and activity are one. Activities are the human interactions with the objective world and the conscious mind is part of the interactions. Not only is activity a prerequisite for learning, but the learner is the central character defining learning activity. Activity and consciousness are mutually supportive and exist together. Consciousness is the unifying agent bringing attention, intention, memory, reasoning, and speech together. Vygotsky claimed “you are what you do” (Jonassen & Rohrer-Murphy, 1999, p. 65).

Intention is another principle of activity theory. Learners adjust and prepare activities. There is a goal orientation inherent in the proposed activity. Activity theory claims that knowing and doing are indivisible and initiated by intention. The basis for
this intention is the object of activity. By transforming the object of activity the learner moves closer to their goal. This transformed object is the motive for other activity. Just like technologies and delivery systems have affordances, objects have affordance for activity. A dynamic relationship exists between the object and the activity (Jonassen & Rohrer-Murphy, 1999).

Nearly all instructional design projects are a vigorous process. According to activity theory, learning intentions emerge from contradictions between what the learner needs to know to accomplish a goal and what they do actually know now. This reframes the development of CLE’s by instructional designers to include embedded tasks that target learner goals and intentions. Authentic has to mean more than just real world, it must include meaningful association between the instruction and application of these exercises. Problem-based-learning (PBL) is one example of framing instruction as the resolution of problems (Windschitl, 2002). Problem solving may offer a well conceived context to make experiences meaningful and memorable. Instructional designers must evaluate instructional solutions not only in terms of technological attributes, but also in terms of constructivist principles. Technologies can provide opportunities to solve complex problems in authentic and supportive environments. Designers must integrate the principles that support learning as an active process, which happens in context, is social and communal in nature and is reflective. Instructional designers must try to match the affordances of technologies with the affordances of objects for learning. Technologies can provide enormous opportunities for social connectivity and communities without the traditional limitations of setting. Instructional designers have the opportunity of creating objects for learning, that permit learners to manipulate resources and engage in ideas using attributes that are unique to
the technologies, but still focused on supporting learners in meeting their goals (Dricoll, 2002).

An intentional shift in the conceptualization of instruction away from teacher and lecture toward constructivism positions the instructional designer to approach design with the learner as the central component. The understanding that the learners approach instruction with prior knowledge and expectations based on their life-worlds supports designing environments that reach the individual learner where they are. Instead of trying to persuade learners that a learning environment approximates the real world, designers should try to create environments that present meaningful and authentic problems that have intrinsic meaning for the learners. Three possible frameworks are: the incorporation of collaborative learning, apprenticeships, and cognitive flexibility. Simplified scenarios that exist primarily in the courseroom reduce the potential for meaningful learning. When learners perceive problems as unrealistic and inapplicable to their lives, these principles are not being met. The challenge then for instructional designers is to use technologies to present critical learning factors supportive of constructivist pedagogy. The instruction should be presented in ways that are related as closely as possible the way the knowledge will be used (Petraglia, 1998, pp.53).

Cognitive Load

The physical environment and the online environment can create additional cognitive load issues for the learner. In the physical world, the use of telephones, social interactions, building acoustics and home office distractions can hinder the learner (Driscoll, 2002). The platform which can include the hardware of choice, learning management system, operating system and even the browser can contribute to the components that make up an e-learning environment (Vaughan, 2004).
There seems to be an overall consensus that for e-learning to be effective it is very important for the learner not to have to think about the technology. This just adds to the cognitive load and erodes learner confidence. The interface is what lies between the learner and the learning. The disciplines of usability and human factors have enhanced the science of interface design (Krug, 2000). Volumes have been written on the nuances of the interface but a few idiosyncrasies are worth mentioning because they so heavily impact learner cognition. The interface should be transparent, instructive, easy to interpret and understand, predictable, aesthetically pleasing, and supportive. The learners must be able to focus limited cognitive resources on the learning (Ambler, 2000).

The idea of cognitive load took form with the proposal of chunking which was first published by George Miller in 1956. This is a set of guidelines that indicates the cognitive system can only process seven plus or minus two items of information at one time. Once more items are introduced to the brain, thinking and learning processes shut down. Cognitive load theory is a universal set of guidelines that apply to all media, all learners, and all types of content (Clark, Nguyen & Sweller, 2005).

Some of the most promising research to date is in the area of cognitive load. Richard Mayer (2001) has developed a theory of multimedia learning and provides an approach to designing multimedia. “Meaningful learning outcomes depend on the cognitive activity of the learner during learning rather than on the learner’s behavioral activity during learning.” (Mayer, 2001, p. 1) The research conducted by Mayer focuses on the dual channel approach which limits the definition of cognition to verbal and pictorial channels in short term memory. The theory operates under the assumption that cognitive resources for each of these channels are limited and not necessarily equal.

Mayer believes that words and pictures can complement each other. Instructional
Multimedia and messages should be designed so that learners have the greatest chance for human understanding and that involves creating messages that integrate visual and verbal messages. Mayer presents three modes of producing multimedia: the delivery mode, the presentation mode and the sensory mode. The delivery mode puts the emphasis on the devices used to present the material rather than on the learner. The presentation mode assumes that the learner is separate from the presentation and relies heavily on Pavio’s dual coding theory. The sensory mode, which Mayer ascribes to, is learner centered and assumes that the individual learner, through the sensory receptors of that learner, processes incoming materials. This is learner centered because it takes into account learner differences (Mayer, 2000).

Another concept is that learning occurs by active processing in the memory system. New knowledge must go through short term memory and then be actively encoded to get into long term memory. The process of encoding the new knowledge is called rehearsal. Instructional methods that overload this short term or working memory make learning more difficult. The combination of information that must be held in working memory the new information, and prior knowledge make up cognitive load. Instructional designs that reduce cognitive load free short term memory and provide more capacity in memory for rehearsal and integration. Instruction should also take into account prior knowledge and context. The probability that retention and transfer will occur is increased if these hooks are added to the new information presented to the learner (Clark & Mayer, 2003).

*Learner Presence*

Learning is an individual, unique and personal accomplishment. No one can learn except the learner. Instructional designers and technologies can not do it for the learner.
In order for learning to occur, the learner must have an active cognitive presence. Perception, recall, analysis, information storage, rehearsal and application can only be done by the learner. In order for learning to take place learners must focus energy on learning. Motivation to learn comes from responding to assessed needs, opportunities and believed rewards (Allen, 2003). Motivation does not come from static observation. Levels of motivation are context sensitive and can be changed.

Interactivity is a way to engage the learner with the instructional materials. “Interactivity allows learners to act on their motivations” (Allen, 2003, 155). Not all interactivity is created equally. The complexity of the content can increase element interactivity. The structure and sequencing of the instruction or the instructional objective an also increase element interactivity. The degree of integration and coordination necessary from the content can be compounded and create an increase on cognitive load. Combining auditory and visual channels when presenting materials can accelerate learning by taking full advantage of available capacity in working memory (Clark et. al., 2005).

Interaction also takes on a broader meaning in instructional design. Bill Clancey a pioneer in constructivist application in the artificial intelligence (AI) community came up wit the concept that what people do is oriented in their interactions. How content is interpreted is itself an interaction and unpredictable. People do not interact in a linear fashion, the continually adjust and reinvent. This has implications for instructional designers. Clancey advocates that instructional designers become participant observers in the community of practice and use ethnographic methods to observe and reflect on the situation. This also has implications for participatory design where the learners actually participate in the redesign process with the designer (Wilson & Meyer, 2001).
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Content and Context

Learners can make meaning out of learning if the content is situated in context (Berge, 2002). Situated Cognition is a theory that implies that learning and thinking take place only in situated context. There is no learning or thinking with an accompanying situation. Context then becomes an integral part of the learning experience. It becomes critical to design learning environments that support the tacit conveyance of knowledge. Because the learner is the one who makes sense out of the material it is nearly impossible to systematically convey knowledge in the way behaviorist principles expounded. Situated cognition can and should be both prescriptive and a deceptive approach to context. Applying situated cognition to real world designs involves applying the constraints and affordance of learning environments to specific situations (Wilson & Meyers, 2000).

Future Trends

Strategy for Developing Effective Multimedia

A strategy for creating effective multimedia instruction must be based on the evidence of how people learn. Unfortunately, designing instruction that is cognitively effective for the learner is not always intuitive. Evaluating the current research based literature is a good place to begin. A realization that the field of multimedia e-learning is and will continue to grow and more and new and perhaps contradictory findings will emerge is also paramount. This strategy takes into account the complexity of the undertaking and recommends an approach based on high-quality research (Allen 2003). Opportunities exist through the analysis, design, development, implantation and evaluation phases of instructional design to apply the knowledge currently available. The
Multimedia and 25 strategic significance must be to create effective instructional environments by taking into account human cognitive processes.

Cognitive load theory is universal so it can support all aspects of multimedia design. It applies to all content and in all contexts and is relative regardless of what combination of text, audio, video, graphics or which delivery technologies are used. It applies to face to face instruction as well as e-learning. It applies to all learners and all instruction and instructors. Evidence based research provides a set of guidelines and principles to be applied with care. Learner similarities and differences must always be considered in conjunction with the learning goals and objectives. A strategy for creating effective multimedia learning must also support creating a learning environment that minimizes wasted mental resources and uses cognitive resources in ways to maximize learning (Clark et. al., 2005).

Supportive Learning Environments

Learner centered designs for multimedia learning environments are created by incorporating cognitive learning theory, utilizing results of empirical research and applying these to a learning situation. This begins by creating multimedia messages that are grounded in how the human mind works.

Messages that are grounded in cognitive methods observe some if not all of the principles of multimedia. The principle of multimedia explains that learners learn better from words and pictures than just words. Observance of the principles of dual processing and limited cognition in concurrence with active processing set the foundations for constructing multimedia messages. Choosing relevant text, organizing words in coherent representation, select relevant visual images, organize the visual images in a coherent representation, and integrating verbal and visual images where possible. Adhering to the
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principle that the processing of spoken verbal information is processed in the auditory channel, pictures are processed in the visual channel, but written words are processes in the visual channel and then the auditory channel. Written words create more load than either pictures or spoken words. By combining words and pictures, and using both channels, learners are presented with an environment that accelerates expertise.

(Mayer, 2001)

The type of cognitive load can influence the effectiveness of multimedia instruction. Interpreting the literature suggests that to create an effective learning environment ineffective forms of cognitive load should be minimized and the helpful forms maximized. Cognitive load comes in three varieties; intrinsic, germane, and extraneous.

Intrinsic load is imposed by the complexity of the content. Intrinsic load is determined by the information and expertise associated with the instructional goals. Germane load is mental work imposed by the instructions to meet the instructional goal and extraneous load is irrelevant and a waste of mental resources. These are accumulative and specific to individual learner and learning goals and objectives. Developing well defined objectives that meet learner needs and organizational goals is critical to managing intrinsic load. Situating the learning in a context supportive of the learner and measuring prior knowledge can support manageable intrinsic load.

Germane load can be managed by a variety of examples to support near transfer and far transfer. Near transfer is the ability of the learner to apply the learning in this situation and the far transfer is the ability of the learner to apply the learning in different settings. Self explanation can help the learners understand the underlying principles and
Multimedia and form basic models and schema. Teaching the learners through rehearsal and metal modeling are also recommended, depending on the situation.

Extraneous cognitive load should be eliminated as much as possible because it is irrelevant to the learning goals and wastes valuable mental capacity. A recommendation to eliminate redundancy in content and extraneous visual, text and audio can minimize extraneous load. To present an environment that is supportive of learning instructional materials should concentrate on the essentials of content and eliminate redundancy in delivery modes (Clark et al., 2005).

Supportive learning environments engage learners in the construction of knowledge and provide the individual with activities that support relevant knowledge in a context that promotes understanding and remembering. This provides an environment where collaboration, activities and reflection combined with feedback and context allow the learner to make meaning out of the content (Berge, 2002).

Active Cognitive Engagement

Active cognitive engagement though is not the same as interactivity. Interactivity is critical component of training and learning. Active cognitive activity though can come in several forms including active, interactive, and reflective e-learning. Active e-learning is designed to be encouraging and directive. Active learning is learner controlled and encourages higher order thinking and exploration. It involves students in original projects and invites inquiry. Interactions with the instructional materials, learners and instructors are an essential part of learning activities in a learner centered environment. Vygotsky theorized that a great deal of learning takes place in a social environment and interactions among people can spark that learning. Active cognition though can also take
place in the learners head. Reflection is often overlooked but one of the most valuable form of cognitive engagement to facilitate transfer and retention (Berge, 2002).

Conclusion

A strategy for developing effective multimedia instruction should be based on research and empirical evidence of how people learn. Yet instructional design is both an art and a science. Without the finding of research guiding instructional design, multimedia learning products run the risk of being unusual and entertaining but not effective. An instructional design strategy for incorporating multimedia at a minimum should embrace; recognizing of learner differences, creating good multimedia messages, managing cognitive load, providing opportunities for active cognition, and monitor learner engagement.

Constructivism is a learner centered approach to learning that focuses on creating supportive learning environments. This is not a single theory but rather a conglomeration of ideas inherent in psychology, instructional technologies, and science. This paradigm is revolutionary in its departure from traditional educational belief. Constructivism makes the learner an active participant in the learning process. This is a dramatic departure from a vision of learning as the transfer of knowledge. Re-conceptualizing learning as an active process has come about at the same time as advances in cognitive sciences and technologies. Understanding how learners learn and how to create supportive environments where learning can occur supports authentic and active instruction.

Constructivist learning environments support activities and interactions that adapt to and engage the learner. Using situated cognition incorporates the idea of activity and context with learning. Incorporating activity theory supports the creation of constructivist
Multimedia and learning environments. It philosophically focuses on the interaction of the human mind and human activity in a relevant environment. Activities are ways that learners interact with the outside world and cognition is part of the interaction. A relevant environment is one that supports the learner in achieving their learning goals. The challenge for instructional designers is to position multimedia in an environment that supports the realization of meaningful learning.

Multimedia should be engaging and not boring for the learner. Effective multimedia instruction must provide the learner with a supportive environment that facilitates retention and transfer of the content. This requires incorporating different learning activities for different types of learners. It also necessitates creating instruction that is grounded in cognitive methods and observes some, if not all, of the principles of multimedia. The principles of multimedia say that mental capacity is limited and that using pictures and words to represent material is a more efficient use of the dual channels in working memory. Good multimedia messages do not require the learner to over think or under think but present the appropriate information in just the right way. Cognitive load can also be managed and extraneous cognitive load should be eliminated because it is irrelevant to learning goals and wastes valuable mental resources. Instructional designers must also build into the environment ways for learners to monitor their intentions and progress. Opportunities for learners to participate in active cognition also enhance the learning environment. Multimedia developed for learner engagement should include active, interactive and reflective e-learning.
References


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Terms and Definitions

*Activity Theory.* This focuses on the interaction of human activity and the human mind in a relevant environmental context. In activity theory there is no separating the activity from the context (Jonassen & Rohrer-Murphy, 1999).

*Behaviorism.* This learning theory considers learning to be a change in observable behavior that results from an experience and lasts over time. Based on B. F. Skinner’s concept that behavior changes because of contiguity or the pairing of stimuli, insights, goals, ideas, and any other change that exists only in the learner’s mind are not considered (Eggen & Kauchak, 1999).

*Cognitivism* is not an uncomplicated or solitary paradigm. Cognitive science is at the root of cognitivism. Learning takes place in cognitivism when a learner processes information that comes from the outside world by building a mental construct of the information. Cognitive science is study of how the mind works. More broadly it can be defined as a multidisciplinary and study of the human mind and behavior (Boring, 2003).

*Constructivism.* This theory says that knowledge comes through an individual’s internalization of events that happen in the outside world. Constructing knowledge is the learners’ attempt to make sense out of their world by interacting with it. Learners are not “empty vessels to be filled” but rather take an active part in the learning process (Driscoll, 2000, p.376).

*Constructivist Learning Environment (CLE)* Constructivist learning environments are learner centered places where knowledge is constructed by each learner rather than transmitted from a teacher or instruction (Wilson, 1996).

*e-Learning.* This is instruction that is designed for and delivered on a computer system is classified as e-learning. Effective e-learning is learning that facilitates transfer and retention of content to the learner and meets the learners learning goals. In good e-learning understanding or knowledge is enhanced, behavior changes, processes are improved or some other function gets better (Allen, 2003).

*Humanism.* This theory which originated in the mid 1950’s has had resurgence because of the emphasis on learner growth and potential. It emphasizes that learning and thinking are driven by a desire to be a complete and fulfilled human being capable of making decisions and positively affecting others. Humanistic views of motivation believe that learners seek gratifying experiences (Eggen & Kauchak, 1999).

*Instructional Systems Design (ISD.)* ISD consists of a systematic approach to creating e-learning through the process of analyzing, designing, developing, implementing and evaluating a learning solution (Clark, 2002).
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*Multimedia.* This can be defined as the combination of pictures and word. Interactive multimedia is the combinations of audio, video, text graphics, and animations that are used to deliver the e-learning (Mayer, 2001).

*Situated Cognition.* This idea says knowledge is developed and used in part by being situated in interactions human beings have with activity, context and culture (Brown, Collins & Duguid, 1989).
Keywords

Instructional design, multimedia, constructivist learning environment, cognitive load, activity theory, situated cognition, active cognitive engagement, constructivism, cognitive science, learner presence, learner engagement, learner differences, e-learning environments, authentic activities, active cognition, interactive multimedia, instructional methods, e-learning, cognitivism, learning by doing.