

# **Past Technologies, Practice and Applications: A Discussion on How the Major Developments in Instructional Technology in the 20<sup>th</sup> Century Affect the Following Qualities – Access, Efficiency, Effectiveness, and Humaneness**

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## **Introduction**

The Association for Educational Communications and Technology defines Instructional Technology as the “theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning” (Seels & Richley, 1994). From the above definition, it can be seen that Instructional Technology can be considered in terms of the use of media (or resources) and the use of “systematic instructional design procedures” (Reiser, 2002, p. 28) that includes the processes such as design, development, utilization, management, and evaluation. For the purpose of this article, I shall refer the latter to *instructional design* for instructional purposes. I summarize the history of Instructional Technology in the 20<sup>th</sup> century using these two qualities – media and instructional design. Also included in this article is a discussion on how these two qualities affect the following four qualities of instructional technology: access, efficiency, effectiveness, and humaneness.

## **History of Media Developments in Instructional Technology**

According to Clark (1996), there are five possible perspectives on media: (a) media as machines, (b) media as tutors, (c) media as socializing agents, (d) media as motivators for learning, and (e) media as mental tools for thinking and problem solving. For the purpose of this article, the first perspective is taken. Drawing upon Dale’s (1969) and Reiser’s (2002) work, I have classified the history of media in Instructional Technology into the following six main periods – Silent visual media, Audiovisual materials, Instructional television, Personal computers, Internet, and wireless tools.

### **Silent Visual Media**

Media developments in instructional technology essentially began with silent visual media that were housed in school museums (Saettler, 1990). These silent media includes stereographs, slides, study prints, charts, and photographs (Saettler, 1968; Dale, 1969). With the advent of the motion picture projector, silent visual instructional films soon appeared in the educational landscape. In 1910, the public school system of Rochester, NY, became the first to adopt silent instructional films for instructional purposes (Reiser, 2002). That same year also saw the publication of the first catalog of instructional films (Reiser, 2001).

### **Audiovisual Materials**

With the advent of media incorporating sound, the silent visual era soon gave way to what is known as the audiovisual instruction movement. As a result, sound incorporated motion pictures became a reality, which led to increased interest in the use of media to enhance learning. Dale (1969), for example, summarized twelve benefits of motion pictures, which include the ability to create reality or reveal the invisibility, compel attention, and promote an understanding of abstract relationships.

In the 1920s, the radio was invented, and soon it was used in carrying on various types of educational activities. Some of its characteristics that made it educationally valuable were its low cost, its ability to bring dramatic feeling into the classroom, and the fact that listening can foster imagination on the part of the listener (Dale, 1969).

### **Instructional Television**

The advent of television soon followed in the 1950s. There was much interest in the use of instructional television then, so much so that by 1955, there were 17 instructional television channels in the U.S., and by 1960, had increased to more than 50 (Blakey, 1979). Distinguishing between the terms “educational television” and “instructional television”, Dale highlighted some major characteristics of the latter:

(a) instructor-guided, (b) systematic with objectives of the course and planned learning experiences, (c) ordered and sequential, and (d) integrated to other learning experiences such as practice, reading, laboratory, and writing. Central to the great interest in the use of instructional television was the belief that this particular medium has the potential to bring demonstrations to the classroom, handles films and other changes from straight classroom presentation with a minimum of transitional difficulty, concentrates attention, and provides a change of pace, often a lift, for the classroom (Schramm cited in Da le, 1969, p. 356).

The interest, however, did not prevail long and by mid-1960s it had abated (Reiser, 2001) due to reasons such as the inability of television alone to adequately present the various conditions necessary for student learning (Tyler, 1975).

### **Personal Computers**

The next media to grab the attention of educators was the personal computer in the 1980s. The use of personal computers for instructional purposes has since increased and by 2003, virtually all U.S. schools have some personal computers and the most recent ratio of students to computers was fewer than four to one (Market Data Retrieval, 2003).

### **Internet**

The explosion of the Internet and world-wide web (WWW) soon followed in the wake of the advent of personal computers. In 1991, Tim Berners-Lee completed the original software for the WWW, the hypertext system he had first proposed in 1989. He had envisioned the WWW as a shared information space, a web of hypertext documents, within which people can communicate with each other and with computers (Moschovitis, Poole, Schuyler, & Senft, 1999). The use of the Internet and WWW is now ubiquitous, with 98% of U.S public schools already connected to the Internet in Fall 2001 (Cattagni & Farris, 2001). The student-per-Internet-connected computer ratio was now 4.3:1 (Education Week, cited in Molenda & Bichelmeyer, in press).

### **Wireless Tools**

Currently, the use of wireless tools such as pocket PCs or personal digital assistants (PDA) is increasingly widespread within K-12 and higher education. According to Park and Staresina (2004), about 8% of schools nationwide provide PDAs for their teachers and 4% provide them for their students. For teachers, the PDAs are useful for lesson preparation and classroom management, such as taking attendance. For students, the PDAs are used as digital readers and graphing calculators, for word processing, and other specific instructional activities such as concept mapping (ISTE, cited in Molenda & Bichelmeyer, in press).

## **Effects of the Major Media Developments on Access, Efficiency, Effectiveness and Humaneness**

One very interesting recurrent pattern can be seen throughout the development of media for instructional purposes, which is the comparison between the anticipated and real effect of media on instructional practices (Reiser, 2001). From Thomas Edison's 1913 famous prediction that films will replace every other media, or the advent of computer instructional programs to the hype created every time a new instructional media is discovered, expectations have been usually greater than outcomes. Many of the media research studies show that students learn equally and effectively well regardless of the types of media used (Clark, 1994; Russell, 1999), leading some researchers to believe that it is the instructional methods rather than media that can influence the effectiveness of student learning (Clark, 1994).

It seems then that the effects of media *per se* on instructional technology are geared more towards the access, efficiency, and humaneness rather than the effectiveness aspect. Media helps increase access to learning by giving students opportunities that never existed before. The use of the Internet and teleconferencing, for example, enables students to sign up for courses from virtually all sorts of geographical locations. Students from far-flung, hard-to-reach places can now have easy access to learning. So do students who have physical disabilities that rendered them immobile.

Closely related to the idea of access is efficiency, which can include concepts such as cost efficiency, time efficiency, energy efficiency, and "delivery-of-information" efficiency. The use of the Internet is a good example of "delivery-of-information" efficiency because information can now be easily structured and presented to many learners at one time. It is also cost efficient to design and develop courses over the Internet because as the number of students taking an online course increased, the development costs were spread across a large student body, making the development cost per student low (Shearer, 2003). Meanwhile, the use of

management tools such as WebCT, and BlackBoard allows instructors a greater degree of flexibility and ease in terms of updating and revising courses (Shearer, 2003). This has brought about time and energy efficiency for the instructors.

The development of certain media has also improved the humaneness aspect by providing rich sensory experiences and individualized learning to students. Television and computers, for example, provide students with vivid three-dimensional images that may help them remember information better, than printed materials can.

### Major Instructional Design Developments in Instructional Technology

Besides the major media developments, there were also major instructional design developments that shaped the field of instructional technology. Many authors have classified these instructional design developments into various categories; these have typically been done in more or less a chronological fashion (e.g. Reiser, 2001, 2002). In this article, however, I chose to succinctly divide the periods of instructional design developments in terms of its design paradigms, ontological, and epistemological perspectives drawing mainly upon the work of Wilson (1997, 2004), Driscoll (2000), and Mertens (1998); yielding the following three categories – (a) behaviorist paradigm, (b) conditions-of-learning paradigm, and (c) constructivist paradigm. I decided to do this because I felt that such a move would better capture the real essence of instructional design developments compared to a chronological method *per se*. Table 1 shows these paradigms as well as the ontological and epistemological perspectives associated with them.

Design paradigm	Ontological perspective	Epistemological perspective
Behaviorist paradigm	Positivism	Objectivism
Conditions-of-learning paradigm	Positivism	Objectivism
Constructivism	Interpretivism and sometimes Postmodernism	Contextualism/situated knowledge

Table 1. *Design paradigm, ontological and epistemological perspectives*

#### Behaviorist paradigm

One of the major concepts that appeared in the 1910s was the claim by John Watson that human and animal behaviors were the *only* legitimate areas of study for psychologists. This signaled the birth of behaviorism as an approach to psychology and learning that emphasizes observable and measurable behavior but ignores mental processes. Watson’s idea was in essence a “descriptive S-R psychology whose goal was to predict and/or control behavior” (Saettler, 1990, p. 287). Edward Thorndike soon followed with his theory of connectionism, which is a descriptive learning theory made up of three laws – the law of effect, the law of exercise, and the law of readiness. These laws are founded on the stimulus-response notion – “a neutral bond would be established between the stimulus and the response when a particular stimulus produced a satisfying response with a given environment” (Saettler, 1990, p. 55). Learning takes place when these bonds formed into patterns of behavior. Building on Thorndike’s and Watson’s ideas, B. F. Skinner came up with the theory of operant conditioning, which basically states that “if the occurrence of an operant is followed by presentation of a reinforcing stimulus, the strength probability is increased” (Saettler, 1990, p. 71). This led to a science of instruction with systematic methods of modifying behaviors, and determining the types of response patterns associated with different reinforcement schedules (Ferster & Skinner, 1957).

Central to the behaviorist paradigm is the notion of using experimental approaches in the study of learning. The works of Hermann Ebbinghaus Edward Thorndike, and Ivan Pavlov, for instance, bore testimony to it. This notion of using experimental approaches as a method of study resonates with the positivist ontological perspective. According to Mertens (1998), the underlying assumptions of positivism include the belief that the social world can be analyzed in the same way as the natural way, that there is a technique for studying the social world which is value-free, and that explanations of a causal nature can be given. In positivist thinking, objectivity is important, whereby the researcher simply manipulates and observes in a dispassionate manner.

#### Conditions-of-learning paradigm

B. F. Skinner’s behaviorism work on contingencies of reinforcement and programmed instruction was the antecedent to the next paradigm- the conditions-of-learning. As noted clearly by Wilson (2004):

In the days of programmed instruction, researchers held to a few general principles of learning, based on behavioral psychology, which were thought to apply universally to all settings and

organisms. Results of programmed instruction, however, showed that some strategies worked better than others, depending on conditions. This led Lumsdaine (cited in Wilson, 2004) and others to articulate a vision for an emerging science of instruction: through factorial experiments, instructional scientists would develop a sophisticated series of rules, sub-rules, and meta-rules for employing instructional strategies to teach different kinds of content in different settings.

The belief that certain strategies would be more appropriate for certain context led to the notion of the conditions-of-learning paradigm. In essence, this paradigm posits that there exists a hierarchy of learning outcomes, and for each desired outcome, there exists a set of conditions which leads to learning (Wilson, 1997). Some of the noted authors and thinkers of this paradigm include Benjamin Bloom (who developed the taxonomy of educational objectives for the cognitive domain), Robert Gagne (who introduced five domains of learning and the conditions necessary for each of them, as well as the nine events of instruction to promote the attainment of any type of learning outcome), and Charles Reigeluth (who discussed the various conditions in his Green books).

In addition to the belief of a rule set that links conditions, instructional methods, and learning outcomes, there were two other important ideas that emerged during this paradigm: (a) the systems approach in instructional design, and (b) the cognitive information-processing theory. In the systems approach, the design of instruction is divided into small manageable components or procedures, where the output of one procedure becomes the input of the next one. A good example would be the ADDIE systems approach which is made up of five procedures: Analysis, Design, Development, Implementation, and Evaluation. The design of instruction proceeds more or less in a linear fashion, beginning with the Analysis phase, and ending with Evaluation. The burgeoning interest in the systems approach spawned many instructional design models (e.g. the Dick & Carey's, 1978), as well as methodologies and concepts (e.g. Mager's 1962 behavioral objectives, Glaser's 1963 criterion-referenced testing, and Scriven's 1967 formative evaluation).

The second important emerging idea in this paradigm was the cognitive information-processing theory which posits that information is transformed as it passes through three main stages of memory: sensory memory, short-term memory, and long-term memory (Atkinson & Shiffrin, 1968). As this idea gained acceptance and popularity, many researchers began to incorporate it in their studies. One of the most notable works based on the cognitive information-processing theory is the nine events of instruction, developed by Robert Gagne.

The conditions-of-learning paradigm also appeared to resonate with the positivist ontological perspective. This is because many researchers in this period still used the experimental design as the main research tool in trying to isolate instructional methods most appropriate for certain contexts. As noted by Driscoll (2000), both Skinnerian Behaviorism, and Gagne's instructional theory rest on objectivist assumptions.

### **Constructivist paradigm**

Constructivism, which states that learning is a process of knowledge construction, rather than acquisition, began to rise in prominence beginning in the early 90s. Duffy and Cunningham (1996) postulated that some of the assumptions that are adopted by constructivists include the following: (1) all knowledge is constructed (i.e., learners construct understanding of the world for themselves (Winn, 2003)), (2) many world views can be constructed, hence there will be multiple perspectives, (3) knowledge is context dependent, thus learning should occur in contexts to which it is relevant, (4) learning is mediated by tools and signs, (5) learning is an inherently social-dialogical activity, (6) learners are distributed, multidimensional participants in a socio-cultural process, and (7) knowing how we know (reflexivity) is the ultimate human accomplishment.

In contrast to the previous conditions-of-learning paradigm which is based on a reductionist view (e.g. the use of task analysis to decompose a subject into various sub-subjects according to its learning outcomes; then instruction is ordered from simple to complex), the constructivist paradigm celebrates complex, authentic tasks that are not broken into smaller components. It emphasizes the creation of rich learning environments and the use of scaffolding to help learners gain the knowledge and skills of a practitioner.

The constructivist paradigm is most aligned with the interpretive ontological perspective. According to Mertens (1998), the basic assumptions guiding the interpretive ontological position are that knowledge is socially constructed by people, and that perceptions of reality may change throughout the process of study. It rejects the notion of objectivism. Constructivism is also consistent with the postmodern perspective. Although I agree with Wilson's (1997) observation that not all constructivists are postmodern in their orientation, I would, however, argue that *most* of the concepts of constructivism appear to be founded on the key ideas of postmodernism. For example, postmodernism posits that knowledge is constructed by people, reality is multiperspectival, and thinking is an interpretive act (Wilson, 1997). These key ideas are congruent with

those held by constructivists.

### **Effects of the Major Instructional Design Paradigms on Access, Efficiency, Effectiveness and Humaneness**

I believe the developments of the major instructional design paradigms primarily influenced the effectiveness and humaneness aspects of instructional technology. For example, design concepts based on the behaviorist, conditions-of-learning, and constructivism paradigms all strive to improve the effectiveness of instruction, with each camp advocating its own advantages, sometimes to unproductive arguments. Nonetheless, there has been a consensus in recent years among educators that the design concepts based on different paradigm each has its own place and value best effective for certain types of learning outcomes such as:

For *discrimination* (recalling facts), *generalizations* (defining and illustrating concepts), *associations* (applying explanations), and *chaining* (automatically performing a specified procedure) types of learning outcome, design concepts based on the behaviorist paradigm would be a good choice (Ertmer & Newby, 1993).

For *advanced knowledge acquisition* and *problem-solving in ill-structured domains* types of learning, design concepts based on the constructivist paradigm would work best (Jonassen, 1991).

However, in terms of humane benefits, there are certain design concepts that lend themselves better than others in providing rich authentic experiences. Design concepts associated with constructivist paradigm, which require learners to solve realistic problems, and take ownership of the learning process (Driscoll, 2000), is a good example.

### **Summary**

There have been many developments both in the media and design process aspects of instructional technology in the 20<sup>th</sup> century. These have in turn affected each of the four instructional technology qualities: access, efficiency, effectiveness, and humaneness. The developments of film, radio, television, and computers in the have each increased the access, efficiency, and humaneness aspects. I believe that media *per se*, however, do not directly affect the effectiveness of learning because it is the method or process that determines it. Design concepts such as behaviorist paradigm, conditions of learning, as well as constructivism, have also affected the effectiveness and humaneness of instructional technology through the provision of rich experiences and individualized learning for students.

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