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ICT as an Enabler for Effective Learning Design: Its Evolving Promise

Barbara Grabowski
Instructional Systems Program
Pennsylvania State University, USA
bgrabowski@psu.edu

ICT innovations bring to learning designers optimism and disappointment. This cyclical reaction to innovation follows designer evaluations of how the promise of better learning is fulfilled. This paper argues, through three observed periods of intertwined paradigm shifts in learning theory with the evolution of technology, that first, technological advances for learning were initially promising but failed because their affordances could not fully engage learners in a manner that matched the way learning actually occurs. Second, technology and learning theories were not wrong; they were just incomplete, and third, perhaps both may now be in harmony to enable effective learning design.

Keywords: Technology, Learning Theory, Behaviorism, Cognitivism, Constructivism, Multimedia, Social Web

Introduction

Life perspectives, processes and social interactions change with new innovation. As ICT evolves, one can envision a pattern of optimism to disappointment with each advancement in innovative —even as we reflect back on life at the time when pencil and paper were innovations for monks. With the innovation, they transformed the events of learning from being verbal transmissions to the study of captured and stored knowledge. It is possible to speculate about the optimism being brought about by being able to have permanency, replicability and greater diffusion of "the Word." But, it is also possible that there was a concern about misinterpretation of "the Word" by the untrained and unmonitored; transmission being the learning design applied in that day. Optimism could have been replaced with disillusionment and disappointment in the innovation, until a new vision of learning or innovation was brought forth.

The ebb and flow of this cycle of optimism to disappointment has been observed in two areas of innovation for instructional designers – that of technology innovation and that of evolving theories of learning. Three such periods have been observed. It is important to note that this case is presented from a observational approach over the three periods. It is written from the perspective of a participant instructional designer in a forty year learning-technology

evolutionary cycle, observing the optimism of promise and disappointment from disillusionment caused by promises unfulfilled, on into our latest period, perhaps, a period of understanding and satisfaction. The concurrent cycles flow from behaviorism to social constructivism, evolving concurrently with presentation media such as instructional television to Web 2.0, the social medium. The evolution of both innovations was disharmonious so that the disappointment of unfulfilled promises pushed advances in the other.

The Cycles Explained

At each innovation's debut, learning designers focused on features that promised potential for learning in ways that were more aligned with existing understanding of how people learn. In each cycle, the optimism came from features that were new or more refined than in previous generations of the innovation. But, naturally, as our understanding of learning became clearer and more precise, designers discovered inadequate or missing features that were important to afford learning. As our understanding of learning theory went up and became more developed, the less satisfied designers were with its current technology. The dissatisfaction with technology pushed scientists to further refine and develop new technology. With further refined and new technology, more features to enable learning were created, causing dissatisfaction with current explanations of learning theory. And so the cycles continued. The evolutionary cycles for both technology and understanding about learning have followed this pattern, characterized as overlapping, yet disharmonious sine waves. See Figure 1. More developed understanding about how learning occurs stimulates disappointment in existing technological innovation. In turn, technology develops to enable fuller implementation of features necessary for learning, until, of course, we learn more about learning. In between each of the overlapping sine waves, there is a period of satisfaction, when we believe that technological capability matches needed designs for learning.

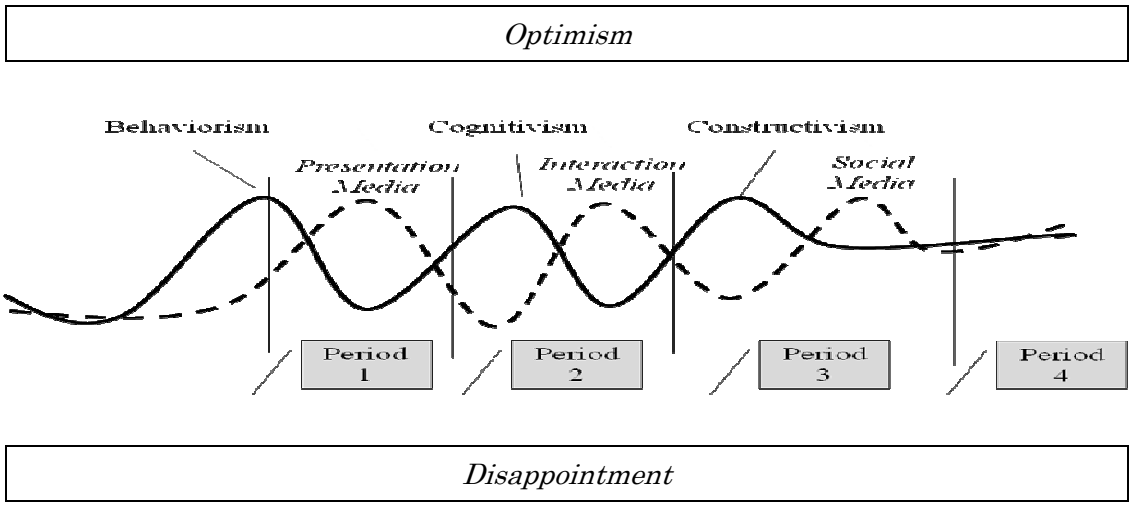

Figure 1. *Learning theory-technology cycle of optimism and disappointment*

Was the disappointment in and disillusion with the technology caused by discovering it as being inappropriate or just not evolved enough? Was this disappointment about what we wished the technology could do prompted by new understandings about how learning occurs? The answers to these questions form two foundational premises to explain the advances and failures of technology and learning theory over the years. First, technological advances for learning were initially promising but failed because their affordances could not fully engage learners in a manner that matched the way learning actually occurs. Second, technology and learning theories were not wrong; they were just incomplete.

Three cycles were observed over this period: Period 1: Behaviorism and the Age of Presentation Media, Period 2: Cognitivism and the Age of Interaction Media, and Period 3: Constructivism and the Age of the Social Media. We are currently in Period 4. Is it the Age of Understanding and Satisfaction?

Period 1: Behaviorism and the Age of the Presentation Media

In the first period, Behaviorism was very prominent in influencing the design of instruction. Fundamental principles included beliefs that designing stimulus material to elicit correct responses was one of the two most important tasks an instructional designer could do. Design of corrective feedback was the second. At the same time behaviorism was evolving, advances in technology brought many new features for visualization. This was a perfect match for learning theory whose focus began with the stimulus. Technological advances expanded the capabilities of how information could be displayed. Technology had emerged from static images and text to one that could display many different types of discriminative stimuli, including color, motion, realistic pictures, graphics, sound, at the same time and in the same medium. Scientists were developing new ways of displaying sound, images, and motion emerging into instructional television, slideshows, film, text and workbooks as the media of the age. Research showed very positive effects of a stimulus response feedback learning cycle (see Figure 2) using behavioristic methods such as programmed instruction. Research at the time was also dominated by investigations of the effects of discriminative stimuli. Designers were optimistic about the potential for using these technologies for learning from designs that were patterned after the principles of behaviorism.

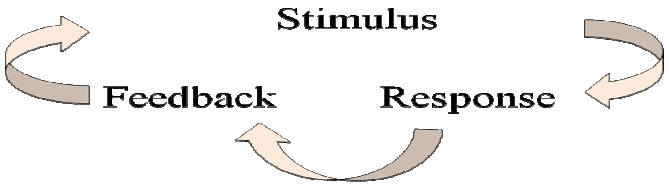

Figure 2. *Learning cycle from Behaviorism*

Teaching methods were marked by lecture, either in a face to face mode or by instructional television, with lots of use of film, slideshows, film loops, and workbooks. Programmed instructional workbooks were also indicative of the period.

A summary of the events of this period from characteristics of learning theory and technology, examples of media and method, along with sources of optimism and disappointments are shown in Table 1.

Table 1. *Table of Learning Theory and Technology Innovation for Period 1*

<table>
<tr><td>Behaviorism:

Explained learning from a stimulus-response-feedback learning cycle

Concern for learning was focused on overt evidence of such learning</td><td>Presentation Media:

Advances in presentation stimulus material displayed via multimedia enables designers to select discriminative stimuli inherent in the learning target.

Designers were concerned with visualization and asked questions regarding color, motion, realism, that is the physical form of the messages.</td></tr>
<tr><td colspan="2">Example Media: Instructional Television, slideshows, film, text, printed materials, early versions of computers
Example Teaching Methods: Lecture, Programmed Instruction, very early renditions of “Tutorials”</td></tr>
<tr><td>The Case for Optimism:

New technology affordances for affecting learning

• Stimulus: The options for mediating a message seemed complete
• Response: The option for students to click a key to advance instruction, or control the medium
• Feedback: being enabled in workbooks, and initially Correct and Incorrect answer feedback in new computer tutorials seemed exciting as compared to not being able to do this before</td><td>Disappointments – the missing elements

• Stimulus: Minimal disappointment, except that students could not directly engage with the visuals themselves
• Response: Technology was “minds-off” and potentially passive
• Response: Opportunities for responses were limited with the current technology
• Feedback: Feedback loop was superficial to nearly impossible without an instructor present</td></tr>
</table>

Learning outcomes, however, were not being fully explained by this paradigm. Behaviorism began to fall out of favor in the design community, while the development of Presentation media continued to advance at a rapid pace. Disillusionment with behaviorism prompted learning theorists to develop new ideas about learning processes, bringing optimism about new ways of designing instruction. Following these new ideas came disappointment in current presentation media as being too limited. As an example, we were excited about the possibility of presenting information in computer based instruction consistent with the tenets of behaviorism, but we were soon disappointed that the level of interaction was superficial, technologically and theoretically.

Was the disappointment in and disillusion with presentation media and behaviorism caused by

discovering it as being inappropriate or just not evolved enough? Was this disillusionment about what we wished the technology could do prompted by new understandings about how learning occurs? My conclusion is that the ability to display a variety of types of media for learning afforded excellent opportunities to visualize and mediate information, guided by Dale's Cone of Experience. But they failed to engage learners fully in a manner that matched the way they actually learn. Behaviorism had the formula correct for stimulus response feedback learning cycle, but technology was not able to provide adequate feedback efficiently. Technology and learning theories were not wrong; they were just incomplete. We add on to our understanding of learning in a stimulus response phase and the affordances of presentation media in the next period.

Period 2: Cognitivism and the Age of Interactive Media

In the second period, disappointment in Behaviorism was yielding to optimistic focus on thinking, and information processing. Cognitivism attempted to explain the mental processes that were internal to the learner, and prompted learning designers to focus on the inductive processes of messages not just the physical form of the messages (Grabowski, 1991). It was not enough that learner attention was gained by the design of the features of the messages; it needed to be sustained by engaging thinking that was stimulated by the message. Research then attended to strategies that promoted thinking in ways that matched organization, conceptualization, and transformation of information in the mind. Generating one's own understanding was important. Overt manipulation of material was recommended to assist in this process to help learners generate their own understanding. The learning cycle proposed in behaviorism was similar, but the focus was different. Stimulus material was still needed, but it was created to stimulate thinking, and then response, followed by feedback. See Figure 3. Concern was also placed on making learning relevant, motivating and prompting reflection.

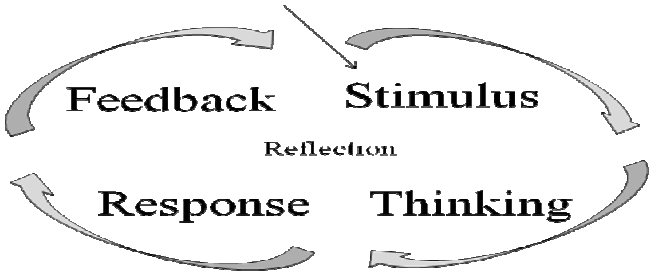

Figure 3. *Learning cycle from Cognitivism*

As Cognitivism was developing as an accepted theory of learning, advances in technology brought many new features for interaction, countering the problems in the Age of Presentation Media. Interactive media included computers and computer-based interactive video, and the Internet. Stimulus affordances available through the advances in technology from the previous age were combined with affordances for learners to interact with materials through graphic manipulations, and receive more targeted feedback from intelligent inference engines. Information sources of content material were rich and vast with the advent of the Internet in its first rendition – Web 1.0. With this technology, too, came a rudimentary, yet new, means for

interacting with others, thereby enabling alternative ways of receiving feedback through email and chat that was more directly related to the task, and at a higher level of specificity and tailoring.

Table 2 describes this period from its emergence from The Period of Behaviorism and the Age of the Presentation Media, to new developments in learning theory and technology. The table concludes with a summary of the sources for optimism and of disappointment in this Period of Cognitivism and the Age of Interactive Media.

While Interactive Media was still winning optimism in learning designers, learning theorists were beginning to realize that the way learning was characterized was problematic, and many became skeptical of the tenets of Cognitivism. It was not as completely dismissed as the previous phase of Behaviorism; however, a new cycle describing how knowledge was constructed was imminent.

Was the disappointment in and disillusion with interactive media and cognitivism caused by discovering that they were inappropriate or just not evolved enough? Was this disillusionment about what we wished the technology could do prompted by new understandings about how learning occurs? My conclusion is that the ability to display a variety of types of media for learning afforded learning designs that visualized and mediated information. These affordances combined with a better understanding of how to engage learners mentally prompted learning designers to provide opportunities for the learner to interact with the medium. But they still failed to engage learners fully in a manner that matched the way they actually learn. Cognitivism had the formula correct for addressing the thinking processes, but technology would not allow for synchronous or asynchronous opportunities to collaborate with others in the construction of new knowledge as we were discovering was necessary. Technology and learning theories were not wrong; they were just incomplete. In the next period, we add on to our understanding of stimulus creation, engagement of thinking with an information rich, individual medium. This led to the last period, the Period of Constructivism and the Social Media.

Period 3: Social Constructivism and the Age of the Social Media

Period 3 began with many ideas that were learned from both Behaviorism and Cognitivism. These include:

- Presentation in the form of stimulus
- Information access
- Inserted questions
- Organized and chunked stimuli
- Learning in context
- Engaging and meaningful questions
- Learner construction of understanding
- Use of the computer as a thinking tool
- Stimulus rich Technology

In Period 3, disappointment in Cognitivism gave way to rising optimism in thinking about the

learner in active engagement with their environment and other individuals. This social construction of knowledge appears to be a more accurate description of how learning occurs.

Table 2. *Table of Learning and Technology Advances for Period 2*

<table>
<tr><td colspan="2">Key ideas from the previous period brought forth in this period:
Cycle of learning as represented by the stimulus response feedback loop, and
• Stimulus: The options for mediating a message seemed complete
• Response: The notion of the importance of designing in opportunities for learner response
Feedback: The notion of being able to provide feedback to learning.</td></tr>
<tr><td>Cognitivism
Explained learning from Stimulus-Thinking –Response-Feedback learning cycle with a central concern for reflection.

Concern was about understanding the mental processes required of a learning task, and developing stimulus materials that took these processes into account</td><td>Interactive Media
Advances in technology enabled more sophisticated interactions with the media including manipulation of visuals and data on the computer screen, and made stimulus response feedback loop easier and as technology advanced further multimedia merged together into one</td></tr>
<tr><td colspan="2">Example Media: Computer Based instruction, Computer Based Interactive Video, Internet 1.0
Example Learning Methods with Technology: Tutorials, Games and Simulations.</td></tr>
<tr><td>The Case for Optimism:
New technology affordances for affecting thinking:

Stimulus: The options for presenting information were already rich, and much was understood about designing the physical form of the message. But new ways of stimulating thinking through the inductive composition of the message were possible, such as:
• Inserted questions that required overt or covert responses
• Organized and chunked stimuli, that could be manipulated by the learner to generate their own understanding
• Contextualized and real data from easy access to actual data from the Internet
• Engaging and meaningful questions that could be judged using sophisticated programming routines
• Technology was stimulus rich --Information and experts were available through multimedia and the internet

Thinking: Opportunities to interact with the stimulus materials grew out of the affordances that enabled learners to physically and mentally engage with the stimulus.
• Technology was “minds on” , stimulating thinking
• Technology enabled learner construction of understanding
• Technology enabled learners to use the computer as a thinking tool
Response: A variety of response inputs, such as touch screen, voice, check boxes, fill in the blanks to tutorial, simulations, and games

Feedback: Intelligent agents that could process more elaborate responses to give correct and wrong answer feedback.</td><td>Disappointments - the missing elements
What was missing?

Stimulus: did not present a problem in this part of the learning cycle. .

Thinking: only afforded opportunities for think individually. Learning was more system controlled rather than learner controlled in meaningful ways

Response: limited to minimal capability of the computer to process responses

Feedback: Two way learning was limited; feedback was limited by the programming capability of the design team, and a long period of time to program intelligent feedback</td></tr>
</table>

Driscoll (2005) synthesized constructivist research and beliefs into 5 recommended principles for instructional design—learning needs to be "embedded in complex, realistic and relevant environments…provide for social negotiation as an integral part of learning, …support multiple perspectives and the use of multiple modes of representation, …encourage ownership in learning, …and nurture self-awareness of the knowledge construction process. These also align with the learner-centered psychological principles as compiled by the APA. Robinson, Molenda and Rezabek (2008) summarize two key attributes—that of engaged learning and authentic assessment.

The learning cycle evolved from stimulus-thinking-response-feedback to include these important tenets of social constructivism. Embedded in the old cycle is individual and group reflection. See Figure 4. Note in this cycle the influence of all three learning theory paradigms. In this cycle of learning, if a learner chooses or only has an opportunity for individual or peer reflection rather than feedback from an expert, the result would be the development of naïve conceptualization of the content, such is the importance of a the type of feedback needed for social development of ideas.

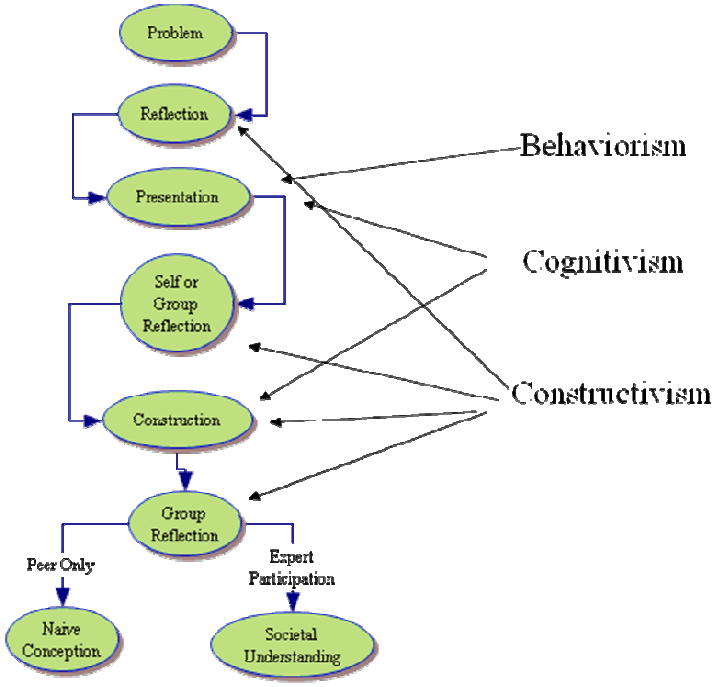

Figure 4. *Cycle of learning influenced by Social Constructivism, Cognitivism, and Behaviorism*

Disappointment in the learning design potential of Interactive Media was a catalyst for new technology innovation. Technology innovation thereby experienced an explosion of new features that transformed Interactive Media into powerful new social media. Web 2.0 tools, games, social spaces, readers, manipulables, interfaces were at the center of this technological explosion. The affordances of these technologies enabled learning designs that take into consideration all the attributes of social constructivism as defined by Driscoll above, and they do them well. These technologies enable multiple contributors, provides an easy means for

communication, such as one expects with wikis, an opportunity for reflection such as through the affordances of blogs, and an easy means for getting important peer or expert feedback as one could get naturally.

Table 3 describes Period 3 from its evolution out the period of Cognitivism and the Age of the Interactive Media, new developments in learning theory along with new developments in technology. The table concludes with a summary of what was optimistic and what was disappointing in this Period of Constructivism and the Age of the Social Media.

Table 3. *Table of Learning and Technology Advances for Period 3*

<table>
<tr><td colspan="2">Key ideas from the previous two periods brought forth into this period:
• Presentation in the form of stimulus
• Information access
• Inserted questions
• Organized and chunked stimuli
• Put learning into context
• Engaging and meaningful questions
• Asked learners to construct understanding
• Used the computer as a thinking tool
• Technology was stimulus rich
• Technology as “minds on”</td></tr>
<tr><td>Social Constructivism

Explains learning from the perspective that individual construction of understanding in social negotiation with peers and experts will enhance learning

Locus of responsibility for learning and social awareness is with the individual

Multiple modes of information representation and sources promotes diversity in thinking</td><td>Age of the Social Media

Brings Internet Web 2.0 Tools and ubiquitous computing that afforded an easy means for communication, and co-construction of knowledge , easy means for individual public and group reflection, and an easy means for getting important peer or expert feedback as one could only get face to face previously.</td></tr>
<tr><td colspan="2">Examples of Media: Blogs, wikis, community documents, social bookmarking, texting, social communities, virtual worlds
Example Learning Methods with Technology: case based instruction, situated cognition, anchored instruction, problem based learning, collaborative learning, distributed cognition and open-ended learning environments (OLEs).</td></tr>
<tr><td>The Case for Optimism:

Problem: Source of realistic problem can come from the vast resources of the internet

Reflection: Computer as a powerful visualization and data analytic tool. Individual, yet public reflection is possible through blogs, Group reflection though discussion boards, wikis, on line surveys, quizzes

Construction: Co-construction is enabled with simple interfaces through web 2.0 tools such as collaborative documents and wikis and presentation media.</td><td>Disappointments –the missing elements

What was missing?

These have not yet been discovered. Promises are still being fulfilled, and optimism runs high</td></tr>
</table>

In this phase, technology tools are continuing to emerge at a rapid rate, such that they are keeping up with the learning needs as defined by social constructivism. Optimism is continuing to run high, though more tempered with every new development, with no disappointment or disillusion with the social media or social constructivism as of yet.

Conclusion and the Period of Satisfaction

Technology and learning theories from the two previous periods were not wrong; they were just incomplete. The understandings about technology and learning theory over the three periods have morphed into a better conceptualization of how learning occurs, and better technology affordances, leading us into a stable period of understanding and satisfaction, both now in harmony to enable effective learning design. From these theories, it can be concluded that there are four prominent needs for effective learning design:

- ICT needs to enable information access
- ICT needs to enable information generation
- Learning with ICT needs to enable social construction of understanding with feedback, and
- Learning with ICT needs to enable self-regulation

From these four criteria, seven main evaluation criteria can be applied to determine effective learner design:

- Is there a problem or context for learning?
- Is there access to rich resources?
- Are there multiple reflection opportunities?
- Is there an opportunity to construct understanding? – and in a social situation?
- Is there expert feedback?
- Is there facilitation for self regulation?
- Does the learner own the responsibility for learning?

Perhaps our current period of satisfaction will last a long time despite the same perception for each prior period. Perhaps it is different in this period because technology innovations to develop every day changing the way we live our life and engage with information and others all over the world.

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