Where I Fit Within Instructional Systems Technology

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As a scholar in the field of Instructional Systems Technology, I am most interested in studying mechanisms for improving people's chances to learn complex performances. I subscribe to the view of learning as an inherently situated and social activity along the lines of Vygotsky's theories as well as those of Lave and Wagner. Like Brian Wilson, Patrick Parrish, David Shaffer and Donald Schön, I will strive to understand how all elements of the students' environment contribute to their learning. Finally, like Dewey, I believe that although there are often similarities in our approaches to problems there is no predictable, uniform, linear process that will always yield high quality results. I am looking to generate new knowledge that can be employed to improve upon the tools and environments available and to optimize the ways in which they are used to support learning complex skills.

In this paper, I will trace the historical support for my perspective and, in doing so, situate my research within the greater context of Instructional Systems Technology.

What is IST?

Formal scholarship in Instructional Systems Technology (IST) stems from difficulties faced in World War II (Seels, 1994). Due to the national conflict between forces that advocated isolationism and those that favored entering the conflict on the side of the allies, our nation was slow to begin increasing the military and training them. Thus, when the expansion came, our military was absorbing large numbers of enlisted men to fight overseas. The organization required that all recruits be able to consistently perform their jobs and there was little time available for training. Our military found it necessary to develop a reproducible process capable of constructing training materials that achieved consistent results with these trainees. Instructional designers studied IST in their efforts to meet this need.

The term "Instructional Systems Technology" itself means different things to different people, but historically, it has been linked to three major concepts: individualized instruction or addressing the learner's unique needs; a systematic approach to instruction; and the use of audiovisual devices for instructional ends (Reiser, 1987). Human Performance Technology is yet another facet of IST, which focuses on the ultimate outcome of performance rather than on the requisite learning which may be necessary to achieve these goals.

My own strong technical background means that I am well suited to the task of building multimedia systems including the automated data collection and analysis tools which would facilitate study of audiovisual devices and their current state of evolution as interactive multimedia systems. This has led me to explore educational simulations and games as well as immersive learning environments. However, in spite of my keen appreciation of the technologies, this never satisfied my curiosity and I looked deeper into myself. Likewise, although I approach problems from a systems perspective and found the complexity of introducing change to be a fascinating challenge, my research interests lay elsewhere. I am most interested in investigating the mechanisms that will facilitate our learning to succeed in complex tasks.

Individualizing Instruction

At the founding of the United States, the populace generally agreed with the idea of schooling for all, but differed on the intended purpose of this schooling as well as how these schools would be maintained and operated. Thomas Jefferson promoted for Virginia the idea of free schooling for all eligible males. Under his system, the top performer, nationwide, would be offered the opportunity to study at the William and Mary College (Kaestle, 1983). However, this idea did not achieve broad support as much of the nation viewed the schools not as a purveyor of general education, but rather a maintainer of social order. The upper class could afford a classical liberal arts education and were expected to apply its benefits towards creation of new knowledge and management of the lower classes. These privileged graduates were expected to gain problem-solving skills by studying the writings of past philosophers and to be able to transfer this knowledge to problems in the future.

At roughly the same time, the burgeoning new republic sparked developments in other disciplines. Adam Smith's example of a production line in a pin factory (1776) exemplifies his pioneering efforts towards standardization and specialization within industry. Impressive results were being achieved within factories and it wouldn't be long before standardization and optimization made their way into education. As time went on and the number of students flowing through the system increased, at all class levels, it was clear the system would have to scale up. Through the 1800s, as we reaped the benefits of process commercially, we began to apply it, informally, towards the problem of assimilating more children into the school system. Joseph

Lancaster's system built upon a highly regimented traditional pedagogy enabling a single master to operate a school with as many as 500 children (Kaestle, 1983).

In the late 1800s, our liberal arts education showed weaknesses, particularly in the area of science education; our graduates were unprepared for what was expected of them in a scientific laboratory environment (Rudolph, 2005). Among the first efforts to remedy this deficiency was a set of defined laboratory skills being instituted as admission requirements for the high-end universities. Inevitably, this led to the distillation of a set of lab exercises being taught and tested to demonstrate the acquisition of these skills, but in a few years it became clear that students who had mastered these lab procedures did not always understand what they were doing and, more important, mastery of the skills did not always lead to transferability to novel contexts.

As this failure was becoming evident, John Dewey was beginning to experiment with education, school design and management at his Laboratory School in Chicago. His Laboratory School empowered its educators, subject matter experts in the fields they taught, by providing the administrative support and infrastructure needed to foster collaboration and peer support (Durst, 2005). He was not the only one to be experimenting at this time. Maria Montessori, after seeing initial success using sensorial materials with the mentally challenged, pioneered her own school system (Lillard, 1972). The method she developed focuses on the whole student by providing an open environment in which the adults in the room functioned more as observers and guides than deliverers of knowledge. Later, in the 1920s, Frederic

Burk and his team (Grittner, 1975) developed the Dalton and Winnetka Plans for individualized instruction, which, still in use today, were influenced by the work of Dewey and the Laboratory School in Chicago.

Later, in his work, *How We Think* (1910) Dewey deconstructed the thought process by describing his approach to solving three distinct problems using a systematic approach to a problem. (The problems were: how best to travel to a specific location; the purpose of a particular pole on a boat; and why bubbles form on the rim of glasses placed on a plate.) Upon publication, this work was a tremendous hit amongst the education community for they immediately recognized the similarities between the three processes and distilled from this a simple, five-step procedure for creating scientific knowledge. At last they had a framework to use in teaching their students how to approach scientific problems and this was dubbed *The Scientific Method*. Dewey was appalled at this oversimplification and attempted to correct the problem by pointing out that the sequence of the steps is not fixed in a follow-up edition, but the genie had already escaped. Our educators were now armed with a clean and neat process for teaching science and they were not about to give it up.

Other professions developed their own techniques for imparting an understanding of their fields, such as the Socratic method of learning case law, medical rounds, critiques in design studios and all the other signature pedagogies identified by Shulman (Shulman, 2005). The Socratic method finds instructors grilling students on the facts, findings and reasoning behind the cases included in the body of law the students are studying; when a student misses the response, another student is called upon to correct them. The practice of performing medical rounds sees students following an experienced attending physician as they meet with patients in a functioning hospital with the students being asked for diagnoses and treatment recommendations along the way. The design studio, common in architecture, is a physical environment provided to support individual students working on their own projects in a communal and supportive environment. Periodically, the instructor or master designer visits individuals for desk crits, or one on one explorations of an individual's progress (Brandt et al., 2008; Schön, 1985; Shaffer, 2007). These last two pedagogies are particularly notable for the fact their unique environments (i.e. hospital and studio) play an important role. These signature pedagogies serve not only to exercise the desired modes of thought, but they also offer a consistency that enables students to know what is expected, freeing them to focus on the content.

The design studio piqued my interest as an environment built specifically for a certain type of learning and which constitutes a complex system whose purpose is the development of design skills in individuals. In this system, the space itself makes it possible for the instructor and students (as a social community) not only to engage in but also to be constantly immersed in activities designed to further their growth. My study, *Searching for Personal Territory in a Human-Computer Interaction Design Studio*, explored one component, territory, in an instance of a design studio. In this exploratory study, I learned that, in this case, the population under observation tended to mark and defend their space as a group and I would be interested in trying to determine whether this supports or interferes in any way with the pedagogical activities.

Early Studies of Learning

Understanding how learning works is crucial to developing effective instruction. As a result, those researchers that have developed and tested learning theories are claimed as forefathers of IST. Many different theories exist and they each have their strengths and weaknesses. Some focus primarily on outcomes while others attempt to understand what occurs within the mind itself. Still others take either a developmental approach or treat learning as a contextually based activity that is necessarily situated within an environment, often emphasizing a social component.

In the late 1800s, Hermann Ebbinghaus took the burgeoning field of psychology in a new direction (Driscoll, 2005). Noting that increased frequency of the experience of associated concepts increases the association within the mind — effectively, this was the first formal theory of learning. Ebbinghaus went on to experiment with association and rules that govern it. Edward Thorndike continued to study association and learning empirically by observing the behavior of animals. Pavlov was also working with animals, developing techniques that would become known as classical conditioning. He demonstrated that it was possible to associate one stimulus with another. This meant a researcher (or instructor) could ultimately introduce only the associated stimulus and induce the response expected of the original stimulus.

Learner-centric approaches to learning

While these lines of study all contributed to our understanding of learning, behaviorism, introduced in 1913 by John B. Watson (Driscoll, 2005), contended that the focus of study should be on changes in behavior since psychological constructs (e.g. associations and their strength) are not objectively measurable. Skinner continued to push Radical Behaviorism and it is his name that is most closely associated with it today. This was the first comprehensive theory of learning as it fleshed out methods of manipulating behaviors through positive and negative reinforcement. Skinner was able to demonstrate the ability to implement a plan to achieve behavior change by extinguishing some and introducing other behaviors.

Behaviorism has been and continues to be highly influential in the field of IST. Much effective training has been developed using behaviorist principles as a guide. One example of this is programmed instruction or books generally designed for self-study and self-paced learning where the learner is frequently presented with questions on the preceding content and provided with immediate feedback to indicate whether they should proceed or review. However, it has been criticized for ignoring what actually occurs within the human mind between processing experience and executing behavior.

One alternative path pursued was that of Cognitive Information Processing (CIP). CIP models developed with the rise of computing and, according to Driscoll (2005), they can all be traced back to Atkinson and Shiffrin. They draw comparisons with the functioning of computers, which accept input, process it and then render some form of output. In the CIP models, sensory input is filtered through sensory memory before it makes it into working memory where it is processed and a response is rendered, possibly including storage in long-term memory. CIP models serve as a foundation for studies of cognitive load (Sweller, 1988)

In the 1960s, Ausubel built upon the earlier work of Ebbinghouse, but while Ebbinghouse's experiments measured retention of new content that was un-relatable to the learner's existing knowledge (nonsense syllables were used) (Driscoll, 2005). Ausubel rejected this practice. He proposed that learning had to be connected to past experiences to be meaningful. This developed into schema theory, which proposed that new knowledge is organized in a hierarchical fashion within the mind. A practical instructional recommendation derived from schema theory is the use of Advance Organizers or activities aimed at activating the existing prior knowledge of the learner.

Although there is value in the computational models presented above, I find that they are too simple to adequately explain or guide development of instruction for imparting concepts or ways of thinking about content. Their techniques are often useful and I employ them where expedient, but other areas offer me richer fields for exploration.

Developmental approaches to learning theory

The developmental psychologist, Jean Piaget took more of a developmental approach to learning (Driscoll, 2005). He determined that human beings work their way sequentially through a series of developmental stages throughout their lives and each successive stage brought with it an increased set of cognitive capabilities, enabling new understandings. Within this framework, Piaget proposed that the introduction of new knowledge instigated one of three processes: assimilation, or a simple integration of new facts into the existing structure; accommodation, or modification of existing knowledge to make way for new content; and equilibration, which occurs when existing knowledge cannot be modified to allow for new information and the learner must develop new capabilities or move into the next developmental stage. Therefore, students develop most when confronted with information that does not align with their existing knowledge and understanding. This model is criticized for its sequential linearity and for the observation that children often exhibit characteristics from many different stages at a time, depending upon the content. Important instructional design recommendations derived from the work of Piaget include careful attention to the learning environment as it's through interaction with and observation of the environment that we learn. Similarly, children learn much from interacting with peers and therefore one must pay attention to the social environment.

Jerome Bruner's study led him to propose that humans structure knowledge in three ways: enactive, or indistinct from doing; iconic, or direct, concrete representations of physical objects or events; and symbolic, or abstract representations such as written language (Driscoll, 2005). Content, according to Bruner, can be delivered in any of these three forms, and a student at a more advanced level could still use those at lower levels, but those at lower levels would gain little from formats that are beyond them. For me, this has meant revisiting concepts in different ways and at different depths.

Piaget sometimes called his approach to learning “Constructivism” because he believed the learner is constantly constructing his own worldview by assimilating new information (Driscoll, 2005). In the late 20th century, theorists including Papert, Jonassen and others, have extended the work of Piaget, Bruner and Vygotsky to develop this theory of learning and to use it to guide instructional design approaches. While behaviorists focus on yielding desired behavioral outcomes and pay little attention to the understanding developed to support that behavior, the Constructivist holds that the learner’s understanding is crucial but unique and unpredictable since it is based upon the set of life experiences the person has been subject to. The instructor approaches their role as facilitators of student learning rather than as a source of knowledge to be replicated. Some approaches based upon this theory include problem-based learning (PBL), experiential learning and inquiry-based learning.

I can identify with these approaches as I incorporate authentic contexts and problems into my own courses and try to accommodate multiple avenues to reach an understanding of the content that fits their worldview. I can also appreciate the criticisms that it is often unguided and ineffective because some instructors may interpret the unpredictability of knowledge construction to mean that the instructor plays only a minor role and that the student must simply flail about in search of meaning (Kirschner, Sweller, & Clark, 2006). I am wary of this, especially because, as only one person, it is unlikely that all my students will understand the messages I send and I employ group work to provide a support structure. My expectation is that they will pool their understandings while completing their assignment and walk away with a sufficiently complete understanding.

These psychological approaches to learning offer insights into patterns of human development and I agree that, owing to the unique circumstances of our lives, no two mental states will ever be identical and therefore it's impossible to replicate understanding from one person to another. Additionally, I appreciate that these theories place importance upon social interactions and the environment within which learning takes place. However, neither of the stage models is accurate enough to be predictive with respect to design of instruction. Additionally, although I appreciate and largely agree with the premises behind Constructivism, it does not provide very much actionable guidance for the instructor or the instructional designer.

Social and contextual learning theories

Perhaps it is because I am inclined to be social and have noticed that I learn much myself through interactions with others that I am most drawn to the following social and contextual learning theories. Early in my journey towards becoming an instructional designer, I simply worked to include interactive conversations in my teaching. However, as I have grown as an educator and learned more about Vygotsky's work and those concepts broadly categorized as situated cognition, I have worked to understand how social interactions can contribute to learning and I lean on group work in my instructional designs.

Russia during and after the revolution, the time period when Lev Vygotsky was entering the Soviet labor force, saw a strong drive to apply a social lens towards all aspects of life (Driscoll, 2005). Vygotsky applied these concepts to learning and is most well known for his theory of the Zone of Proximal Development (Z.P.D.). He observed that when we test a student working alone, we attempt to measure what they can do on his or her own (Vygotsky, 1978). If they were to work with a more skilled other, they prove themselves capable of more. However, two students that perform at the same level alone may achieve different levels with the more skilled other. The Z.P.D. refers to the gap between their ability on their own and their ability with assistance. Furthermore, he surmised that it was when the student performed at this higher, socially-induced level that learning occurs. Internalization is the name he gave the process by which the child infers the meaning of his actions from the responses they elicit from those around him (Driscoll, 2005). For Vygotsky, learning was a thoroughly social activity and his disciple, Leontiev, went on to develop Activity Theory, a framework which views the activity as the unit of analysis and proposes that materials only exist within the context of an activity (Nardi & Kaptelinin, 2006).

In the late 1980s, theorists Jean Lave and Etienne Wenger pioneered the theories of situated learning and community of practice. Situated learning derives from situated cognition, which states that knowledge is situated or that knowledge alone (e.g. rote memorization) is incomplete and that it must be contextualized relative to activity. The theory of Community of practice stipulates that that context must be a social one and, according to this theory the process of becoming an expert in a given topic begins with the learner approaching a community and observing from the fringes. As their understanding and confidence builds, they take on increasingly complex tasks as they work their way in towards the experts at the center of the community. This process is known as Legitimate Peripheral Participation (Lave & Wenger, 1993).

While my understanding of learning is informed by all of the foregoing theories and each provides a valuable perspective in certain circumstances, it is these social/contextual theories that hold my interest. As complex learning, or the ability to coordinate and integrate skills in authentic tasks (van Merriënboer, Clark, & Croock, 2002), is increasingly in demand, it is by paying attention to social dynamics and understanding the entire learning environment that we will best be able to achieve positive learning outcomes.

Audiovisual Devices

While the work of Johann Comenius in the 1600s and later that of Johann Pestalozzi in the 1800s both studied and promoted the use of visuals in instruction and instructional materials, it was really in the 1900s that education began its push beyond the realm of words (Reiser, 1987). In addition to the creation of a few school museums, it was at this time that motion picture projectors were coming into use in schools.

The development and usage of audiovisual materials to enhance education continued and in 1923, the Department of Visual Instruction of the National Education Association was created (Reiser, 1987). This later became the Association for Educational Communications and Technology (AECT, the organization whose activity is directed towards "improving instruction through technology" (AECT website). It is the primary professional organization for IST researchers and practitioners.

World War II was the greatest test of the growing understanding of instructional design and, specifically, effective methods of employing film for training purposes. The opposing forces cited the speed with which this technology enabled us to prepare our troops as the major reason for their loss of the war (Reiser, 1987). This success spurred interest in the field and researchers were investigating the uses of audio and visual materials in instruction to provide scalable, authentic experiences to masses of students (e.g. Weintraub, 1949) as well as the skills required for an instructor to successfully utilize such materials (DeBernardis & Brown, 1946).

The study of message design

The education researcher Edgar Dale, with his love of words (as evidenced by Dale, 1984) focused on language learning and the transmission and reception of messages, an area of study that would be called message design. In 1946, he published his famous Cone of Experience which has influenced instructional designers ever since (Wagner, 1970). This graphic represented the forms of educational experiences available at the time (e.g. reading text, viewing images, performing a task, etc.) and mapped them to both learning and retention expectations.

In 1958, the United States passed the National Defense Education Act in response to the launch of Sputnik, the first man-made satellite (Reiser, 1987). This meant millions of dollars in funding for educational research. Naturally, it led to an increase in research into instructional technology and efforts to professionalize the field of audio-visual technology (Finn, 1953). This accompanied the publication of the *Audio-Visual Communication Review* in 1953, the research journal that would become *Educational Technology Research and Development*, the flagship journal of AECT.

The study of instructional materials has continued and has branched out into the emerging field of computing. Instructional designers and theorists became fascinated, as am I, with the possibilities offered by these powerful tools. In 1960, the Programmed Logic for Automatic Teaching Operations (PLATO) system was developed at the University of Illinois to deliver computer-aided instruction and represents an early exploration of the possibilities (D. L. Bitzer & Skaperdas, 1968). It was used not only to deliver content to students (version two and above allowed multiple students on at once), but it also administered tests and kept records of student performance. Content areas covered included mathematics, engineering, biology and nursing. One particular benefit found in analysis of nursing student activity was enabling students to gather information in different ways depending upon their preferences (M. Bitzer, 1966). In the late 1990s, when working with interactive, non-linear video, it would be this same potential to use computing technologies to customize learning to individuals that would lure me into the field of education, but it is not what would keep me there.

In the 1970s and 1980s, this dream of dynamic content edged closer to reality when personal computers began to reach the market. In 1978, Fleming and Levie (Fleming & Levie, 1993) first published their book of directives and advice for achieving maximum effect with instructional materials. However, in the 1980s, the focus was shifting towards computer-based delivery with researchers studying optimal layout for CRT-based instruction (Grabinger & Amedeo, 1988) and investigating the possibilities offered by computer-aided instruction (Hannafin & Rieber, 1989). Educators were also experimenting with videodisc technology at this time as a means of delivering high quality video and offering the learner a measure of control over the learning process (Anderson, 1985; Korn, 1983).

Multimedia content

The 1990s saw multimedia capabilities arrive on desktop computers. As an undergraduate student, I was excited to have the opportunity to build CD-ROM-based training materials professionally while on an internship. Tools like Macromedia Director, Authorware and even Hypercard enabled us to deliver impressive content and simulate realistic environments for training purposes and I was enthralled. At the same time, the Internet was gaining in popularity and I was already challenging myself to make use of it to reduce the materials I carried physically. While Clark (1994) and Kozma (1994) debated the influence of media types on learning and while Dillon and Gabbard (1998) studied the advantages of hypermedia, I spent my nights reaching out across the web to soak up all the information I could find.

Web content grew increasingly dynamic and interactive and, in 1998 I dreamed of using the streaming video technology of the company I was working for to build a video safari. With individual streams and clickable hotspots, Johnny could click a butterfly to follow it while Jane chased after a lizard that caught her eye and, at the end of the day, their teacher could review a report of what interested which students and gain insight into how best to stoke their curiosity. With the computer performing the rote, repetitive tasks it did best, it could empower the teacher to do what he did best: relate to and guide his students. It was possible to construct a virtual environment that responded to our students exactly as we told it to and which could unblinkingly observe and analyze data for our teachers to combine with their own observations and intuition to customize the next lesson.

When I began taking classes towards my Masters in Instructional Design, Development and Evaluation from Syracuse University, I was living in South Korea, teaching English to gain classroom experience. This was my first time taking classes at a distance and I was extremely apprehensive. I knew about correspondence courses advertised since I was a kid, where you sent for your materials, worked through them and mailed them back for a grade and I'd even seen an early online course management system during my undergraduate studies. I was scared because interacting with (and often irritating) my instructor and fellow students was what I enjoyed most about school. I quickly learned that, when done properly, my distance interactions could be even more meaningful than any class I'd taken previously. Without someone standing up and set apart as the teacher, it was possible to launch into debates with my peers and the instructor no longer maintained the status of purveyor of knowledge or source of truth; I began to feel as though my instructors were my peers and that they were learning from me while I was learning from them. This impacted my own teaching as I began to intentionally create situations where my students would see that, although I knew more in some areas (English), I could still learn a great deal from them in others (Korean).

With my strong technical background, when I read about how games were being leveraged in education (Gee, 2003; Prensky, 2001; Shaffer, 2006), I thought to myself: I could build that. Unfortunately, it took me a long time to realize that, although I could build these games and although I would be happy to see them used, they were overkill if I wanted to understand or harness complex learning in group settings. As I dug into immersive learning environments, I found myself drawn to the physical rather than the virtual. I was frequently reminded of my own second-language experience of not being allowed to use the bathroom until I could ask to go in the language I was immersed in – the ultimate in problem-based learning.

As new technologies emerge, there will be those that will study how they might be used to improve learning and it's likely that I will want to use many of these technologies in my own designs. However, I am convinced that it's not the arrow, it's the Indian; the technology will only ever be as useful as the designer or educator that wields it.

Systems

As IST has grown, we've recognized the fact that education and instruction are not simple procedures on individual parts, but rather complex systems with many interrelated subsystems. Seemingly innocuous changes can have ripple effects throughout and sometimes the system itself seems to act as an entity resisting your efforts to change it. To achieve a desired outcome, one must cultivate a systems view and consider myriad variables when planning an intervention (Banathy, 1995). Reigeluth's (1987) proposal offers an example of such an approach as endemic problems are identified in the existing system and the replacement attempts to account for stakeholder needs, incentives as well as the economics of the proposed changes.

Rogers' (Rogers, 2003) diffusion of innovations theory caught my interest during my undergraduate studies in part because it was taught using an engaging and challenging game, but mostly because the theory itself focused on the social aspects of change and where one might effectively apply pressure to achieve a desired end. Many of our contemporary thinkers echo this insight as they involve the community in school reform (Lee & Reigeluth, 2007) or point out that enlisting the support of the target population is crucial to a successful change strategy (Dormant, 1999; Markus & Benjamin, 1997).

I've found the systems approach appealing for two reasons. First, is the challenge of trying to contain a complex system within my mind and trying to notice and understand all the moving parts. The prospect of considering and counterbalancing all the resultant changes without missing anything is a daunting but exciting task. The second reason derives from past experiences in which I found myself part of an organization that would benefit from structural changes but which was unsuccessful in implementing them.

An important component of systems thinking is taking a systematic approach to solving problems. This is exemplified by the many instructional development models that exist for different purposes (Appelman, 2009; Gustafson & Branch, 2002). Of course, the most famous of these is the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model, which seems to have existed since the dawn of time even if its actual origin is uncertain (Molenda, 2003). Our students are taught to follow this five-step process, much as our aspiring scientists are with the scientific method, to produce high quality instruction.

When approaching an instructional design problem, the process indicates our first step is a task analysis. From it we determine the gap between the present and desired states and derive a set of learning objectives for the training (Jonassen, Tessmer, & Hannum, 1999). The results of analysis feed the design process and we promote numerous design models which describe, at a relatively abstract level, the form of an effective instructional design (Reigeluth,1979, Gagne, 1988, Merrienboer, 2002, Merrill, 2009). However, these models and their resultant designs tend to focus on the information to be conveyed, perhaps the mechanisms for conveying them and the ethics involved, but this only addresses the first three of the four pillars upon which instructional design practice stands (Wilson, 2005). My study, *Searching for Personal Territory in a Human-Computer Interaction design studio* explored the second and fourth pillars of outside connection and aesthetic experience.

After development and implementation have been completed, the training is to be evaluated. Two frameworks for evaluation which have been used for over fifty years are Bloom's Taxonomy (Krathwohl, 2002) and Kirpatrick's Four Levels (Kirkpatrick, 1994). Both of these models are designed to frame the measurement of instructional outcomes, but more recently, Bichelmeyer (Bichelmeyer & Horvitz, 2006) has questioned this approach. She calls for a more thorough validation of the training, beginning with the theory behind the design of the instruction, continuing on to check whether or not the content of the training is aligned with the logic model. The forms of evaluation described above are summative and are the most common formal evaluation strategies.

Formative evaluations also have their place as they may be used to course-correct during the delivery rather than waiting until all the damage is done (Fitzpatrick, Sanders, & Worthen, 2004). While I see the value in determining the effectiveness of what has been completed, in todays world, it is more possible than ever to collect in-flight data for formative evaluations and, if one would like, then to re-analyze the data upon completion. I plan to investigate into ways of integrating formative assessment into everyday instruction because I believe providing more information will help everyone to improve their performance. Specifically, I am interested in following up on the research of Tucker and Reynolds' (2006) into the use of collaborative projects and continuous peer assessment of individuals' contributions.

In spite off all this codified process, according to Rowland (Rowland, 1992), our experienced practitioners, much like our experienced scientists, don't actually do their jobs as prescribed by our literature. It seems as though we, like our science educators, teach a highly regimented and simplified version of our practice to novices and expect them to use this as a starting point from which to develop their own techniques. Boling (Boling, 2005) suggests that we ought to look to other design fields to help us understand and improve upon our own design methods and techniques. According to Lawson (Lawson, 1997), design does not follow a predictable or identifiable series of steps, but rather it jumps back and forth between them. Jane Darke's research (Darke, 1979) indicates that designers begin with a concept, a primary generator, which they use to test their explorations and from which the final result does not often deviate significantly.

This appeals to me, as it seems clear that the methods we teach do not correspond to professional practice, but I'm also not sure that this seeming misstep isn't necessary. Rowland (Rowland, 1991) found that the methods employed by the entirely uninitiated were more similar to those of experts than were those of novices. He concluded that we should investigate this apparent problem with our approach, but the path to becoming an expert designer may not be linear and some missteps might actually be necessary. This is corroborated by conversations with Marty Siegel who indicated that, in his more than 20 years of delivering the same design class, when he was able to anticipate student difficulties and head them off, they simply turned up later instead.

Design is a complex and messy problem that defies being solved with a single correct solution. Instead, these wicked problems are satisficed – 'satisfice' being a portmanteau of 'satisfy' and 'suffice.' These are challenging problems and, in this age of facts and calculations at one's fingertips, those who can tackle design problems will be the source of innovation and hold the keys to our future. I aim to understand and improve upon instructional systems that produce designers.

Human Performance Technology

The field of Human Performance Technology (HPT) shares many common roots with IST, but instead of focusing on learning as the end goal, it focuses on the end result: performance. Indeed, Tom Gilbert, widely regarded as the father of HPT, began in 1978 by defining worthy performance as "the ratio of valuable accomplishments to costly behavior" (Gilbert, 2007, p. 18). His key insight was that knowledge (or a lack thereof) is not the only barrier to human achievement. Often, it's not even a significant barrier. From this perspective it becomes clear that training is not always the solution as tended to be the assumption when working within the construct of IST. As HPT is outcomes-based, it is natural that it finds its roots in behavioral psychology.

A crucial component of HPT interventions is a thorough analysis and practitioners must therefore cultivate a systems point of view to ensure they are able to see the entire picture (Addison & Haig, 2006). Also, as is the case with IST, their goal is to effect a positive change and people are usually affected by, if not the direct targets of interventions.

The selected interventions themselves are frequently a differentiator from IST as they actively try to look past the initial request for training (Mager & Pipe, 1997). While many theorists have proposed human performance models, David Wile (1996) has distilled them down to the components that contribute. The resultant seven components represent both the areas for analysis and the types of interventions possible. This high level view of performance and contributing factors leads to significant overlap with other fields of study such as organizational development (OD) and human resource development (HRD) as well as human factors, ergonomics and information technology.

Coming from the world of software, I am used to products that are advertised as either consumer edition or enterprise edition, with the latter targeting businesses as customers. The feature sets and marketing materials offered a very different slant with the consumer versions offering flashy end-user features while the enterprise editions focused on raw performance and efficiency. I can't help but draw a parallel with IST and HPT. The former has had an impact on the corporate world, but really focuses on developing people, whereas HPT speaks the language of business; one doesn't have to dig deep into the Handbook of HPT to find references to return on investment and cost effectiveness (Pershing, 2006, p. 16).

I see a great deal of overlap between IST and HPT. Specifically, one might easily view HPT as a superset of IST because of its explicitly broad approach, assuming that training is not always the solution, while IST drills down deep into the skills/knowledge component. I feel as though I take almost an HPT approach to instruction itself. The performance outcome I aim to achieve is the development of design skills.

Tying it All Together

My research looks at how we learn to perform complex activities with a focus on those mechanisms that increase the likelihood that such learning will take place. Solving design problems is such a complex activity and, as design skills are frequently applied and in demand, it serves as a significant area of concern.

As I've come to experience design, it is not a skill that can be directly taught, but rather it's a 'practice makes perfect' sort of skill. I'm not convinced that beginning with procedures is ideal since we know that they tend to be somewhat misleading oversimplifications of actual practice. We know that, as Dewey warned the science educators of his day, there is a point at which the student will find that the process does not apply and that they will find it necessary to stray from the prescribed path. On the other hand, Kirschner, Sweller and Clark (2006) point out that allowing the pendulum to swing in the opposite direction might find us unleashing wicked problems upon students and hoping for the best.

I see promise in the studio approach in which the instructor provides an open-ended problem, which the students attack individually or in groups. The instructor may introduce resources or techniques as the students work, but initially much of the learning stems from the critical interaction between the instructor and the student (Schön, 1987). As the course continues, these critiques take on new forms with pin-ups in front of a jury of professionals or critiques by colleagues.

In my corporate life, I often found myself working as part of a team and I believe the quality improved as a result. Brooks (2010) argues that design does not benefit from working in a team and that this leads to weak designs as team members allow unnecessary feature requests for political reasons. While I've no doubt that this sort of design by committee process occurs and that it might have detrimental results for the product, in my experience, it does not happen all the time and I have yet to see it in academic environments. I've found it valuable to work with others who can reflect and improve upon my ideas and share the workload. Invariably students' skills are unevenly matched, which places them in Vygotsky's Z.P.D. if the workload is, indeed spread.

I have found group work to be a powerful tool for complex learning as it brings multiple perspectives to the situation and asks participants to communicate their views to their team. However, as an instructor, it can problematic to implement because their opaque nature makes it difficult for the instructor, as an outsider, to see the contributions of individuals. This makes it difficult to determine a student's progress and to diagnose potential problems. Colin Gray's preliminary analysis of his research data indicates that groups play an important role in students' development as designers and my own experience leads me to agree, but how do these social interactions contribute to the development of design skills and which skills actually benefit? Are there skills that are hindered by teamwork? Is it possible to monitor a student's development and help to make sure that process remains on track and what effects might this have on the students' performance? Perhaps it's possible to identify problems with enough forewarning that one can intervene beneficially? I intend to explore these questions as I pursue my research agenda.

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