The Points of Viewing Theory for Engaged Learning with Digital Media

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Introduction

> Theories are dangerous things. All the same we must risk making one this afternoon since we are going to discuss modern tendencies. Directly we speak of tendencies or movements we commit to, the belief that there is some force, influence, outer pressure that is strong enough to stamp itself upon a whole group of different writers so that all their writing has a certain common likeness. — *Virginia Woolff, The Leaning Tower, lecture delivered to the Workers' Educational Association, Brighton (May 1940).*

With full acknowledgement of the warning from the 1940 lecture by Virginia Woolf, this chapter begins by presenting a theory of mind, knowing only too well, that "a whole group of different" learning theorists cannot find adequate coverage under one umbrella. Nor should they. However, there is a movement occurring, a form of social activism created by the affordances of social media, an infrastructure that was built incrementally during two to three decades of hard scholarly research that brought us to this historic time and place. To honor the convergence of theories and technologies, this paper proposes the Points of Viewing Theory to provide researchers, teachers, and the public with an opportunity to discuss and perhaps change the epistemology of education from its formal structures to more do-it-yourself learning environments that dig deeper and better into content knowledge. As the saying goes, we live in interesting times. Let's not make this saying a curse. Let's "deschool" society as Ivan Illich suggested in 1971 and design more equitable systems of learning across mediated platforms.

The Points of Viewing Theory is the foundation upon which this chapter on computers, the Internet, social media, embodied cognition and interactive digital media learning environments, including games for learning, is constructed. According to this theory developed by one of the authors, Ricki Goldman, formerly Ricki Goldman-Segall, learners actively layer their viewpoints and their interpretations to elicit patterns, themes, and groupings of ideas that lead to a deep understanding of the content under investigation and to reach agreements—if only partial (Goldman, 2007; Goldman-Segall 1996a & 1998a). The Points of Viewing Theory (POV-T) is not limited to making meaning with from a solitary standpoint. Indeed, the purpose of applying POV-T is to enable learners to learn from one another by seeing each other's viewpoints through perspective-taking and for learners to be able to see *their own* changing perspectives on a subject in diverse contexts and settings. As Rowland points out: We come to know through interpretation, dialog, and negotiation of meaning with … others, through a conversation with manipulation of the materials of a situation (Rowland, 2004, p. 43)

The theory also strengthens content knowledge by layering the ideas of participants and stakeholders in a shared learning environment using a range of methods, tools, and "documents." POV-T also provides a framework for finding underlying patterns that lead to agreements. Tools that make evident this theory are called perspectivity technologies because they provide a *platform for multiloguing* (Goldman-Segall, 1994), a place and space for building cultures or communities of practice where one "catches sight" of the other while participating in learning. Given the problematics of living in a complex global society facing enormous cultural, social, environmental, and economic differences of opinion, this theory is critical for communicating with each other and reaching what Ivan Illich calls *conviviality* (1972), Clifford Geertz calls *commensurability* (1973), and Goldman-Segall (1995) calls *configurational validity*—a form of *thick* *communication* which emerges from using media tools to layer views and perspectives into agreements.

POV-T incorporates how each person at different times and contexts will understand the same content whether it be a process, event, document in any media, or action “with new eyes.” Research on what Black (2010) calls the *embodied/grounded cognitive perspective* takes advantage not only of our visual perceptual systems for learning, but also our entire full body perceptual systems. Recent brain scanning research has shown that many cognitive tasks that were thought to be purely symbolic actually involved a multisensory perceptual simulation. The best preparation for such task requires a fully embodied learning experience. The use of computer game-like learning environments (such as the Wii and Kinect™) will continue to open the doors for exploration into how the social mind makes sense of experiences. Moreover, given the rise of social media and games for learning, as well as the recent findings on the plasticity of mental interpretations, the brain’s capacity for mental mirroring, and the intimate relationship between emotion and social intelligence that shows how minds can be reconfigured with changes to embodied experiences, the Points of Viewing Theory, a foundational theory of minds presented in this chapter, is the one that can move forward our understanding of learning with computers from the advent of early instructionist approaches to more recent constructionist and socio-constructionist applications.

In this chapter, the authors explore a range of concepts and tools that have been designed for learning. The authors expect that readers will create new configurations as they read the text. Indeed, that is the idea behind the theory—to learn from both a layering of each other’s ideas as well as from the diverse perspectives each of us, as solitary readers (if there is such a thing) can make meaning of different contexts to build knowledge, together. Mantra: *Make meaning, not war!*

Contexts and Intellectual History

We start by unfolding how the Points of Viewing Theory provides us with a lens from which to better connect the writings of past and present leading theorists. Our goal is to envision future directions, and, simultaneously, tease out some of the sticky webs that have confused decision makers and academicians. The underlying theme running through this chapter is that many routes combining a vast array of perspectives are needed to shape an educationally-sound approach to learning and teaching with digital media technologies. There is no one fix, no one solution. Rather an openness to appreciate diversity and a layering of points of viewing. To open this journey, we first discuss the the legacy of the Enlightenment magnified the age-old debate between empiricism and idealism.

In the early part of the 20th century, this debate shifted: science could be used to not only observe the external world with microscopes and telescopes, but to change, condition, and control behavior. Russian physiologist Ivan Pavlov experimented with dogs, calling his theory *conditioning*. Dogs "learned" to salivate to the sound of a bell that had previously accompanied their eating, even without receiving the food. Pavlov's theory of conditioning played a central role in inspiring John B. Watson, who is oft cited as the founder of Behaviorist psychology. As early as 1913, Watson, while continuing to work with animals, applied Pavlov's theories to children, believing that people act according to the stimulation of their nervous system and can just as easily as dogs be conditioned to learn. A turbulent personal turn of events—leading to his dismissal from Johns Hopkins University—extended Watson's behaviorist approach into the domain of marketing. He landed a job as vice-president of J. Walter Thompson, one of the largest US advertising companies, and helped change the course of advertising forever (Daniels, 2000). As media, education, and business enter a convergent course in the 21st century and new tools for learning are being designed, behaviorist theories are still a strong silent partner in the new knowledge economy.

An early behaviorist, Edward Thorndike, with his 1899 article on "Animal Intelligence" and subsequent book called *Educational Psychology* in 1903, is often called the founder of the field of educational psychology. Curiously, his educational psychology book made recommendations for teaching students, but they were based on his research on animals (the Law of Effect and the Law of Exercise that establish connections between stimuli and responses) – but his was typical for the first half of the 20th Century. (He did later conduct many studies with students using this same basic framework.) Another noted behaviorist in the educational domain, Burrhus Frederic (B.F.) Skinner, contributed the idea of *operant conditioning*—how positive and negative reinforcement (reward and punishment) can be used as stimuli to shape how humans respond. With this variation, the theory of behavior modification was born. All human actions are seen to be shaped (caused) by the stimulus of the external world on the body. In short, there is no *mind* creating reality, merely a hard-wired system that responds to what it experiences from external sources. Infamous for designing the glass "Air Crib" which his daughter—observed, measured and "taught" how to behave—spent time living in, Skinner not only practiced what he preached but led the way for even more elaborate experiments to prove how educators could shape, reinforce, and manipulate humans through repeated drills. What is salient in the Behaviorist approach is that the proponents addressed the role of external stimuli—that our bodies send messages to the brain that can be interpreted. What was misssed was selectivity of the brain and now perceptions affect, not only behavior, but create new perspectives. However, it is the interaction between what is felt in the body and what is interpreted that is paramount to learning. In short, even with the advent of new man-machine studies in the post-World War II period, perception was missing the crucial connection with perspectivity, the role of interpretation as the mind's greatest function. With the advent of the computer, intrepid behavioral scientists designed and used drill-and-practice methods to improve memorization tasks (e.g., Suppes, 1966). They turned to an examination of the role and efficacy of computers and technology in education, a subject understood in a behaviorist research agenda that valued measurable results and formal experimental methods, as Koschmann (1996, pp. 5-6) notes in his critique of the period. Accordingly, a large amount of learning research in the 1960s, 1970s, and 1980s asked how the computer (an external stimulus) affects (modifies) the individual (a hard-wired learning system). Research questions focused on how the process of learning could be improved by using the computer, applied as enhancement or supplement to an otherwise unchanged learning environment.

We see these classic debates between empiricism and idealism as being connected with bifurcation and dualism. It was not possible at the time to understand how the working of the brain, a network of perceptions, could be connected with perspectives, the interpretations that people as individuals and as a society, make. In short, an embodied notion of how learning is not internally nor externallly "located." A wholistic view of the world did not seem possible, and for many scholars, unfortunately, it still is.

It is clear that any approach one takes to using technologies in the learning setting is rooted in one's concept of the mind. The mind as a site of research (and not just idealization or speculation) has its modern roots in the work of Jean Piaget (b. 1896), a natural scientist trained in zoology but most renowned for his work as a developmental psychologist and epistemologist. After becoming disillusioned with standardized testing methodologyat the Sorbonne in France, Piaget returned to Geneva in 1921 to dedicate the rest of his academic life to studying the child's conception of time (Piaget 1969), space (Piaget & Inhelder, 1956), number (Piaget 1952) and the world (Piaget, 1930). Although the idea that children could do things at one age that they could not do at another was not new, it was Piaget who was able to lay out a blueprint for children's conceptual development at different stages of their lives. For example, the classic theory of *conservation* eludes the young child: a tall glass contains more water than a short one even if the young child pours the same water from one glass into the other. Until Piaget, no one had conducted a body of experiments asking children to think about these phenomena and then mapped the diverse views that children use to solve problems into categories. By closely observing, recording his observations, and applying these to an emerging developmental theory of mind, Piaget and his team of researchers in Geneva developed the famous hierarchy of thinking stages: sensori-motor, pre-operational, concrete, and formal.

Piaget did not limit all thinking into these four rigid categories but rather used them as a way to deepen discussion on how children learn.

What is fundamentally different in Piaget's conception of mind is that unlike the behaviorist view that the external world affects the individual—a uni-directional approach with no input from the individual—the process of *constructivist* learning occurs in the mind of the child encountering, exploring, and theorizing about the world as the world is encountered as it moved through pre-set stages of life. The child's mind *assimilates* new events into existing cognitive structures and the cognitive structures *accommodate* the new event, changing the existing structures in a continually interactive process. *Schema* are formed as the child assimilates new events and moves from a state of disequilibrium to equilibrium, a state only to be put back into disequilibrium every time the child meets new experiences which cannot fit the existing schema. Beers (2001) has called the assimilation/accommodation process a *dialectical inter-action* among person, objects of creation (artifacts), and the curricular world in which the artifacts are created.

However, Piaget also believed that learning is a spontaneous, individual cognitive process, distinct from the sort of socialized and non-spontaneous instruction one might find in formal education, and that these two are in a somewhat antagonistic relationship. Critiquing Piaget's Constructivism, the great Soviet psychologist L.S.Vygotsky wrote:

We believe that the two processes—the development of spontaneous and of nonspontaneous concepts—are related and constantly influence each other. They are parts of a single process: the development of concept formation, which is affected by varying external and internal conditions but is essentially a unitary process, not a conflict of antagonistic, mutually exclusive forms of mentation. (Vygotsky 1962, p. 85)

Vygotsky heralded a departure from individual mind to social mind, and, as under his influence, educational theorizing moved away from its individual-focused origins and toward more socially or culturally situated perspectives. The paradigmatic approaches of key theorists in learning technology reflect this change as contributions from anthropology and social psychology gained momentum throughout the social sciences. The works of Vygotsky and the Soviet cultural-historical school (notably A. R. Luria and A. N. Leontiev), when translated into English, began to have a major influence, especially through the interpretations and stewardship of educational psychologists like Sylvia Scribner, Jerome Bruner, and Michael Cole (Scribner & Cole, 1981; Bruner 1990; Cole & Engeström, 1993; Cole & Wertsch, 1996). Vygotsky focused on the role of social context and mediating tools (language, writing, etc.) in the development of the individual, and argued that one cannot study the mind of a child without examining the "social milieu, both institutional and interpersonal" in which she finds herself (Katz & Lesgold, 1993). Vygotsky's influence, along with that of pragmatist philosopher John Dewey's seminal *Democracy in Education* (1916), opened up the study of technology in learning beyond individual cognition, thereby revealing its role in fostering social interaction and the betterment of a diverse, interconnected society. The ground in the last decade of the twentieth century thus became fertile for a growing range of new media and computational environments for learning, teaching, and research based on new advances in brain-based cognitive science coupled with a socially-mediated and distributed approach to the acqusition of knowledge (Pea & Bransford et al., 2000). This critical dichotomy between post-positivism and interpretivism would provide the philosophical inspiration for learning sciences research on technology in the first decade of the twenty-first century. But the path to social constructionism at the end of the twentieth century first took a circuitous route through what was known as CAI—*Computer-Aided Instruction*.

Instructional Technology: CAI Beginnings

An examination of the theoretical roots of computers in education exposes its behaviorist beginnings: the computer could reinforce activities that would bring about more efficient learning. For some, this meant "cheaper," for others, "faster," and for yet others, it meant without needing a teacher (see Bromley 1998 for a discussion). The oldest such tradition of computing in education is *Computer-Aided Instruction*, or CAI. This approach dates back to the early 1960s, notably in two research projects, at Stanford under Patrick Suppes (1966), and the PLATO project at the University of Illinois at Urbana-Champaign under Donald Bitzer and Dan Alpert (1970). Both projects utilized the then-new "time-sharing" computer systems to create learning opportunities for individual students. The potential existed for a time-sharing system to serve hundreds or even thousands of students simultaneously, and this economy of scale was one of the main drivers of early CAI research. A learner could sit at a terminal and engage in a textual dialogue with the computer system: question and answer. As such, CAI can be situated mostly within the behavioral paradigm (Koschmann, 1996, p. 6), though its research is also informed by cognitive science (e.g., Suppes applied new cognitive learning and memory theories to guide the interactions with students).

The Stanford CAI project explored elementary school mathematics and science education, and the researchers worked with local schools to produce a formidable amount of research data (Suppes, Jerman, & Brian, 1968; Suppes & Morningstar, 1972). Suppes began with tutorial instruction as the key model, and saw that the computer could provide individualized tutoring on a far greater scale than was economically possible before. Suppes envisioned computer tutoring on three levels: the simplest is drill-and-practice work, in which the computer administers a question and answer session with the student, judging responses correct or incorrect, and keeping track of data from the sessions. The second level was a more direct instructional approach: the computer would give information to the student, and then quiz the student on the information, possibly allowing for different constructions or expressions of the same information. In this sense, the computer acts much like a textbook. The third level was to be more sophisticated dialogic systems, in which a more traditional tutor-tutee relationship could be emulated (Suppes, 1966). Clearly, the simple drill-and-practice model is the easiest to actually implement, and as such the bulk of the early Stanford research uses this model, especially in the context of elementary school arithmetic (Suppes, Jerman, & Brian, 1968).

The research results from the Stanford experiments are not surprising: students do tend to improve over time with practice. For the time (the 1960s), however, to be able to automate the process was a significant achievement. More interesting from our perspective are the reflections Suppes offers, regarding the design of the human-computer interface: How and when should feedback be given? How can the system be tailored to different cognitive styles? How best to leverage the unprecedented amount of quantitative data the system collected about each student's performance and progress? (Suppes, 1966). These questions still form the cornerstone of much educational technology research.

The PLATO (Programmed Logic for Automated Teaching Operations) project at UIUC had a somewhat different focus (Alpert & Bitzer, 1970). Over several incarnations of the PLATO system through the 1960s, Bitzer, Alpert, and their team worked at the problems of integrating CAI into university teaching on a large scale, as indeed it began to be from the late 1960s. The task of taking what was then enormously expensive equipment and systems and making it economically viable in order to have individualized tutoring for students drove the development of the systems, and led PLATO to a very long career in CAI—in fact, the direct descendants of the original PLATO system are still being used and developed. The PLATO project introduced some of the first instances of computer-based manipulables, student-to-student conferencing, and computer-based "distance" education (Woolley, 1994).

From these beginnings, CAI and the models it provides for educational technology are now the oldest tradition in educational computing. While only partly integrated in the school system, CAI is widely used in corporate training environments, in remedial programs, and has had something of a resurgence with the advent of the World-Wide Web as online training has become popular. It is worth noting that the company Suppes started with Richard Atkinson at Stanford in 1967, Computer Curriculum Corporation, and NovaNet, a PLATO descendant spun off from UIUC in 1993 were both recently acquired by Pearson Education, the world's largest educational publisher (Pearson Education, 2000).

Cognitive Science and AI Research

In order to historically situate the development of learning technology, it is also important to appreciate the impact of the "cognitive revolution" (Gardner, 1985) on both education and technology.

For our purposes, the contribution of cognitive science is twofold. First, the advent of the digital computer in the 1940s led quickly to research on artificial intelligence (AI). By the 1950s, AI was already a substantial research program at universities like Harvard, MIT, and Stanford. And while AI research has not yet—nor, we believe, is likely to—produced an artificial mind, the legacy of AI research has had an enormous influence on our present-day computing paradigms, from information management to feedback and control systems and from personal computing to the notion of programming languages. All derive in large part from a full half-century of research in AI.

Second, cognitive science—specifically the contributions of Piagetian developmental psychology and AI research—gave the world the first practical models of mind, thinking, and learning. Prior to the cognitive revolution, our understanding of thinking was oriented either psychoanalytically or philosophically, out of the western traditions of metaphysics and epistemology, or empirically, via behaviorism. In the latter case, as mentioned earlier, cognition was regarded as a black box between stimulus and response. Since no empirical study of the contents of this box was possible, speculation as to what went on inside was both discouraged and ignored.

Cognitive science, especially by way of AI research, opened the box. For the first time, researchers could work from a model of mind and mental processes. In 1957, AI pioneer Herbert Simon went so far as to predict that AI would soon provide the substantive model for psychological theory, in the same way that Newton's calculus had once done for physics (Turkle, 1984, p. 244). Despite the subsequent humbling of AI's early enthusiasm, the effect this thinking has had on research in psychology and education and even the popular imagination (consider the commonplace notion of one's "short term memory") is vast.

The most significant thread or thrust of early AI research was Allen Newell and Herbert Simon's "information processing" model at Carnegie-Mellon University. This research sought to develop a generalized problem-solving mechanism, based on the idea that problems in the world could be represented as internal states in a machine and operated on algorithmically.

Newell and Simon saw the mind as a “physical symbol system” or “information processing system” (Simon 1981 [1969], p. 27), and believed that such a system is the “necessary and sufficient means” for intelligence (p. 28). One of the venerable traditions of this model is the chess-playing computer, long bandied as exemplary of intelligence. Ironically, world chess master Gary Kasparov's historic defeat to IBM's “Deep Blue” supercomputer in 1997 had far less rhetorical punch than AI critic (and chess novice) Hubert Dreyfus’ defeat in 1965, but the legacy of the information-processing approach cannot be underestimated.

Yet it would be unfair to equate all of classical AI research with Newell and Simon's approach. Significantly, research programs at Stanford and MIT, though perhaps lower profile, made significant contributions to the field. Two threads in particular are worthy of comment here. One was the development of “expert systems,” concerned with the problem of knowledge representation—for example Edward Feigenbaum's DENDRAL, a system which contained large amounts of domain-specific information in biology. Another was Terry Winograd's 1970 program, SHRDLU, which first tackled the issue of indexicality and reference in an artificial microworld (Gardner ,1985). As Gardner (1985) points out, these developments demonstrated that Newell and Simon's “generalized” problem- solving approach would give way to more situated, domain-specific approaches.

The culmination of this approach are the Cognitive Tutors out of Carnegie Mellon University. These are both a successful product widely used in schools (www.carnegielearning.com) and an active ongoing research project (coordinated through the Pittsburgh Science of Learning Center –www.learnlab.org). The Cognitive Tutors apply John Anderson’s ACTR (Anderon, 1993) cognitive architecture (which is descended from Newell and Simon’s) to represent the knowledge to be taught (mostly If-Then production rules) then this knowledge is represented in the tutor so that it can understand what the student is doing when solving problems and provide "intelligence" feedback (Anderson Corbet, Koedinger & Pelletier, 1995). These tutors show impressive results in tests comapred to classroom intruction and when compared to traditional CAI (like the Suppes kind): they do around one effect size (one standard deviation) better than classroom instruction – tradition CAI does 0.3 effect size better than classroom instruction so the Cognitive Tutors are 3 times as effective as traditional CAI (Kulik & Kulik, 1991). However, what these Cognitive Tutors are so effective at is teaching how to solve problems in areas like high school Algebra and Geometry; there is some question remaining whether they can also teach an understand of why these solution methods work.

At MIT in the 1980s, Marvin Minsky's work led to a theory of the "society of minds"—that, rather than intelligence being constituted in a straightforward representational and algorithmic way, intelligence is seen as the emergent property of a complex of subsystems working independently (Minsky, 1986). The notion of *emergent AI*, more recently explored through massively parallel computers, has with the availability of greater computing power in the 1980s and 1990s become the mainstream of AI research (Turkle, 1995, pp. 126-127). Interestingly, Gardner (1985) points out that the majority of computing—and therefore AI—research has been located within the paradigm defined by Charles Babbage, Ada Lovelace, and George Boole in the 19th century. Babbage and Lovelace are commonly credited with the basic idea of the programmable computer; Lady Ada Lovelace's famous quote neatly sums it up: "The analytical engine has no pretensions whatever to originate anything. It can do whatever we know how to order it to perform." George Boole's contribution was the notion that a system of binary states (0 and 1) could suffice for the representation and transformation of logical propositions. But computing research began to find and transcend the limits of this approach.

The rise of emergent AI was characterized as "waking up from the Boolean dream" (Douglas Hofstadter, quoted in Turkle 1995, p, 135). In this model, intelligence is seen as a property emergent from, or at least observable in, systems of sufficient complexity. Intelligence is thus not defined by programmed rules, but by adaptive behavior within an environment.

From Internal Representation to Situated Action. The idea of taking contextual factors seriously became important outside of pure AI research as well. A notable example was the reception given to Joseph Weizenbaum's famous program, ELIZA. When it first appeared in 1966, ELIZA was not intended as serious AI; it was an experiment in creating a simple conversational interface to the computer—outputting canned statements in response to certain "trigger" phrases inputted by a user. But ELIZA, with 'her' reflective responses sounding a bit like a Rogerian analyst, became something of a celebrity—much to Weizenbaum's horror (Turkle 1995, 105). The popular press and even some psychiatrists took ELIZA quite seriously. Weizenbaum argued against ELIZA's use as a psychiatric tool, and against mixing up human beings and computers in general, but ELIZA's fame has endured. The interface and relationship that ELIZA demonstrates has proved significant in and of itself, regardless of what computational sophistication may or may not lie behind it.

Another contextualist effort took place at Xerox' Palo Alto Research Center (PARC) in the 1970s, where a team led by Alan Kay developed the foundation for the "personal computing" paradigm we know today. Kay's team is most famous for developing the mouse-and-windows interface—which Brenda Laurel (1990) later called the "direct manipulation" interface. However, at a more fundamental level, the Xerox PARC researchers defined a model of computing that branched away from a formalist, rules-driven approach, and toward a notion of the computer as curriculum: an environment for designing, creating, and using digital tools.

This approach partly came from explicitly thinking of children as the designers of computing technology. Kay wrote:

We were thinking about learning as being one of the main effects we wanted to have happen. Early on, this led to a 90-degree rotation of the purpose of the user interface from 'access to functionality' to 'environment in which users learn by doing.' This new stance could now respond to the echoes of Montessori and Dewey, particularly the former, and got me, on rereading Jerome Bruner, to think beyond the children's curriculum to a 'curriculum of user interface.' (Kay, 1996, p. 552)

In the late 1980s, Terry Winograd and Fernando Flores' *Understanding Computers and Cognition: A New Foundation for Design* (1986) heralded a new direction in AI and intelligent systems design. Instead of a rationalist, computational model of mind, Winograd and Flores described the emergence of a de-centered and situated approach. The book drew on the phenomenological thinking of Martin Heidegger, the biology of perception work of Humberto Maturana and Francisco Varela, and the speech-act theory of John Austin and John Searle to call for a situated model of mind-in-the-world, capable of (or dependent upon) commitment and intentionality in real relationships. Winograd and Flores' work raised significant questions about the assumptions of a functionalist, representational model of cognition, arguing that such a view is based on highly questionable assumptions about the nature of human thought and action.

In short, the question of how these AI and cognitive science developments have affected the role of technology in the educational arena can be summed up in the ongoing debate between instructionist "tutoring" systems and constructivist "toolkits." While the earliest applications of AI to instructional systems attempted to operate by creating a model of knowledge or a problem domain and then managing a student's progress in terms of deviation from that model (Suppes, 1966; Wenger, 1987), later and arguably more sophisticated construction systems looked more like toolkits for exploring and reflecting on one's thinking in a particular realm (Brown & Burton, 1978; Papert, 1980).

Kinds of Digital Media Learning

When theorizing about the role of digital media learning environments in learning, the tendency is often to use an instrumentalist and instructionist approach—the computer, for example, is a useful tool for gathering or presenting information (which is often and incorrectly equated with knowledge). Even within the constructionist paradigm, the social dimension of the learning experience is forgotten, focusing only on the individual child. And, even when we remember the Vygotskian *zone of proximal development* (ZPD) with its emphasis on the socially-mediated context of learning, we tend to overlook the differences that individuals themselves have in their learning styles when they approach the learning experience. And even when we consider group and individual differences, we fail to examine that individuals themselves try out many styles depending on the knowledge domain being studied and the context within which they are participating. And, most importantly, even when the idea that individuals have diverse points of viewing the world is acknowledged, technologists and new media designers often do little to construct learning environments that truly encourage social construction and knowledge creation.

Designing and building tools as perspectivity technologies, we argue, enables learners to participate as members of communities experiencing and creating new worlds from the points of viewing of their diverse personal identities while contributing to the public good of the digital commons. Using perspectivity technologies, learners—like stars in a constellation—are connected to each other within a force that enables them to change their position and viewpoint yet stay linked within the larger and also moveable construct of the total configuration of many constellations, galaxies, and universes. It is within the elastic tension among all the players in the community—the learner, the teacher, the content, the artifacts created, and most importantly the context of the forces within which they communicate—that new knowledge in, around, and about the world is created.

The next section has been organized less chronologically and more functionally, examining technologies from a variety of perspectives: as information sources, curricular areas, communications media, tools, environments, partners, scaffolds, and finally, as perspectivity toolkits. We also return to the importance of using the Points of Viewing Theory as a framework for designing new media applications and tools. These assorted technology approaches are not intended to be mutually exclusive; they are headers that often illustrate one aspect of a technology from a particular angle. How a technology should be characterized depends on how it used *in situ*. A learning technology may be designed in a monological fashion while in the context of use it becomes dialogical with the presence of human actors (Bakhtin, 1981; Wegerif, 2007). And vice versa—technologies designed from a social constructionist framework may find their promise betrayed if used to serve instructionist goals and a single prevailing world view. With the explosion of ubiquitous learning with handheld devices in recent years, eroding the traditional distinction between formal and informal learning, the potential for complex, meaningful, dialogically rich learning is greater than it has ever been (Burbules, 2009). Within this context, it is essential to consider how perspectivity technologies can better accomodate these changes and provide a guiding light for future research and development.

Digital Media for Information

When we investigate how meaning is made, we can no longer assume that actual social meanings, materially made, consist only in the verbal-semantic and linguistic contextualizations (paradigmatic, syntagmatic, intertextual) by which we have previously defined them. We must now consider that meaning-in-use organizes, orients, and presents, directly or implicitly, through the resources of multiple semiotic systems. (Lemke, 1998)

Access to information has been the dominant mythology of computers in education for many educators. Not taking the time to consider how new media texts bring with them new ways of understanding them, educators and educational technologists have often tried to add computers to learning as one would add salt to a meal. The idea of technology as information source has captured the imagination of school administrators, teachers, and parents hoping that problems of education could be solved by providing each student with access to the most current knowledge (Graves, 1999). It is no different these days: legislators and policy makers are still trying to bridge the "digital divide." As of 2012, the state of Maine is the only state in the US with an Internet-connected computer on every desktop.

While a growing number of postmodern theorists and semioticians see computers and new media technologies as *texts* to deconstruct (Lemke, 2001; Landow, 1992), it is more common to see computers viewed as *textbooks*. In spite of Lemke's reminder that these new media texts require translation and not only digestion, the computer is commonly seen as merely a more efficient method of providing instruction and training, with *information* equated with *knowledge*. Learners working with courseware are presented with information and then tested or questioned on it, much as they would using traditional textbooks. The computer can automatically mark student responses to questions and govern whether or not the student moves on to the next section, freeing the teacher from this task—an economic advantage noted by many educational technology thinkers.

In the late 1980s, *multimedia*—audio, graphics, and video—dominated the educational landscape. Curriculum and learning resources, first distributed as textbook and accompanying floppy-disc, began to be distributed on videodisc or CD-ROM, media formats able to handle large amounts of multiple media information. In the best cases, multimedia resources employed *hypertext* or *hypermedia* (Landow, 1992; Swan, 1994) navigation schemes, encouraging non-linear traversal of content. Hypermedia, as such, represented a significant break with traditional, linear instructional design models, encouraging users to *explore* resources by following links between discrete chunks of information rather than simply following a programmed course. One of the best early exemplars was Apple Computer's classic *Visual Almanac: An Interactive Multimedia Kit* (1989), which enabled students to explore rich multimedia vignettes about interesting natural phenomena as well as events from history and the arts.

The rise of Internet and search engines such as Google, has stimulated the production of computer-based curriculum resources once again. As a sort of universal multimedia platform, the web's ability to reach a huge audience very inexpensively has led to its widespread adoption in schools, training centers, corporations, and, significantly, the home. More than packaged curriculum, however, the use of the Internet and World Wide Web as an open-ended research tool has had an enormous impact on classrooms. Since the software for browsing the web is free (or nearly free) and the technology and skills required to use it are so widespread, the costs of using the web as a research tool are largely limited to the costs of hardware and connectivity. This makes it an obvious choice for teachers and administrators often unsure of how to best allocate technology funds. The popular reputation of the web as a universal library or as access to the world's information (much moreso that its reputation as a den of pornographers and pedophiles) has led to a popular mythology of children reaching "beyond the classroom walls" to tap directly into rich information sources, communicate with scientists and experts, and expand their horizons to a global view. Of course, such discourse needs to be examined in the light of day: the web is a source of bad information as well as good, and we must also remember that *downloading is not equivalent to learning.* As early as 2000, Roger Schank observed that

"access to the Web is often cited as being very important to education, for example, but is it? The problem in the schools is not that the libraries are insufficient. The Web is, at its best, an improvement on information access. It provides a better library for kids, but the library wasn't what was broken (Schank, 2000). Indeed he made a good point that the problem is elsewhere, yet within a short decade the "possibility" of better use of the access to a universe of materials has arrived.

In a similar vein, "correspondence schools"—both university-based and private businesses dating back to the 19th century—are mirrored in today's crop of online distance learning providers (Noble 1999). In the classic distance education model, a student enrolls, receives curriculum materials in the mail, works through the material and submits assignments to an "instructor" or "tutor" by mail. Hopefully, the student completes everything successfully and receives accreditation. Adding computers and networks to this model changes very little, except for lowering the costs of delivery and management substantially (consider the cost savings of replacing human tutor/markers with an AI system). Again, in one decade is not uncommon for leading universities to offer high quality online degrees. Most programs have some courses that are available to students and the "push-back" from resistant faculty who associated Do-It-Yourself (DIY) learning has all but disappeared. Anya Kamenetz's 2010 *DIYU: Edupunks, Edupreneurs, and the Coming Transformation of Higher Education* became an instant read across higher education with blogs and tweets that raised fear throughout the academic establishment. The title of a May 3, 2010 article in the Chronicle of Higher Education by Seth Godin was *The Coming Meltdown in Higher Education (as Seen by a Marketer).* Jay Cross and colleagues from the Internet Time Alliance, created the 2010 version of his "unbook," which he and his friends call "*Working Smarter: Informal Learning in the Cloud.*" Updates to the unbook can be found regularly by Cross and friends at http://www.internettime.com.

Despite this current groundswell, the basic pedagogical questions about education remain: to what extent do learners in isolation actually learn? The introduction of electronic communication and conferencing systems into distance education environments has no doubt be shown to improve student's experiences (Hiltz & Goldman, 2004), and this has certainly been a widespread development, but the economic and educational challenges driving online learning still make it an abivalent choice for both students and educators concerned with the learning process and accreditation. It will take a new system of evaluation of credentials before institutuional bricks and mortar will become even close to obsolete. Aftetr two decades of knowing introducing technologies into day-to-day work and study,

institutions of higher education are finally responding with full force to create new kinds of learning environments that include formal and informal learning (ateliers and open community labs) as well as online mixed with face-to-face (f2f) classroom learning. The next major hurdle will be addressing global learning, a subject that New York University, for example, has moved into with full force with branches in Abu Dhabi and Shanghai, not to mention satelite programs and infrastructure in Buenos Aires, Paris, London, Florence, Acra, Singapore, Prague, London, Tel Aviv, and more recently, Madrid.

Digital Media for Literacy in STEM

Economic urgency and a chronic labor shortage in IT (Information Techologies) and STEM (Science, Technology, Engineering, and Mathematics) professions and the increasingly changing needs for updating computers and networks in the workplace continue to drive the demands for gaining design and compuational literacy. Learning in both formal and informal settings, including businesses and schools, requires access to information and people who can design, built, and create curricular learning environments in disciplinary and cross-disciplinary areas. Although the field of Technology Studies as a program area has existed in high schools and universities since the 1970s, it is interesting to note how much variation there is in the curriculum, across grade levels, from region to region, and from school to school—perhaps increasingly so as years go by. Apart from the US College Board's Advanced Placement (AP) Computer Science Curriculum, which is focused on professional computer programming, what one school or teacher implements as the "computer science" or "information technology" curriculum is highly varied, and probably very dependent upon individual teachers' notions and attitudes toward what is important. The range includes straightforward computer programming (as in the AP curriculum), multimedia production (Roschelle *et. al.* 1998), technology management (Wolfson & Willinsky, 1998), exploratory learning (Harel & Papert, 1991), textbook learning about bits and bytes, and so on. Standards are hard to come by, of course, because the field is so varied and changing.

A most straightforward conclusion one may draw from looking at our economy, workplace, and prospects for the future is that computer-based technologies are increasingly part of how we work. It follows simply that knowing how to effectively use computers is a requirement for many jobs or careers. This basic idea drives the "job skills" approach to computers in education. In this model, computer hardware and software, particularly office productivity and data processing software are the cornerstone of technology curriculum, since skill with these applications is what "employers are looking for." One can find this model at work in most high schools and it is dominant in re-training and economic development programs. And while its simple logic is easy to grasp, perhaps this model is a reminder that simple ideas can be limiting. Heeding this dilemna, Seymour Papert, invoking curriculum theorist Paolo Freire, writes

If "computer skill" is interpreted in the narrow sense of technical knowledge about computers, there is nothing the children can learn now that is worth banking. By the time they grow up, the computer skills required in the workplace will have evolved into something fundamentally different. But what makes the argument truly ridiculous is that the very idea of banking computer knowledge for use one day in the workplace undermines the only really important "computer skill": the skill and habit of using the computer in doing whatever one is doing. (Papert, 1992, p. 51)

Papert's critique of computer skills leads to a discussion of "computer literacy," a term almost as old as computers themselves, and one that is notoriously elusive. As far back as 1985, Douglas Noble noted that no one is sure what exactly computer literacy is, but everyone seems to agree that it is good for us (Noble, 1985, p. 64).

Sharon Derry and Daniel Zalles (2011) go beyond a theory of literacy to exploring how literacy is important for scientific civic reasoning. They propose "that active, collective citizenship through responsible civic reasoning, empowered by tools of science and technology, is an important educational goal of our time." They challenge the public to explore the connection between societal phenomenom and discipline-based science, using a six step approach: 1) seeking consensus around what is worth studying; 2. leveraging the power structures to ensure adequate funding; 3. Operationalizing systematic research; 4. employing a "culture of principled, unbiased, constructive critical discourse;" 5. finding evidence for setting policy and taking civic action; and 6. evaluating effectiveness. In short, they argue that a civil society requires that children be literate/fluent with both civics and technologies.

Take a different perspective, we note that the two books by John Willinsky, *The New Literacy* (1990) and *The Access Principle: The Case of Open Access to Research and Scholarship* (2006) expand upon the idea that one needs to be "literate in literacy" (p. 236), a phrase we now change to *literate in digital literacies*. Willinsky's *The New Literacy* emerges from the roots of popular culture, the Progressive Education Movement and even further back to the Romantics. It is grounded in the critical and yet inspirational work that can be reached through the thoughtful inquiry of teachers and students working together to redefine a new kind of place for themselves. In essence, the school becomes the language of this new literacy. Fifteen years later in *The Access Principle*, Willinsky focuses more on how we come to know and share what we know in open access digital environments. Pointing to a long history to make knowledge public, Willinsky encourages the movement of cloistered knowledges held in most part by institutional repositories toward the democratization of knowledge.

> "…[A]n open access to scholarly publishing is not simply a side issues, a matter of bussiness plans and delivery systems, in the pursuit of truth…. Rather, the potential expansion in the circulation of ideas is much about the quality of truth pursued in such

> settings. I would agrue that the global scale of knowledge's circulation is critical to its very claim as knowledge. (2006, p. 34).

Certainly, Willinsky could not have predicted what came to be called the Arab Spring in 2011. In this time of protest against the existing regimes in individual countries (Tunesia, Egypt, Syria, etc.) that are embodied in the fight for greater freedom acrosss the Arab world, we can see how easy to use and accessible mobile technologies as well as social media software such as Twitter™ and Facebook™gave access to information that led to communities sharing their perspectives and critiquing existing traditions of truth through a more negotiated understanding of what was felt and understood on the ground. Although it is unclear how the quality of truth can ever be reached, perhaps, what can be found in these contested spaces is incremental agreements that bring about verisimilitude and a more general acceptance that differences of experiences and understandings can be reached through access to knowledge, resources, and power to make changes for the good of society. If Michel Foucault's book *Knowledge/Power* (1980) ever needed a rereading, it is in times of not only a literacy explosion, but also one that is seeped in issues to do with who decides what the best way of interpreting information to build a more just system.

Still, we must ask, what is the nature of literacy in STEM learning? Early attempts to define it come from such influential figures as J.C.R. Licklider, one of the founders of what is now the Internet, and whose notion of computer literacy drew much on John Dewey's ideas about a democratic populus of informed citizens. As computers became almost ubiquitous in the first decade of the 21st Century, people began what now seems like a lifelong exploration to understand the role of these new technologies in their lives. The inevitable reduction of "computer literacy" to a laundry list of knowledge and skills (compare with E.D. Hirsch's controversial *Cultural Literacy*) prompted Papert to respond with appeals to the richness of what "literacy" means:

When we say "X is a very literate person," we do not mean that X is highly skilled at deciphering phonics. At the least, we imply that X knows literature, but beyond this we mean that X has *certain ways of understanding the world that derive from an acquaintance with literary culture.* In the same way, the term computer literacy should refer to the kinds of knowing that derive from computer culture. (1992, p. 52) *italics added*

Other contributions to the notion of digital literacy remain rooted in the particular perspectives of their contributors. Alan Kay (1996) wrote of an "authoring literacy." Journalist Paul Gilster (2000) talked about "digital literacy." Andrea diSessa (2000), creator of the *Boxer* environment, wrote extensively on "computational literacy," a notion he hopes will rise above the banality of earlier conceptions.

Clearly, by computational literacy I do not mean a casual familiarity with a machine that computes. In retrospect, I find it remarkable that society has allowed such a shameful debasing of the term *literacy* in its conventional use in connection with computers. (diSessa 2000, p. 5)

Rand Spiro and colleagues (2007 & 2001), an educational pioneer of how learning changes with hypermedia, multimedia, and now web-base interactive media, explained how learners become literate using the global and well-known approach called Cognitive Flexibility Theory (CFT). Using the following analogy of "criss-crossing landscapes," they weave a way for learners to gain "deep learning" in knowledge domains that are "ill-structured."

When one criss-crosses landscapes of knowledge in many directions (the main instructional metaphor of CFT, drawn from Wittgenstein, a revisiting is not a repeating. The result is knowledge representations whose strength is determined not by a single conceptual thread running through all or most parts of the domain's representation, but rather from the overlapping of many shorter conceptual "fibers" (Wittgenstein, 1953), as befits an ill-structured domain. (Spiro, Collins, & Ramchandran, 2007, p. 96).

The difficulty of coming to terms with computer or digital literacy in any straightforward way has led Mary Bryson to identify the "miracle worker" discourse that results, in which "experts" are called upon to step into a situation and implement the wonders that technology promises.

[W]e hear that what is essential for the implementation and integration of technology in the classroom is that teachers should become "comfortable" using it ... we have a master code capable of utilizing in one platform what for the entire history of our species thus far has been irreducibly different kinds of things ... *every conceivable form of information can now be comined with every other kind to create a different form of communication, and what we seek is comfort and familiarity?* (de Castell, Bryson, & Jenson, 2000) *italics added*

Familiarity and comfort, indeed! Bring on the affordances, they are proposing!

However difficult to define, some sense of "literacy" is going to be an inescapable part of thinking about digital technology and learning. If we move beyond a simple instrumental view of the computer and what it can do, and take seriously how it changes the ways in which we relate to our world, then the issue of how we relate to such technologies, in the complex sense of a *literacy*, will remain crucial.

Digital Media as Thinking Tools

David Jonassen is perhaps best known in the educational technology domain as the educator connected with bringing to prominence the idea of computer as *mindtool* (2005; 1996). Breaking rank with his previous instructionist approach detailing what he termed *frames for* *instruction* (Duffy & Jonassen 1992), Jonassen's later work reflects the inspiration of leading constructionist thinkers like Seymour Papert. One of the classic quotations on the use of the computer as a tool from Papert's landmark book, *Mindstorms: Children, Computers, and Powerful Ideas* (1980), is:

For me, the phrase "computer as pencil" evokes the kind of uses I imagine children of the future making of computers. Pencils are used for scribbling as well as writing, doodling as well as drawing, for illicit notes as well as for official assignments (Papert, 210).

While it is easy to think of the computer as a simple tool—a technological device which we use to accomplish a certain task as we use a pen, abacus, canvas, ledger book, file cabinet, and so on—a tool can be much more than just a better pencil. It can be a vehicle for interacting with our intelligence—a thinking tool and a creative tool. For example, a popular notion is that learning mathematics facilitates abstract and analytic thinking. This does not mean that mathematics can be equated with abstract thinking. The computer as a tool enables learners of mathematics to play with the elements that create the structures of the discipline. To use Papert's example, children using the Logo programming language explore mathematics and geometry by manipulating a virtual "turtle" on the screen to act out movements that form geometric entities (Papert, 1980). Children programming in Logo think differently about their thinking, becoming epistemologists. As Papert would say, Logo is not just a better pencil for doing mathematics but a tool for thinking more deeply about mathematics, by creating procedures and programs, structures within structures, constructed, deconstructed, and reconstructed into larger wholes.

Papert led a groundbreaking series of research projects that brought computing technology to school-children using Logo. In *Mindstorms,* Papert explained that Logo puts children in charge of creating computational objects— originally, by programming a mechanical "turtle" (a 1.5 foot round object that could be programed to move on the floor and could draw a line on paper as it moved around), and then later a "virtual" turtle that moved on the computer screen. Aprotégé of Jean Piaget, Papert was concerned with the difficult transition from "concrete" to "formal" thinking. Papert saw the computer as the tool that could make the abstract concrete:

Stated most simply, my conjecture is that the computer can concretize (and personalize) the formal. Seen in this light, it is not just another powerful educational tool. It is unique in providing us with the means for addressing what Piaget and many others see as the obstacle which is overcome in the passage from child to adult thinking (Papert, 1980, p. 21).

Beyond Piaget's notion of constructivism, the theory of *constructionism* focused its lens less on the stages of thought production and more on the artifacts that learners build as creative expressions of their understanding. Papert understood the computer as not merely being a tool (in the sense of a hammer) but as an *object-to-think-with* that facilitates novel ways of thinking.

Constructionism—the N word as opposed to the V word—shares constructivism's connotation of learning as building knowledge structures irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe (Papert, 1991, p. 1).

By the late 1980s, the research conducted by the Learning and Epistemology Research Group at MIT was one of the most influential forces in learning technology. A large-scale intensive research project called Project Headlight was conducted at the Hennigan School in Boston, studying all manner of phenomena around the experience of school-children and Logoequipped computers. A snapshot of this research is found in the edited volume, *Constructionism* (Harel & Papert, 1991), which covers the perspectives of sixteen researchers. For example, Aaron Falbel and Ricki Goldman-Segall situated their research in Ivan Illich's theory of conviviality as described in *Tools for Conviviality* (Illich, 1973)—a theory that, in its simplest form, recommends tools be simple to use, accessible to all, and beneficial for humankind. Falbel worked with children to create animation from original drawings and to think of themselves as convivial learners. Goldman-Segall conducted a three-year video ethnography of children's thinking styles in computer-rich learning cultures and created a computer-based video analysis tool called *Learning Constellations* to analyze her video cases. In Judy Sachter's work, children explored their understanding of 3-D rotation and computer graphics, leading the way for understanding how children understand gaming. At the same time, Mitchell Resnick, Steve Ocko, and Fred Martin designed smart LEGO™ bricks controlled by Logo. These LEGO™ objects could be programmed to move according to Logo commands (Resnick & Ocko, 1991; Martin & Resnick, 1993). Researcher Nira Granott asked adult learners to deconstruct how and why these Lego robotic creatures moved in the way they did. Her goal was to understand the construction of internal cognitive structures that allow an interactive relationship between creator and user (Granott, 1991).

Granott's theory of how diverse individuals understand the complex movements of Lego™/Logo "creatures" was woven into a new fabric which Resnick—working with Lego/Logo robots— called *distributed constructionism* (Resnick, 1991& 1994). Uri Wilensky, with Resnick, deepened the theoretical framework around the behavior of complex systems, introducing a "levels" framework (Resnick & Wilensky, 1998; Wilensky & Resnick, 1999; Wilensky & Reisman, 2006).). To model, describe, predict and explain emergent phenomena in complex systems, Resnick and Wilensky designed StarLogo™; Wilensky has more recently designed the more widely used successor, NetLogo™ (Wilensky, 1999) which also includes a module for conducting participatory simulations (Wilensky & Stroup, 1999). Wilensky, a mathematician concerned with expanding mathematics education, connected it more to science education and to probability (Wilensky, 1993), is oft cited for his asking a simple question to young people: How do geese fly in formation? The answers that young people give show how interesting yet difficult emergent phenomena are to describe.

Mathematics was an important frame for much of the research conducted in Project Headlight. Papert himself was a noted mathematician. In one study at the Hennigan School, Harel worked with groups of children creating games in Logo for other children to use in learning about fractions. The idea that children could be designers of their owrn learning environments was developed further by Yasmin Kafai who introduced computer design to understand how girls and boys think when playing and designing games, a topic of great interest to video game designers (Kafai, 1993; 1996). Kafai has spent more than a decade creating a range of video game environments for girls and boys to design environments for learning. In short, Kafai connected the world of playing and designing to the life of the classroom in a number of studies in the 1990s and early 2000s. Here current work at the University of Pennsylvania focuses on topics connected with the Learning Sciences, Constructionism, games, virtual worlds, and gender.

Continuing to expand Papert's legacy with a new generation of graduate students, Kafai (then) at UCLA, Resnick at the MIT Media Lab, Granott at the University of Texas in Dallas, Ricki Goldman at New York University, and Wilensky at Northwestern University, continue to explore the notion of computer device as a thinking tool from the constructionist perspective.

Constructionism is now more social, distributed, and complex an approach and has also been re-interpreted with a more situated and ecological perspective than in the mid-1980s. To be expected given the technological changes.

Digital Media for Scaffolding

The computer as *scaffold* is yet another alternative to tool, environment, or partner. This version makes reference to Vygotsky's construct of the *zone of proximal development* (ZPD), defined as

...the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, 1978, p. 86)

The scaffold metaphor originally referred to the role of the teacher, embodying the characteristics of providing support, providing a supportive tool, extending the learner's range, allowing the learner to accomplish tasks not otherwise possible, and being selectively usable (Greenfield, 1984, p. 118).

Vygotsky's construct has been picked up by designers of educational software, in particular the CSILE project at the Ontario Institute for Studies in Education (OISE). At OISE, Marlene Scardamalia and Carl Bereiter worked toward developing a collaborative knowledge-building environment and asked how learners (children) could be given relatively more control over the ZPD through directing the kinds of questions that drive educational inquiry (Scardamalia & Bereiter, 1991). The CSILE environment provided a scaffolded conferencing and note-taking environment in which learners themselves could be in charge of the questioning and inquiry of collaborative work—something more traditionally controlled by the teacher—in such a way that kept the endeavour from degenerating into chaos.

Another example of technological scaffolding comes from George Landow's research into using hypertext and hypermedia—non-linear, reader-driven text and media—in the study of English literature (Landow & Delany, 1993). In Landow's research, a student could gain more information about some aspect of Shakespeare, for example, by following any number of links presented in an electronic document. A major component of Landow's work was his belief in providing students with the context of the subject matter. The technological scaffolding provides a way of managing that context—so that it is not so large, or complicated, or daunting that it prevents learners from exploring, but flexible and inviting enough to encourage exploration beyond the original text. The question facing future researchers of these non-linear and alternately structures technologies may be this: can the computer environment create a place in which the context or the culture, as anthropologist Clifford Geertz (1973) would say, is felt, understood, and can be communicated to others? More controversially, perhaps, can these technologies be designed and guided by the learners themselves without losing the richness that direct engagement with experts and teachers can offer them?

Digital Media for Cognitive Partnering

Somewhere amid conceiving of computing technology as artificial mind and conceiving of it as communications medium is the notion of computer as partner. This somewhat more romanticized version of "technology as tool" puts more emphasis on the communicative and interactive aspects of computing. A computer is more than a tool like the pencil that one writes with because, in some sense, it writes back. And while this idea has surely existed since early AI and ITS research, it wasn't until an important article in the early 1990s (Salomon, Perkins, & Globerson, 1991) that the idea of computers as "partners in cognition" was truly elaborated.

As early as the 1970s, Gavriel Salomon had been exploring the use of media (television in particular) and its effect upon childhood cognition (Salomon 1979). Well versed in Marshall McLuhan's (1964) adage, *the medium is the message*, later to become *the medium is the massage*, Salomon has built a bridge between those who propose an instrumentalist view of media (media effects theory) and those who understand media to be a cultural artifact in and of itself. Along these lines, in 1991, Salomon, David Perkins, and Tamar Globerson drew a very important distinction:

Effects *with* technology obtained during partnership with it, and effects *of* it in terms of the transferable cognitive residue that this partnership leaves behind in the form of better mastery of skills and strategies" (Salomon, Perkins, & Globerson, 1991, p 2).

Their article came at a time when the effects of computers on learners were being roundly criticized (Sloan 1985; Pea & Kurland, 1987), and helped break new ground toward a more distributed view of knowledge and learning (Brown, Collins, & Duguid, 1996 [1989]; Pea, 1993).To conceive of the computer as a partner in cognition—or learning, or work—is to admit it into the cultural milieu, to foreground the idea that the machine, in some way has *agency* or at least influence in our thinking.

If we ascribe agency to the machine, we are going some way toward anthropomorphizing it, a topic Sherry Turkle has written about extensively (Turkle, 1984; 1995). Goldman-Segall writes of her partnership with digital research tools as "a partnership of intimacy and immediacy" (1998a, p. 33). MIT interface theorist Andrew Lippman defined interactivity as mutual activity and interruptibility (Brand, 1987), and Alluquere Rosanne Stone goes further, referring to the partnership with machines as "a prosthetic device" for constructing desire (Stone, 1995). Computers are, as Alan Kay envisioned in the early 1970s, *personal* machines.

The notion of computers as cognitive partners is further exemplified in research conducted by anthropologist Lucy Suchman at Xerox. Suchman's *Plans and Situated Actions: The Problem of Human- Machine Communication* explored the difference between rational, purposive plans, and circumstantial, negotiated, situated actions. Rather than actions being imperfect copies of rational plans, Suchman showed how "plans" are idealized representations of real-world actions. With this in mind, Suchman argued that, rather than working toward more and more elaborate computational models of purposive action, researchers give priority to the contextual situatedness of practice:

A basic research goal for studies of situated action, therefore, is to explicate the relationship between structures of action and the resources and constraints afforded by physical and social circumstances. (Suchman, 1987, p. 179)

Suchman's colleagues at Xerox PARC in the 1980s designed tools as structures within working contexts; innovative technologies such as collaborative design boards, real-time virtual meeting spaces, and video conferencing between co-workers were a few of the environments at PARC where people could *scaffold* their existing practices.

Media for Social Constructionism

Historically, constructivist learning theories were rooted in the epistemologies of social constructivist philosopher John Dewey, social psychologist Lev Vygotsky, developmental and cognitive psychologist Jerome Bruner. Knowledge of the world is seen to be constructed through experience; the role of education is to guide the learner through experiences that provide opportunities to construct knowledge about the world. In Piaget's version, this process is structured by the sequence of developmental stages. In Vygostsky's cultural-historical version, the process is mediated by the tools and contexts of the child's sociocultural environment. As a result of the influence of Vygotsky's work, researchers in a variety of institutions view the computer and new media technologies as environments, drawing on the notion that learning happens best for children when they are engaged in creating personally meaningful digital media artifacts and sharing them publicly. Learning and Epistemology Group, the Center for Children and Technology, Vanderbilt's Cognition and Technology Group, TERC, the Concord Consortium in Boston, Georgia Tech, and SRI are just a few of the exemplary research settings involved in the exploration of learning and teaching using technologies as learning environments during the 1990s. Several of these communities (SRI International, Stanford, Berkeley, and the Concord Consortium) formed an association called CILT, the Center for Innovation in Learning and Teaching which became a hub for researchers from many institutions. More recently, a National Science Foundation Science of Learning Center called LIFE (Learning in Informal and Formal Environments), was established. It is hosted at the University of Washington in partnership with Stanford University and SRI International.

The range of methodological perspectives employed in these various research institutions, however, is as diverse as might be expected. Moreover, the discussion about what constitutes good research varied from community to community with some using mostly qualitative methods and others using quantitative measures and methods. Qualitative research methods, with their emphasis on case studies and in-depth analyses, best describe the conclusions of a study that is constructionist by design. Constructionists tend to be interested in digging around in the complexity of a small set of events while instructionists tend to focus on the organization of a larger set of variables. An instructionist tends to first look at a whole system and then break the whole into smaller units to be learned or processed; constructionists build up. They put together small units and combine micro- procedures into the elements—or chunks—of larger structures and wholes. This does not mean that constructionists don't have plans as they tinker or play with computational objects. Far from it; constructionists have plans which are in continual flux as the parts of any whole program are built, assembled, and integrated (Suchman, 1987). Even the smallest change in a procedure can dramatically alter the outcome of a program. The designer/constructionist "tweaks" code at both top and bottom levels in the infinite refinement of an artifact.

When individuals and groups create digital media artifacts, those artifacts then inhabit the learning environment, creating an ecology that we share with one another and with our media constructions. Technology can be seen as an expressive tool that allows learners to manipulate *objects-to-think-with* and through exploration and reflection to come to more formal understandings of systems and relationships. Technology is thus not just an instrument we use within an environment, but is part of the social and ecological environment itself.

Digital Media for Collaborative and Distance Learning

The most significant advancement of collaborative learning with computers is the development of the Computer-Supported Collaborative Learning (CSCL) community which hosts a bi-annual conference and a journal called the *International Journal of Computer-Supported Collaborative Learning.* In a 1996 article, Timothy Koschmann suggested that the major educational technology paradigm of the late 1990s would be CSCL, a close relative of the emerging field of computer-supported collaborative work (CSCW). Educational technology, Koschmann pointed out, is now concerned with collaborative activities, largely using networks and computer conferencing facilities. Whether or not CSCL constitutes a paradigm shift is a question that is yet to be answered, but Koschmann's identification of the trend is well noted.

Two oft-cited research papers by Margaret Riel (and colleagues) into this category: Margaret Riel, James Levin, and colleagues on “teleprenticeship” (Levin, Riel, Miyake, & Cohen, 1987) and “learning circles” (Riel, 1993; 1996). Learning circles connected many students at great distances—classroom to classroom as much as student to student—in large-scale collaborative learning.

Hiltz and Turoff's *Network Nation* (1978), although originally concerned mostly with business communications and management science, explored teaching and learning with network technologies, applying their insights to practical problems of teaching and learning online.

In general, the more the course is oriented to teaching basic skills (such as deriving mathematical proofs), the more the lecture is needed in some form as an efficient means of delivering illustrations of skills. However, the more the course involves pragmatics, such as interpretations of case studies, the more valuable is the CMC [Computer Mediated Communication] mode of delivery. (Hiltz & Turoff, 1993 [1978] p. 471)

(Looking a bit further back in time, one needs to reflect for a moment on the earliest beginnings of this research. It is often credited to the work of Douglas Engelbart at SRI in the 1960s (Bootstrap Institute, 1994). Englebart's work centered around the oNLine System (NLS), a combination of hardware and software that facilitated the first networked collaborative computing, setting the stage for workgroup computing, document management systems, electronic mail, and the field of *computer-supported collaborative work* (CSCW).)

The first computer conference management information system, EMISARI, was created by Murray Turoff while working in the US Office of Emergency Preparedness in the late 1960s and was used for monitoring disruptions and managing crises. Turoff continued developing networked, collaborative computing at the New Jersey Institute of Technology (NJIT) in the

1970s working with Starr Roxanne Hiltz. Turoff and Hiltz founded the field of *computer-mediated communication* (CMC) with their landmark book, *The Network Nation* (1993 [1978]). The book describes a new world of computer conferencing and communications, and is to this day impressive in its comprehensive insightfulness. Hiltz and Turoff's work inspired a generation of computer mediated communication researchers, notably including technology theorist Andrew Feenberg (1987; 1993) at San Diego State University, and Virtual-U founder Linda Harasim (1990; 1993) at Simon Fraser University.

Parallel to the early development of CMC, research in CAI (Computer Assisted Learning) began to take seriously the possibilities of connecting students over networks. As mentioned earlier, the PLATO system at the University of Illinois was probably the first large scale distributed CAI system. PLATO was a large timesharing system, designed (and indeed economically required) to support thousands of users connecting from networked terminals. In the 1970s, PLATO began to offer peer-to-peer conferencing features, making it one of the first online educational communities (Woolley, 1994).

Distance education researchers were interested in CMC too, as an adjunct to or replacement for more traditional modes of communication, such as audio teleconferencing and the postal service. The British Open University was an early testbed of online conferencing. Researchers like A.W. Bates (1988), and Alexander Romiszowski and Johan de Haas (1989) were looking into the opportunities presented by computer conferencing and the challenges of conducting groups in these text-only environments. More recently, Bates has written extensively about the management and planning of technology- based distance education, drawing on two decades of experience building “open learning” systems in the UK and Canada (Bates, 1995).

In the 1990s, Hiltz wrote extensively about Computer Mediated Communication (CMC) and education. Her 1994 book, *The Virtual Classroom*, elaborates a methodology for conducting education in computer-mediated environments emphasizing the importance of assignments using group collaboration to improve motivation. Hiltz hoped that students would share their assignments with the community rather than being "mailed" to the instructor. Hiltz was surely on a major player in the late 1980s and early 1990s as researchers around the world began to realize the promise of "anyplace, anytime" learning (Harasim, 1993) and study the dynamics of teachers and learners in online, asynchronous conferencing systems.

Hilz & Goldman (2004), in a collaborated on an edited book called *Learning Together Online: Research on Asynchronous Learning Networks* discuss the past, present, and future educational research on Asynchronous Networked Learning (ALN) community A host of authors with theoretical and practical experience in running ALNs contributed to the book. In the final chapter by Goldman & Hilz (2010), the researchers remind us that being part of a social network does not have to mean "wasting time;" it is about growing a culture of learners. Using the example of jazz players, they note that …

> …while some artists say they find that the required social networking keeps them away from their real passion, creating their works, many maintain that the continual push and pull with … the social world of their artistry enables them to see things with a greater perspective when returning to their work. What we are describing is a culture where the learners drive to create is appreciated, the artifacts that are created have a public sphere to be shown in, and the system is supported because it offers important values to the healthfulness of society. In short, cultures are created supporting members' activities and these cultures then produce sub-cultures while affecting changes to the overall culture.

In the early 1990s, students, teachers, and researchers around the world began to engage in networked collaborative projects. At the Institute for the Learning Sciences (ILS) at Northwestern University, the Collaborative Visualization (Co-Vis) project involved groups of young people in different schools conducting experiments and gathering scientific data on weather patterns (Edelson, Pea, and Gomez 1996). Research at the Multimedia Ethnographic Research Lab (MERLin) at the University of British Columbia focused on how young people, teachers, and researchers conducted ethnographic investigations on a complex environmental crisis at Clayoquot Sound on the west coast of Vancouver Island (Goldman-Segall, 1994), with the aim of communicating with other young people in diverse locations. The *Global Forest* project was centered around a CD-ROM database of video but used the World-Wide Web to allow participants from around the world to share diverse points of viewing and interpretation of the video data.

At the TERC research center, large-scale collaborative projects were designed in conjunction with the National Geographic Society Kids Network (Tinker, 1996; Feldman, Konold, and Coulter, 2000). The TERC project was concerned with “network science” and as with Riel's learning circles, multiple classrooms collaborated together, in this case gathering environmental science data and sharing in its analysis.

For example, in the NGS Kids Network Acid Rain unit, students collect data about acid rain in their own communities, submit these data to the central database, and retrieve the full set of data collected by hundreds of schools. When examined by students, the full set of data may reveal patterns of acidity in rainfall that no individual class is able discover by itself based on its own data. Over time, the grid of student measurements would have the potential to be much more finely grained than anything available to scientists, and this would become a potential resource for scientists to use. (Feldman, Konold, & Coulter, 2000 p. 7)

One of the most interesting developments in CMC since the advent of the Internet is immersive virtual reality environments—particularly MUDs and MOOs—within which learners can meet, interact, and collaboratively work on research or constructed artifacts (Dede, 1994; Haynes and Holmevik, 1998; Bruckman, 1998). Virtual environments, along with the popular but less interesting "chat" systems on the Internet, add synchronous communications to the asynchronous modes so extensively researched and written about since Hiltz and Turoff's early work. One could position these immersive, virtual environments as perspectivity technologies as they create spaces for participants to create and share their worlds.

There were many who predicted the cultural, social, economic, and educational impact of the Internet as a site for collaboration. Indeed, from the standpoint of the 21st Century, most non-material collaborations and works created collaboratively, in some way, involve the Internet. The result is that all education computing is a communications system, involving distributed systems, peer-to-peer communication, telementoring, or some similar construct—quite as Roxanne Star Hiltz and Murray Turoff predicted in the 1970s. Along with "social media" as a common activity, perspectivity technologies (technologies which enable, encourage, and expand users' points of viewing) can be designed to create more democratic, interactive, convivial, and contextual communication that involve stakeholders' decisions. (Goldman-Segall, 2000).

The Internet has clearly opened up enormous possibilities for shared learning. The emergence of broad standards for Internet software has lent a stability and relative simplicity to learning software. Moreover, the current widespread availability and use of Internet technologies could be said to mark the end of CMC as a research field unto itself, as it practically merges CMC with all manner of other conceptualizations of new media technological devices: CAI, intelligent tutoring systems, simulations, robotics, smart boards, wireless communications, wearable technologies, pervasive technologies, and even smart appliances.

Digital Media as Perspectivity-Sharing

One could trace the first glimmer of perspectivity technologies to Xerox' PARC in the 1970s. There, Alan Kay was inventing what we now recognize as the "personal computer," a small, customizable device with substantial computing power, mass storage, and the ability to handle multiple media formats. Kay's advances, while simply pedestrian today, were at the time revolutionary. Kay's vision of small, self-contained *personal* computers was without precendent, as was his vision of how they would be used: as *personalized* media construction toolkits that would usher in a new kind of literacy. With this literacy would start the discourse between technology as scientific tool and technology as personal expression.

The particular aim of [Xerox' Learning Research Group] was to find the equivalent of writing—that is, learning and thinking by doing in a medium—our new "pocket universe." (Kay, 1996, p. 552)

At Bank Street College in the 1980s, a video and videodisc project called *The Voyage of the Mimi* immersed learners in scientific exploration of whales and Mayan cultures. Learners identified strongly with the student characters in the video stories. Similarly, the Cognition and Technology Group at Vanderbilt (CTGV) were working on video-based units in an attempt to involve students in scientific inquiry (Martin 1987). *The Adventures of Jasper Woodbury* was a series of videodisc-based adventures which provide students with engaging content and contexts for solving mysteries and mathematical problems (Vanderbilt Learning Technology Center website). While both of these environments were outstanding exemplars of students using various media forms to get to know the people and the culture within the story structures, the lasting contribution is not only one of enhanced mathematical or social studies understanding, but rather a connection to people who are engaged in real life inquiry.

With an AI orientation, computer scientist, inventor, and educator Elliot Soloway at the University of Michigan built tools to enable learners to create personal hypermedia documents, reminiscent of Kay's personalized media construction toolkits. In his more current work with Joe Krajcik, Phyllis Blumenfeld, and Ron Marx, Soloway participates with communities of students and teachers as they explore project-based science through the design of sophisticated technologies developed for distributed knowledge construction (Soloway, Krajcik, Blumenfeld, & Marx, 1996). Similarly, at Berkeley, Marcia Linn analyzed the cognition of students who wrote programs in the computer language LISP, and Andrea diSessa worked with students who were learning physics using his program called *Boxer*. For diSessa, physics deals with

...a rather large number of fragments rather than one or even any small number of integrated structures one might call 'theories.' Many of these fragments can be understood as simple abstractions from common experiences that are taken as relatively primitive in the sense that they generally need no explanation; they simply happen. (diSessa, 1988, p. 52)

Andrea diSessa's theory of physics resonates strongly with the notion of *bricolage*, a term first used by the French structural anthropologist Claude Lévi-Strauss (1968) to describe a person who builds from pieces and does not have a specific plan at the onset of the project. Lévi-Strauss was often used as a point of departure for cognitive scientists interested in the analysis of fragments rather than in building broad generalizations from top-down rationalist structures. By the 1990s, French social theory has indeed infiltrated the cognitive paradigm, legitimizing cultural analysis.

However influenced by the notion of *bricolage,* one might ask if these technology researchers were aware of the fact that they had designed perspectivity platforms for interations between individuals and communities? Perhaps not, yet we propose that these environments be re/viewed through the perspectivity lens to understand how learners come to build consensual theories around complex human-technology interactions. Not surprisingly, Goldman's previous digital ethnographies of children's thinking (1990; 1991; 1998) and her current one in New York City with girls designing games (Kwah, Milne, Goldman & Plass, submitted) are exemplars in perspectivity theory. Goldman-Segall established unique partnerships among viewer, author, and media texts; a set of partnerships that revolves around, and is revolved around, the constant recognition of cultural connections as core factors in using new-media technologies (2008 & 2003). Situating her digital ethnographic work in Clifford Geertz's notion of the thick description, she continues to explore the tenuous, slippery, and often permeable relations between creator, user, and media artifact through an online environment for video analysis (1989; 1998; 2007). A video segment, for example, is the representation of a moment in the making of cultures. A video object is a cultural object and also a "personal subject-to think-with," something to turn around and reshape together. And, just as we change it through our manipulation, so it changes both our cultural possibilities and us. A fuller description of this field can be found in *Video Research in the Learning Sciences* (2007), published with sixty-seven learning science video researchers. Another good example of a perspectivity technology is described in the doctoral work of Maggie Beers who explored how pre-service teachers learning modern languages build and critique digital artifacts connecting self and other (Beers 2001; Beers & Goldman-Segall, 2001). Beers has shown how groups of pre-service teachers create video artifacts as representations of their various cultures in order to share and understand each others' perspectives as an integral part of learning a foreign language. The self becomes a strong reference point for understanding others while engaged in many con/texts with media tools and artifacts.

Another exemplary application of perspectivity theory is demonstrated by Gerry Stahl. Stahl has been working on the idea of perspective and technology at the University of Colorado for more than a decade. His *WebGuide* forms the technical foundation into an investigation of the role of artifacts in collaborative knowledge building for deepening perspective. Drawing on Vygotsky's theories of cultural mediation, Stahl's work develops models of collaborative knowledge building, and the role of shared cultural artifacts—and particularly digital media artifacts—in that process (Stahl 1999).

In sum, perspectivity technologies enhance, motivate, and provide new opportunities for learning, teaching, and research because they address how the personal point of view connects with evolving discourse communities. Perspectivity thinking tools enable knowledge-based cultures to grow, creating both real and virtual communities within the learning environment to share information, to alter the self/other relationship, and to open the door to a deeper, richer partnership with our technologies and one another. Just as a language changes as speakers alter the original form, so will the nature of discourse communities change as cultures spread and variations are constructed.

In conclusion, perspectivity technologies are what makes a range of social media and interactive video and computer games so compelling: learners/participants become collaborators, creators, and builders of their own learning communities and have the opportunity to become connected with each other in ways that enable commensureability.

Digital Media for Playing and Learning with Games

Video and computer games are popular and motivating environments, and there have been calls to use them as a way to get students more engaged in education and to use them as very effective environments for learning (e.g., Prensky, 2007). James Gee (2007) makes the case that video games have many of the characteristics that learning science researchers often recommend for the design of effective learning environments. When well-designed digital games represent conceptual play spaces in which learners/players can work in teams or by themselves to creatively solve problems, develop and test hypotheses, and investigate the game system and its rules (Barab, Sadler, Heiselt, Hickey & Zuiker, 2007; Shaffer, 2006), learners can play at their own pace, set their own goals, and regulate their own exploration behaviors in an environment that also engages them on behavioral, cognitive, and emotional levels (Domagk, Schwartz, & Plass, 2010). However, the results from studies of how people learn content from and with video games are mixed. This suggests that careful research is needed to show under what conditions games are effective for learning.

What we do know at this time is that experimental research has shown strong improvements of basic perceptual and cognitive processes as a result of playing certain video games. Several studies have shown that action games, i.e., video games that require players to divide their attention over multiple targets (e.g., *Halo*), result in significant increases in players' contrast sensitivity, as well as in the players' ability to do divided attention tasks, which is a basic attention cognitive skill (Greenfield, et al, 1994; Green & Bavelier, 2003). Play of video games using visual and spatial skills (e.g., *Tetris*) also increases those basic cognitive processes (Subrahmanyam & Greenfield, 1994); and, play of action video games (e.g., *Unreal Tournament*) results in increased spatial resolution and visual acuity (Green & Bavelier, 2007).

To understand the benefit of using video games in a learning context, one needs to examine their potential future function in the learning process. Heuristics of existing games suggest four such functions: (1) prepare for future learning, (2) teach new knowledge or skills, (3) automate existing knowledge or skills, and (4) acquire 21st Century Skills (Plass, Perlin, & Isbister, 2010).

Preparation for Future Learning. Games to prepare for future learning do not aim to teach specific knowledge or skills, but to provide learners with a shared experience based on which content can be taught. Game genres typically used for such games therefore include adventure games, open-ended simulation games, and role-playing games where students have an opportunity to take on different perspectives through role playing. Research by Hammer and Black (2009) suggests that the best use of video games in content (and perhaps other) learning might be in providing experience with the subject matter that will lead to better future learning of related material from a more formal learning setting. In one study, Hammer and Black looked at expert players of the Civilization history simulation game and found that these expert players did not know any more about the historical content contained in the game than expert players of another unrelated game (Sim City) did. So far, this is consistent with the comparison research on content learning with video games. However, this study also examined how much the expert Civilization players would learn from reading a college textbook chapter on related historical content, and found that the Civilization players learned much more from reading the chapter than the expert players of the Sim City comparison game. Thus, having the experience of grappling with historical issues in the game may have provided the players with a set of experiences, as John Dewey (1938) said, that better prepared them for future learning from a more formal learning approach (Bransford and

Schwartz, 2001).

A related approach is the Teachable Agents project by Schwarz, Biswas and colleagues (in press). Using the Teachable Agents system, students learn by creating a concept map for a topic (e.g., river ecology) that then becomes what their online agent (avatar) knows about the topic. The system then puts questions to the agent and the students can see how well they know the topic by how well the agent does (and revise their and their agents knowledge by changing the concept map and trying again). There is even a version where students' agents can "play" against each other in a simulated TV quiz show, so that the students can see which concept maps work the best. Experimental research studies showed that students learning with Teachable Agents learned better (especially causal chains) than alternative approaches like standard classroom instruction and using concept maps.

Teach New Knowledge and Skills. A strong case can be made that most if not all games teach the learner new knowledge or skills (Gee, 2007). However, the effectiveness or efficacy of games for learning at a large scale has not yet been sufficiently investigated. Disagreement among researchers exists whether the very features that make games motivating and engaging—the use of narratives to provide context and relevance, the design of emotional experiences, opportunities for discovery and exploration, and the use of compelling visual representations—facilitate learning or whether they introduce extraneous cognitive processing demands on working memory that suppress learning (Kirschner et al 2006).

Studies that have compared learning academic content (as opposed to attention and visual-spatial cognitive skills) have shown negative results for learning from video games. For example, Egenfeldt-Nielsen (2005) compared learning about European history from playing a history simulation game to learning the same content in a classroom, and found that students learned more from the classroom. Similarly, Mayer, MacNamara and Adams (2011) found that students learned more about ecology by merely going through Powerpoint slides than they did from playing an ecology simulation game.

On the other hand, qualitative and observational studies have showed student learning from video games (Squire, 2004; Barab, Zuiker, Warren, Hickey, Ingram-Goble, Kwon, Kouper & Herring, 2007. These results suggest that more sophisticated research methods have to be employed that use both qualitative and quantitative data in an interwoven way, such as through the adoption of POV-T (1998), to investigate the effectiveness of games for the acquisition of new knowledge and skills.

The game-plus approach is defined entails game learning in conjunction with other activities. Consistent with this games-plus approach, Steinkuehler and Duncan's (2009) found that players of Massively Multiplayer Online Games like *World of Warcraft* show informal scientific reasoning skills in online discussion forums that are supplements to the games and where players share their experiences. Another study consistent with this approach is Ahn (2007) and Black (2011) who looked at college undergraduates learning from an entrepreneurship simulation game (from Harvard Business School) as part of an entrepreneurship college course. The study found that students learned much more from playing the game (multiple times) when they also reflected on and articulated their business and game-playing strategies, and related them to background readings in textbooks for the course (this is like the college textbook reading in the Hammer and Black study). They did not learn nearly as much from the game play if they did not reflect on how it relates to this background reading.

All of the video game studies covered so far involve students learning from playing video games. However, a different, but effective, approach to video games and learning is to have students learn by creating video games themselves. Early studies by Harel (1991) and Kafai (1995) showed that students learned more about both fractions and computer programming (the Logo programming language designed for kids) if they created educational software or computer games to teach other students about fractions than they did if they learned about fractions and computer programming separately. Building on this work, Harel (now Harel Caperton) has established an online social networking environment called *World Wide Workshop* for kids to learn by creating online games (http://www.worldwideworkshop.org/). In related more recent work, Fadjo and Black (2011) have found that having students act out what they want their video game avatars to do, then programming a simple video game in which the avatars perform these actions (see discussion of embodied cognition in this chapter), is a more effective way for students to learn the programming and math skills than having them learn in alternative ways.

In a games and gender study involving the game *Rapunsel*, designed to teach middle school girls how to program by using a Java-like language to customize the avatars in the game, the strongest impact of the game was not on cognitive learning outcomes. After using the game for only four sessions, students' general self-efficacy, programming-related self-efficacy, and self-esteem increased significantly, suggesting that games are able to impact learners' identity formation in a way that positively changes their attitudes toward their ability to perform science-related tasks (Plass, Goldman, Flanagan & Perlin, 2009).

Automate existing knowledge or skills. The majority of games used for learning do not aim to teach significant new knowledge or skills, but are designed to help the learner automate existing skills, such as basic arithmetic, algebra, Newtonian mechanics, History, or others. Game genres used for such games therefore typically include puzzle games, platformers, labyrinth games, and race games, often implemented as relatively short mini games. Research has shown that such games provide a venue for players to use their knowledge of biological and physical science topics, such as the water cycle (Lim, Nonis & Hedberg, 2006) and principles of electromagnetism (Squire, Barnett, Grant, Higginbotham, 2004), as well as math topics, such as measurement, whole numbers, equations, and graphing (Ke & Grabowski, 2007). Children as young as six years of age have been found to develop stronger numeracy skills after playing computer games that provide practice in number sense and counting (Rasanen, Salminen, Wilson, Aunio, & Dehaene, 2009). At the high school level, videogames have been found to be effective tools for the reinforcement of algebra skills in an immersive 3D environment (Kebritchi, Hirumi & Bai, 2010) as well as computer science concepts integrated into a labyrinth game (Papastergiou, 2009).

Acquire 21st Century Skills. Many games do not aim to teach academic knowledge or skills, or to automate existing knowledge or skills, but rather focus on the development of skills that has collectively have come to be known as 21st Century Skills, although most of them have been recognized for many decades, if not centuries, to be important predictors of success in life. These skills include creative problem solving, communication skills, team collaboration, emotional intelligence, and many others. Game genres typically used for such games include adventure games and role-playing games with large numbers of players, which are known as MMOs (Massive Multiplayer Games). Studies have shown that such games facilitate the acquisition of systems based reasoning and social knowledge construction (Steinkuehler &

Duncan, 2009), collaborative problem solving (Squire, 2004), and civic thinking (Bagley & Shaffer, 2009).

All of the studies cited above assume that the games used in the investigations were well designed to facilitate learning. However, as Plass, Homer, and Hayward (2009) have shown, the design of games for learning is a highly complex and difficult process for which very little theory based, empirically validated guidance for designers exist. Another line of research has therefore been concerned with the identification of design patterns for effective games for learning. This research, which is in part based on research of the design of effective simulations, has shown that icons are effective visual representations of key information, especially for younger learners and learners with low prior knowledge in the subject matter (Plass, Homer, Milne, Jordan, Kalyuga, Kim & Lee 2009; Homer & Plass Chang, Frye, Kaczetow, Isbister & Perlin, 2011).

Other research has investigated the mode of play for games teaching math skills, comparing collaborative play and competitive play to a single player version of a game. Results indicate that players enjoy playing with others more (in collaborative or competitive mode) and solve more problems in the competitive mode, but that they acquire a higher math fluency, an expression of the acquired math skills, when playing by themselves.

A final study investigated the use of different learning mechanics in a game to teach middle school geometry. Players were asked to solve missing angles in order to clear the path for their avatar to free a peer from imprisonment. One mechanic was designed to require the player to compute the correct value of the missing angle and enter this number as response, whereas another mechanic asked learners to identify which rule (e.g., complementary angles rule, supplementary angles rule, opposite angles rule, or the like) they would apply to solve the problem. Results suggest that computing the correct angles value was more situationally interesting than identifying the correct rule. However, participants in the rule condition were found to perform better in the game than those in the number condition. Results further suggest that in the number condition, but not the rule condition, playing more levels in the game diminishes the gain from pretest to posttest (Plass, Homer, Hayward et al., 2011).

Games are an emerging medium for learning that requires research concerning both its effectiveness for learning and related design patterns. This research topic would benefit from mixed methods, or what Goldman and colleagues call Quisitive Research (Goldman et al 2004; Goldman-Segall 1996). In quisitive research perspectives from a fuller range of stakeholders use both quantitative and qualitative research methods along with emerging digital text and video tools for data analysis in order to investigate this topic further.

Emotion, Empathy, Affective Computing, and Pespective-Taking

The history of emotional and social learning can be said to date back to the works by John Dewey's *Experience in Education*. It became a "mantra" of the Civil Rights Movement as well as the progressive, cooperative, and the whole child movements of the 1960s and 1970s. Currently, the cluster of terms being used includes: social and emotional, empathetic learning, affective computing, and perpective-taking learning. According to Zins and Elias (20XX):

> … [S]ocial and emotional learning (SEL) is the capacity to recognize and manage emotions, solve problems effectively, and establish positive relationships with others… SEL is the process of acquiring and effectively applying the knowledge, attitudes, and skills necessary to recognize and manage emotions; developing caring and concern for

others; making responsible decisions; establishing positive relationships; and handling challenging situations capably.

A series of research projects under computer scientist, Rosalind Picard, are aimed at investigating the emotional and environmental aspects of digital technologies. This work on "affective computing" (Picard, 2010 &1997) resarches areas that include computer recognition of human affect, computer synthesis of affect, wearable computers, and affective interaction with computers. (See http:// www.media.mit.edu/affect/).

Needless to add, emotional learning has been of interest in the use of *persuasive technologies* in political and product advertising campaigns, as Ian Bogust (2007) points out. In educational research on gaming, interest in the emotional aspect of designing games for social good and as well as on developing historial empathy are curently at the forefront of renewed interest in emotions and learning.

Belman & Flanagan (2010) argue that "games are particularly well-suited to supporting educational or activist programs in which the fostering of empathy is a key method or goal. As we discussed in the previous section, there a is growing interest in harnessing the power of games for education. Belman and Flanagan ask: why not design games to advance empathy and social activism? Some software interaction designers and academics have proposed that engaging players on the emotional level is a key element of their use. Sasha Barab and his colleagues (2005) designed Quest Atlantis, for example, promotes children's educational and activist pursuits by engaging them with a fantasy that resonates at an emotionally meta-level of cogntion. Belman and Flanagan (2010) suggest that activist designers would find it useful to encourage empathetic play, a mode of play in which "players intentionally try to infer the thoughts and feelings of people or groups represented in the game, and/or they prepare themselves for an emotional response, for example by looking for similarities between themselves and characters in the game."

Taking a curricular and epistemological perspective, James Diamond, asks: How does game play in a history video game influence students' achievement of *historical empathy*? Although historical empathy is a construct that connotes "perspective taking-in-historical-context, Diamond includes *theory of mind* in the construct. Using the video game, *Mission US*, he describes not only "*if* players' abilities to achieve historical empathy change in the course of game play, but *how* students play and if their playing can inform future designs of games constructed to help students contextualize other people's thinking and behaviors.

> Preliminary research has revealed four areas that influenced the ways in which these students came to think about historical characters' diverse perspectives: role-play; game play strategies; prior knowledge; and, thinking about game play in narrative terms. These findings are in line with the "points of viewing theory (Goldman-Segall, 2008)" Students' own, real-life perspectives are considered in the same relationship to the learning as the character perspectives that students try-on through role-play to infer others' motives. In this study, the students begin to catch sight of the historical characters, thereby crossing the bridge of historical time. (Diamond & Goldman, submitted)

This is a finding that Ashby & Lee (1987), who are often cited as the pioneers of work on empathy in history educaion, would be pleased to learn.

The authors of this paper consider emotional learning a major thematic for the future of educational research with digital media environments. Moreover, emotional learning along with social learning using social media, and emdodied learning using interactive Wii and Kinect-like environments constitute the convergence of, not only new digital media technologies, but also a new paradigm of learning that depends upon the willingness of learners to share viewpoints and knowledge with each other. As Picard (2010), in an article called *Emotion Research by the People, for the People* asks, how do we remind ourselves as researchers that the public as well must become part of the scholarly discourse, and that together we explore this new domain called emotional learning and perspective-taking.

> Today when a child teaches a distinguished scientist to upload video on the Internet, when non- researchers can participate in scientific labeling from home, and when gathering autonomic nervous system data 24/7 is as easy as slipping on a sweatband, emotion research is ready for a major leap forward. Ordinary people can gather data, upload it, compare their patterns, share what they learn, and if they wish, share it with scientists for emotion research. Research can be done by the people, for the people. Of course scientists still have to be involved: there is no substitute for deep scholarly study across experiments and for the rigorous development and test of new hypotheses and theories. At the same time, there is no longer any excuse for leaving people out of findings. *Emotion research can benefit all its participants, scientists and laypeople, instead of becoming academic in the modern definition.* (Picard, 2010, italics added)

Digital Media for Embodied Cogntion / Learning

Some of the current criticisms of traditional formal learning suggest that: learning can be fragile and lacking in depth; learning does not become a part of the way the student thinks about and interacts with the everyday world; and students too often forget what they have learned after the end of the learning events if it does not get applied to relevant situations outside the learning setting. In the 2010s, as new technological environments such as Wiis and Kinect™ allow for a more physical interaction, this technology along with an embodied cognition approach may provide a new appoach on what it means to learn. Along with the increased interest in emotions, the nervous system, neurobiology, as well as tools for leaving traces of our activities and emotional responses, cognitive science has also taken on this term to use Gibbs' (2006) statement that "conceptual systems and thought processes are shaped by body-based interactions and experiences in the world" (Kwah, Milne, Goldman & Plass (submitted for 2012). In this same paper, they add that emotional experiences influence cognition and must play a role in engagement in learning. As Gibbs (2006) so aptly wrote: "The brain is certainly part of an integrated dynamic system devoted to the moment-by-moment embodied dynamic of everyday life (p. 9) ." He goes on to claim that "the regularities in people's kinesthetic-tactile experience not only constitutes the core of their self-conceptions as persons, but form the foundation for higher-order cogntion (p. 15).

We emphasize that an embodied approach can provide guidance for the design of new kinds of learning environments that can make knowledge more accessible, useable, and beneficial for society, in accordance with the three tenets of Ivan Illich' definition of *convivial tools* (1973). For the purpose of this paper on the advances of digital media and how they affect learning, it mean that embodied digital media tools and environments can provide an alternative to the scenario of designig learning for the solitary person sitting in front of a monitor.

One increasingly prominent approach to cognition is called embodied or perceptually-grounded learning approach. This approach proposes that a full understanding of something involves being able to create a mental perceptual simulation of it when retrieving the information or reasoning about it (Barsalou, 2008, Glenberg, 1997). Both behavior and neuroimaging results have shown that many psychological phenomena that were thought to be purely symbolic show perceptual effects. For example, property verification (e.g., retrieving the fact that a horse has a mane) was thought to involve a search from a concept node (horse) to a property node (mane) in a symbolic propositional network and thus the time to answer and errors was determined by how many network links needed to be searched and how many other distracting links were present. However, embodied cognition research shows that perceptual variables like size (e.g., more important propertyies are retrieved faster) affect verification times and errors. Also, neuroimaging results (e.g., fMRI) show that perceptual areas of the brain (involving shape, color, size, sound and touch) also become active during this task, not just the symbolic areas. Thus, if one is familiar with horses and manes then doing even this simple property verification involves a perceptual simulation.

Glenberg, Gutierrez, Levin, Japuntich, & Kaschak (2004) discuss teach reading comprehension using a grounded cognition approach. These studies found thathaving 2nd grade students act out stories about farms using toy farmers, workers, animals and objects increased their understanding and memory of the story they read. Further, if the students also imagined these actions for another related story after acting it out with the toys, they seemed to acquire the skill of forming the imaginary world of the story (Black, 2007) when reading other stories, and this increased their understanding and memory of these stories. Thus, this grounded cognition approach increased the students reading comprehension. These studies also seem to indicate that there are three steps involved in a grounded cognition approach to learning something: have an embodied experience; learn to imagine that embodied experience, and imagine the experience when learning from symbolic materials. Interestingly, it has also been shown that moving objects corresponding to story characters on a compuer screen works just as well as moving toy objects in the physical environment (Glenberg, Goldberg and Zhu, 2009).

An example of using an embodied cognition approach to designing learning environments and the learning advantages of doing so is provided by the graphic computer simulations with movement and animation that Han & Black (in press) used in perceptually enhancing the learning experience. Chan & Black (2006) found that graphic computer simulations involving movement and animation were a good way to learn functional relations between system entities. Han and Black (in press) have enhanced the movement part of these interactive graphic simulations by adding haptic force feedback to the movement using graphic and sound simulations. Here the student moves the gears shown in the screen by moving a joy stick, and then bar graphics on the screen show the input and output force levels for the two gears. Allowing the student to directly manipulate the gears enhances the students' learning, and enriching the movement experience by adding force feedback increases the students' performance even more. Thus the richer the perceptual experience, and therefore the mental perceptual simulation acquired, the better the student learning and understanding.

Black, Segal, Vitale & Fadjo (in press) reported on a number of embodied cognition technology learning environment projects and concluded that the richer the perceptual environment using multiple sensory modalities (e.g., usng visuals, voiceovers, and movement) during initial learning the better the student learning. Secondly, they found that utilizing movements (e.g., gestures) that are conceptually congruent with the knowledge being learned increases student performance, learning, understanding, and motivation. A third finding was that students who directly experience a phenomenon through activities like acting it out by moving their own bodies, learn about the topic in a more general way which also increases learning, understanding, and motivation as does, fourthly, embodying their understanding in surrogates and then observing the surrogate behavior through activities like programming video-game-like virtual environments with avatar surrogates (with the Scratch programming environment) and programming robot surrogates like the LEGO NXT. Other recent technological developments, such as the Wii, offer mathematics-education researchers new ways of investigating deep cognitive and epistemological questions pertaining to the nature of knowing, learning, and teaching. For example, in Gerofsky's study of secondary school students' learning about the features of graphs, such as roots, extrema, symmetries, asymptotes, reflections over certain lines, domain and range, she found that embodied work appears to contribute to secondary school students' mathematical engagement and understanding (Gerofsky, 2011). She notes that:

> An integrated pedagogy that moves back and forth among explicit teaching of new concepts, embodied exploration of the 'feel' and 'sound' of mathematical graphs, and sessions of mathematical inquiry and problem solving would appear to be an ideal kind of balanced program to promote mathematical understanding…"

Another increasingly prominent approach to embodied cognition has been proposed by Dor Abrahamson, director of Embodied Design Research Lab at University of California, Berkeley. The EDRL research group uses design-based research and video analysis to study embodied mathematics learning, along with a growing group of researchers in a variety of research universities and labs (Antle, Corness, & Droumeva, 2009; Cress, Fischer, Moeller, Sauter, & Nuerk, 2010; Dam, 2011; Howison, Trninic, Reinholz, & Abrahamson, 2011; Leong & Horn, 2011; and Kwah & Goldman, 2011; Nemirovsky, Tierney, & Wright, 1998; Goldman et al., 2011). Abrahamson's research group creates useful empirical settings to pursue the (somewhat controversial) grounded-cognition conjecture that mathematical reasoning is not encoded and processed in the mind in the form of amodal symbols, but rather is enacted and evoked as embodied, dynamical, multimodal schemes. This conjecture can be traced back to the work of phenomenology philosophers (Heidegger, 1962; Merleau-Ponty, 1958/2005), yet it is converging with perspectives and empirical findings from the cognitive and learning sciences (Barsalou, 2010; Bruner, Oliver, & Greenfield, 1966; Dourish, 2001; Goldin, 1987; Hommel, Müsseler, Aschersleben, & Prinz, 2001; Núñez, Edwards, & Matos, 1999; Piaget & Inhelder, 1969; Skemp, 1983).

In one type of embodied-interaction design that is being investigated by Abrahamson and collaborators (Abrahamson, Trninic, Gutiérrez, Huth, & Lee, 2011; Petrick & Martin, 2011), students interact with the Mathematical Imagery Trainer for Proportion (hence, "MIT-P"). The MIT-P is an embodied-interaction system designed to foster the development of perceptuomotor schemas grounding notions of proportion. Participants use both hands to remote-control a pair of virtual objects on a computer display monitor, one object per each hand, in attempts to "make the screen green." The screen will be green only if the hands rise proportionately, in accordance with an unknown ratio set on the instructor's console. Once students determine qualitative interaction principles, such as that "the higher you go, you need a bigger distance between the hands," mathematical instruments are interpolated onto the screen, such as a Cartesian grid and numerals. Students develop the cognitive foundations of proportions via objectifying and articulating their *a*mathematical solution strategies using the available semiotic resources (Bamberger & diSessa, 2003; Bartolini Bussi & Mariotti, 2008; Radford, 2003).

As such, Abrahamson's MIT tasks are defined in terms of a specified goal state of an interactive system, which the student is to effect, that is, a target phenomenal invariance that the student is to generate. As a learning activity, this task is dramatically different from traditional schoolwork, because the solution method is unknown to the child. Moreover, this task is different from what mathematicians do, because there is no theorem to prove. Rather, this task is closest to forms of inquiry that scientists engage, for example a botanist who first encounters a specimen of an unknown species and is trying to understand its properties, or a chemist who has discovered a new element and is attempting to determine its reactions to various agitations. But then again, scientists who discover an undocumented phenomenon or material do not know a priori its potential behaviors that they have yet to witness (e.g., green), so that their interactions with the phenomenon are not oriented toward generating any specified goal state. As such, the MIT task is rather unique.

In addition to analyses of student unmediated discovery (Abrahamson et al., 2011), researchers have examined the design from the perspectives of human computer interaction (Howison et al., 2011), design heuristics (Abrahamson & Trninic, 2011), and design process (Trninic, Reinholz, Howison, & Abrahamson, 2010).

Yet another approach to understanding embodied learning includes a close look at classroom gestures, perspectivity, and "cubist compositions" (Nemirovsky, Tierney, & Wright, 1992; Goldman & Maxwell, 2003.) Nemirovsky, who was influenced by his work with Seymour Papert's notion of becoming the turtle when learning programming, along with Ferrara propose that mathematical reasoning proceeds through a process of imagining a situation from various viewpoints, through a form of "cubist composition" en route to articulating the rules and principles that unify knowledge of the whole. In their studies, they found that gestures were an essential modality for composing these partial perspectives of the whole.

The perspective of the gesture has received little attention in studies of gestures in classroom learning with the exception of studies by Crowder and colleagues (Crowder & Warburton, 1995; Crowder, 1996). Crowder's studies indicated that first and third person perspectives in gesture reflected different knowledge orientations with a subjective, exploratory approach to knowing reflected in first-person perspectives, and a summative approach reflected in the third-person. Many representational gestures convey a sense of being performed from a first or third person perspective, what has been termed the "character viewpoint" (McNeill, 1992). Goldman, also working closely with Seymour Papert during the same period as Nemirovsky, takes a similar view on the need for subjective, first-person perspective as a way to reach configurational validity (1995)—multiple viewpoints that become robust by "looking through layers" of interpretation (1996). Goldman calls this the Perspectivity Framework (Goldman-Segall & Maxwell, 2003). The framework maps out how students learning to program build physical artifacts that represent a first-person embodied object/subject-to-think-with. Enabling children to not only create their first-person viewpoints, but to critically share their collective viewpoints (or what she coined, *points of viewing* (1998), builds *thick interpretation* (Goldman-Segall, 1998; Goldman, 2008, p. 24). For example, demonstrating the embodied understanding of children learning to make circles in the Logo programming language, Goldman's film called *The Growth of a Culture* (1988) shows a group of girls making a circle with their bodies. When asked to make a circle as the Logo turtle would, Tnisha did not turn 360 degrees from one standpoint, but rather walked around the circle as the turtle icon in Logo would have done: forward 50, right angle 90 degrees, over and over again. At the same time, she looked into the camera saying that the circle is “right here,” while she gently pounded her left chest with her right palm of her hand. Papert in a filmed conversation with Goldman (1990), said that young children learn to program and to think mathematically through becoming the turtle. Clearly, Papert was pointing toward what we are calling, empathic embodiments.

In a more recent exploratory case study in a junior high school programming class, Kwah & Goldman (2010) observed, interviewed, and videotaped teacher gestures during instruction as well as both teacher and student gestures during problem-solving interactions. They found that “a teacher’s gestures are flexible constructions that enable programming concepts to be visibly modeled from multiple perspectives.” (p.1) More interesting, given that gestures are visible actions, students shared (mirrored), as artifacts of embodied imagery, the teacher’s gestures while explaining the same ideas to their peers. While Kwah and Goldmans are not, from this exploratory study, generalizing that students mirroring of teacher guestures increases learning, this research does, at the very least, indicate that gestures can serve as an aid for teachers to explain complex ideas of programming not as accessible to learners in more abstract ways. In short, understanding which gestures can promote understanding could become part of a cognitive toolkit for teachers that would benefit student learning.

In conclusion, although embodied interaction is the keystone activity in a multi-billion dollar gaming industry, sometimes called Body Movement-Controlled Video Games (BMCVGs), it is still little understood from a learning-sciences perspective, yet appears to promise rewarding design-based research into the nature of knowing, teaching, and learning.

Pioneering Learning Environments

In this age of Google™, Facebook ™, Twitter™ and a host of other social media environments, games for learning environments, and handheld smart device to augment learning and create communities, it is difficult to select the educational tools and decide which were the *most* pioneering ones that actaully led to the kinds of tools and environmetns we use every day. Handheld computational devices are now ubiquitous and continually changing with each new "App". People of almost every age, socio-economic and ethnic background, country, and gender are texting, tweeting, and sharing private photos and videos. Websites and online tools are used continuiously to share, promote, and flame. They have become part of the mediated reality within which work, study, and play are mediated. On buses, subways, trains, planes, and while crossing city intersections, people are connecting with each other. If there is one thing the Arab Spring that first erupted in Tunisia on January 9, 2011—with protesters confronting the regime of the president Zine el Abidine Ben Ali—taught us, it is that people have access to mobile handheld devices that are not only phones, but have the capacity to communicate instantly, create groups, share images and text, and whatever else can be found somewher the web in seconds, engaging in a new form of public-centric journalism and curatorialship. The average person with effort can become a knowledge maker, a trend-setter, an investigator, and an expert who has curatorial power, if only over certain domains. A compelling personal narrative or story has become the vehicle for power, even political power as it is played out every day, not only by presidential hopefuls, but by leaders of repressive and violent groups. At this time, the quality of learning with these social media devices is not easy to evaluate—the major critique being that the networked population is *distracting itself to death*, a play on the title of Neil Postman's book in 1985, *Amusing Ourselves to Death: Public Discourse in the Age of*

Show Business. Other critiques are that multi-tasking, the method of moving around the various applications with different purposes, leads to shallow concentation and lack of focus. Of course, others argue that the human mind is capable and ready for this kind of activity. That boredom is the real villain of learning. Others argue that social media, games, and surfing the web expand our ability to learn, help us keep in touch with communities and individuals, and promote new ways to socialize, find partners and select friend recommended hotels, run businesses, and shop. There is some truth to both sides of each of these arguments, as one might expect. Early adopters are enthusiastic about what is coming down the pipe and fall into each new device with few complaints. Luddites refuse to give up their vinal albums and enjoy the time and space that the lack of constantly learning the next applicaton affords. Added to those extremes, there is every shade between the two poles. More and more, parents, teachers, and users create methods to control time online and keep balance in the lives of their children and their own lives. In short, the jury is still out about the effectiveness of using social media as a learnng device in spite of the fact that it seems like a seductive augmentation tool for accessing an infinite amount of information and fun.

The authors of this chapter now focus on the historical roots of these current digital media environments, making the case that the earlier software were percursors to social media and games for learning. This next section is a selection of some of the pioneering and perspectival technological systems developed to aid, enhance, and inspire learning and research using one or more elements of the Points of Viewing Theory. This montage is an authorial selection, not a representation of all pioneering systems for learning. It provides the reader with a snapshot of precursor tools rooted in the role of learners to build their own environments and become partners in the learning and research process.

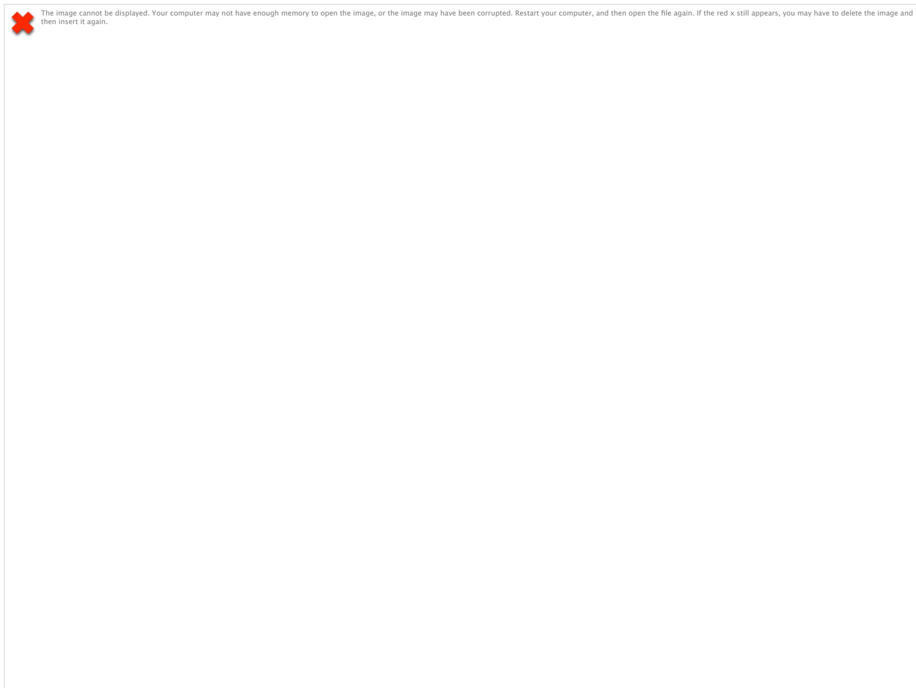
LOGO

Stager.org Dreamtime Logo Project

Logo, one of the oldest and most influential educational technology endeavours, dates back to 1967. Logo is a dialect of the AI research language LISP, and was developed by Wally Feurzig's team at BBN, working with Papert. This program made computer programming accessible to children, not through dumbing down computer science, but by carefully managing the relationship between abstract and concrete. Logo gave children the means to concretize mathematics and geometry via the computer, which made them into explorers in the field of math. As mentioned before, Papert believed that if the best way to learn French is not to go to French class, but rather to spend time in France, then the best way to learn mathematics would be in some sort of "Mathland" (Papert. 1980, p.6). Logo provided a microworld operating in terms of mathematical and geometric ideas. By experimenting with controlling a programmable "turtle," children had direct, concrete experience of how mathematical and geometric constructs work. Through reflection on their experiments, they would then come to more formalized understandings of these constructs. Children became *epistemologists* thinking about their thinking about mathematics by living in and creating computer cultures.

With the growing availability of personal computers in the late 1970s and 1980s, the Logo turtle was moved onscreen, and the notion of the turtle in its abstract world called a "microworld," a notion that has been the lasting legacy of the Logo research (Papert, 1980). The Logo movement was popular in schools in the 1980s, andversions of the language were developed for different computer systems. Some implementations of Logo departed from geometry microworlds, and were designed to address other goals, such as the teaching of computer programming (Harvey, 1997). Implementations of Logo are freely distributed on the Internet. See http://www.cs.berkeley.edu/~bh/logo.html. The Logo Foundation at http://el.www.media.mit.edu/groups/logo-foundation/ has continued to expand the culture of Logo over the years.

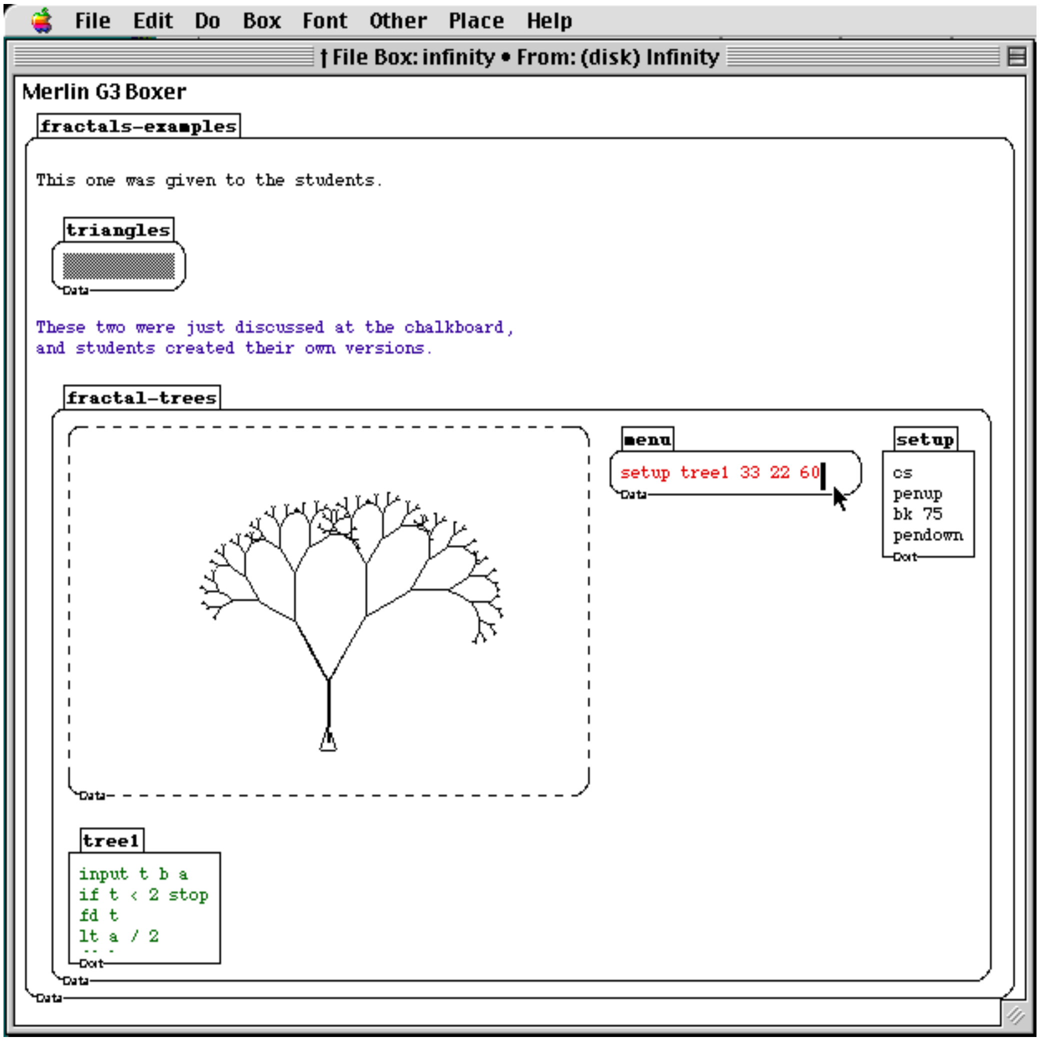
Squeak



The Squeak environment showing Midi Score player (audio), Web Browser, and Documentation.The Squeak 3.9 Desktop

Squeak is the direct descendant of Alan Kay's Dynabook research at Xerox PARC; the Dynabook was built the 1970s. Squeak is a multi-media personal computing environment based on the SmallTalk object-oriented programming language which formed the basis of Kay's investigations into "personal" computing (Kay, 1996). It is notable in that it is freely distributed on the Internet, runs on almost every conceivable computing platform, and is entirely decomposable—while one can create new media tools and presentations as with other environments, one can also tinker with the underlying operation of the system— how windows appear, or how networking protocols are implemented. A small but enthusiastic user community supports and extends the Squeak environment, creating such tools as web browsers, music synthesizers, 3D graphics toolkits, and so on entirely within Squeak. See http://www.squeak.org

Boxer



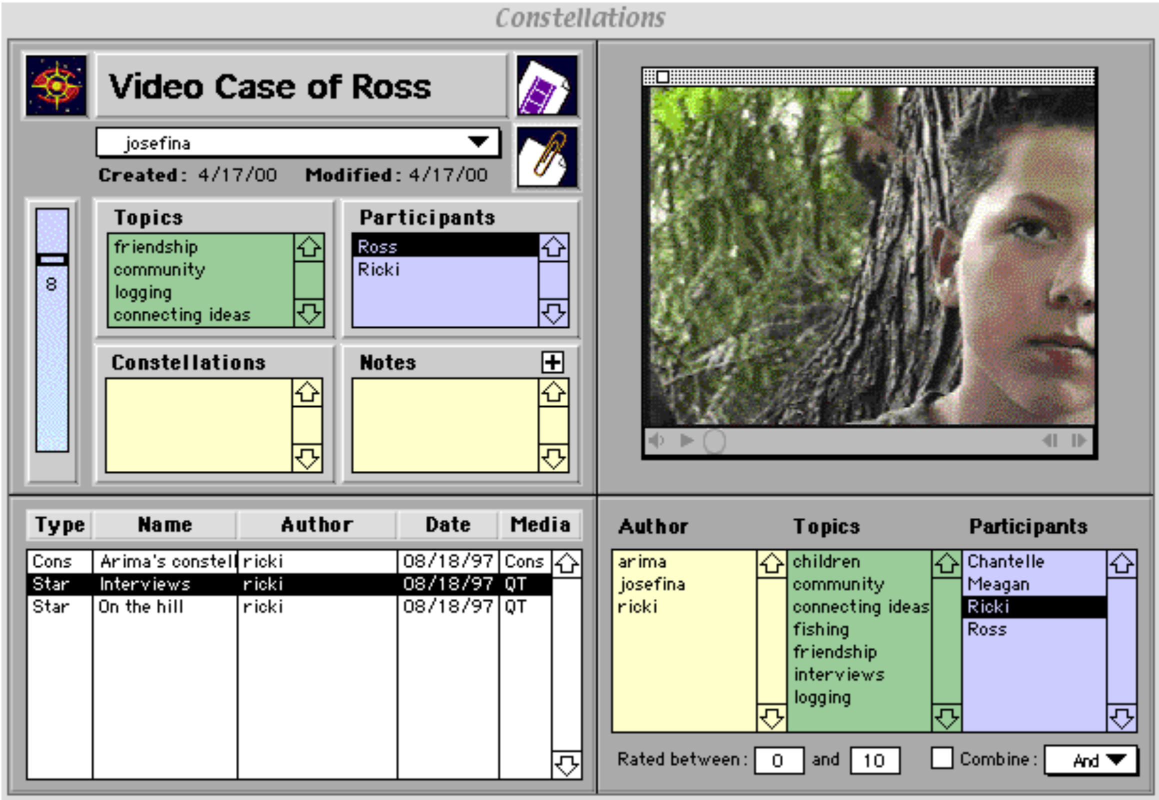
The Boxer environment showing interactive programming of fractals.

Boxer is a "computational medium"—a combination of a programming language, a microworld environment, and a set of libraries and tools for building tools for exploring problem solving with computers. Developed by diSessa, Boxer blends the Logo work of Papert (1980) and the "mutable medium" notion of Kay (1996) in a flexible computing toolkit. diSessa's work has been ongoing since the 1980s, when he conceived of an environment to extend the Logo research into a more robust and flexible environment in which to explore physics concepts (diSessa 2000). Boxer is freely distributed on the Internet.

HyperCard

It is important to remember that in 1987 Apple Computer was exploring multimedia as the fundamental rationale for people wanting Macintosh computers. But, as there was very little multimedia software available in the late 1980s, Apple decided to bundle a multimedia authoring toolkit with every Macintosh computer. This toolkit was *HyperCard*, and it proved to be an enormously popular with a wide variety of users, and especially in schools. HyperCard emulates a sort of magical stack of 3x5 index cards, and its multimedia documents were thus called “stacks.” An author could add text, images, audio, and even video components to cards and then use a simple and elegant scripting language to tie these cards together or perform certain behaviors. Two broad categories of use emerged in HyperCard: the first was collecting and enjoying pre-designed “stacks”; the second was *authoring* one’s own. In the online bulletin board systems of the early 1990s, HyperCard authors exchanged great volumes of “stackware.” Educators were some of the most enthusiastic users, either creating content for students (a stellar example of this is Apple’s *Visual Almanac*, which married videodisc-based content with a HyperCard control interface) or encouraging students to create their own. Others used HyperCard to create scaffolds and tools for learners to use in their own media construction. A good snapshot of this HyperCard authoring culture is described in Ambron and Hooper’s *Learning with Interactive Multimedia* (1990). HyperCard development at Apple languished in the mid-1990s and disappeared in the 2000s.

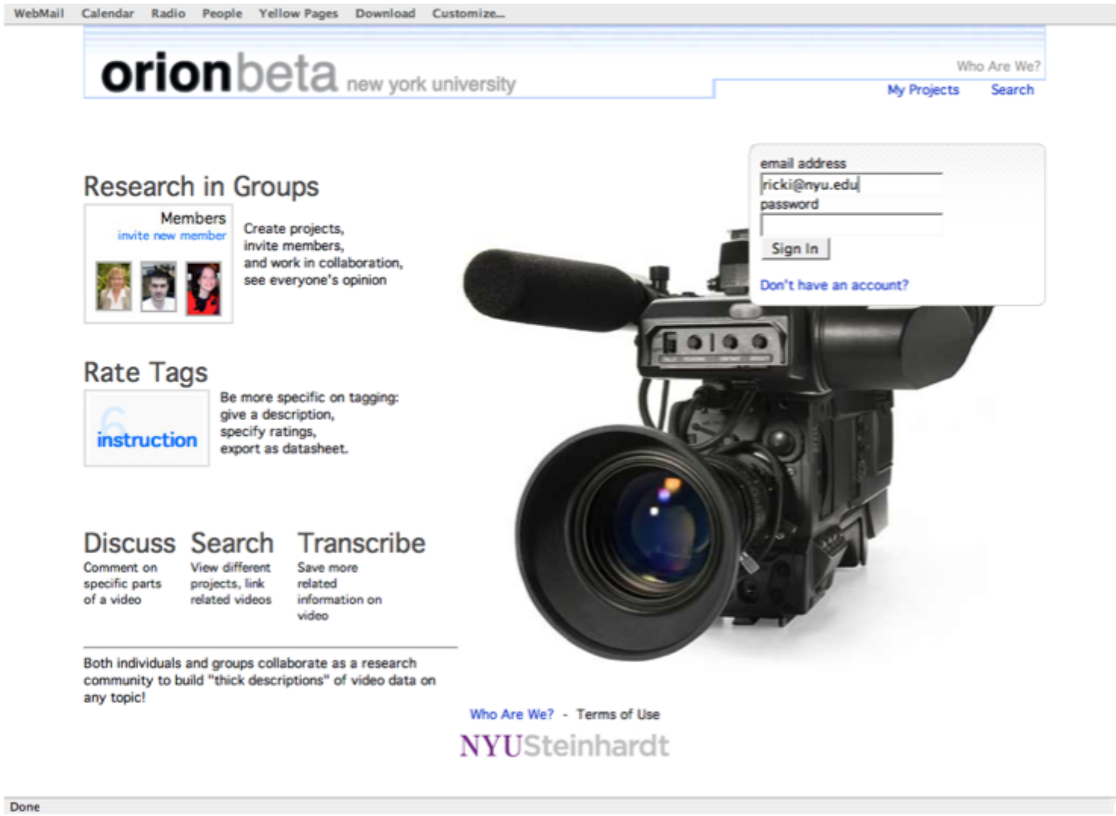
Constellations / WebConstellations / Orion 1.0 / Orion 2.0



Constellations 2.6 (circa 1993) showing Star video node and collaborative ranking/annotation interface.

Building on the HyperCard platform, Learning Constellations (Goldman-Segall, 1989) was a collaborative video annotation tool that builds on the metaphor of stars (video chunks) and constellations (collections). Star video chunks could be combined to make constellations, but *different users may place the same star in different contexts, depending on their understanding by viewing data from various perspectives*. Learning Constellations was a data-sharing system, promoting Goldman-Segall's notion of configurational validity by allowing different users to compare and exchange views on how they contextualize the same information differently in order to reach valid conclusions about the data. It also features collaborative ranking and annotation of data nodes. While other video analysis tools were developed in the 1980s and early 1990s, (Kennedy 1989; Mackay 1989; Roschelle, Pea, & Trigg, 1990; Harrison & Baecker, 1992), Learning Constellations (aka Constellations) was the first video date analysis tool to analyze a robust video ethnographic data (Goldman-Segall, 1989 & 1990).

Continuing to use the HyperCard plaftorm, Goldman-Segall developed a updated version of Learning Constellations as a stand-alone application in 1993. She added a *significance measure* to layer descriptions and "rate attributes" the themes and keywords (Goldman-Segall, 1993). In 1998, the tool went online as a web-based collaborative video analysis tool called WebConstellations (Goldman-Segall, 1998c & 1999). Every media type—website page, text document, video chunk, or photo could become a star chunk and could be tagged, rated, and juxatposed for comparative analysis. The most recent version, Orion 2.0 returned back to its original functionality of being a tool only video chunking, sorting, analysis, ethnographic theory-building and story-making. As a perspectivity technology, individuals enter into Orion, creating their own home page and inviting others to join in the analysis. Taking a lead in feature development, by 2007 each user could have a number of simultaneous projects with diverse research communities, in somewhat the same way that social media now enables groups to work.



Orion 2.0 Welcome Page: http://www.videoresearch.org

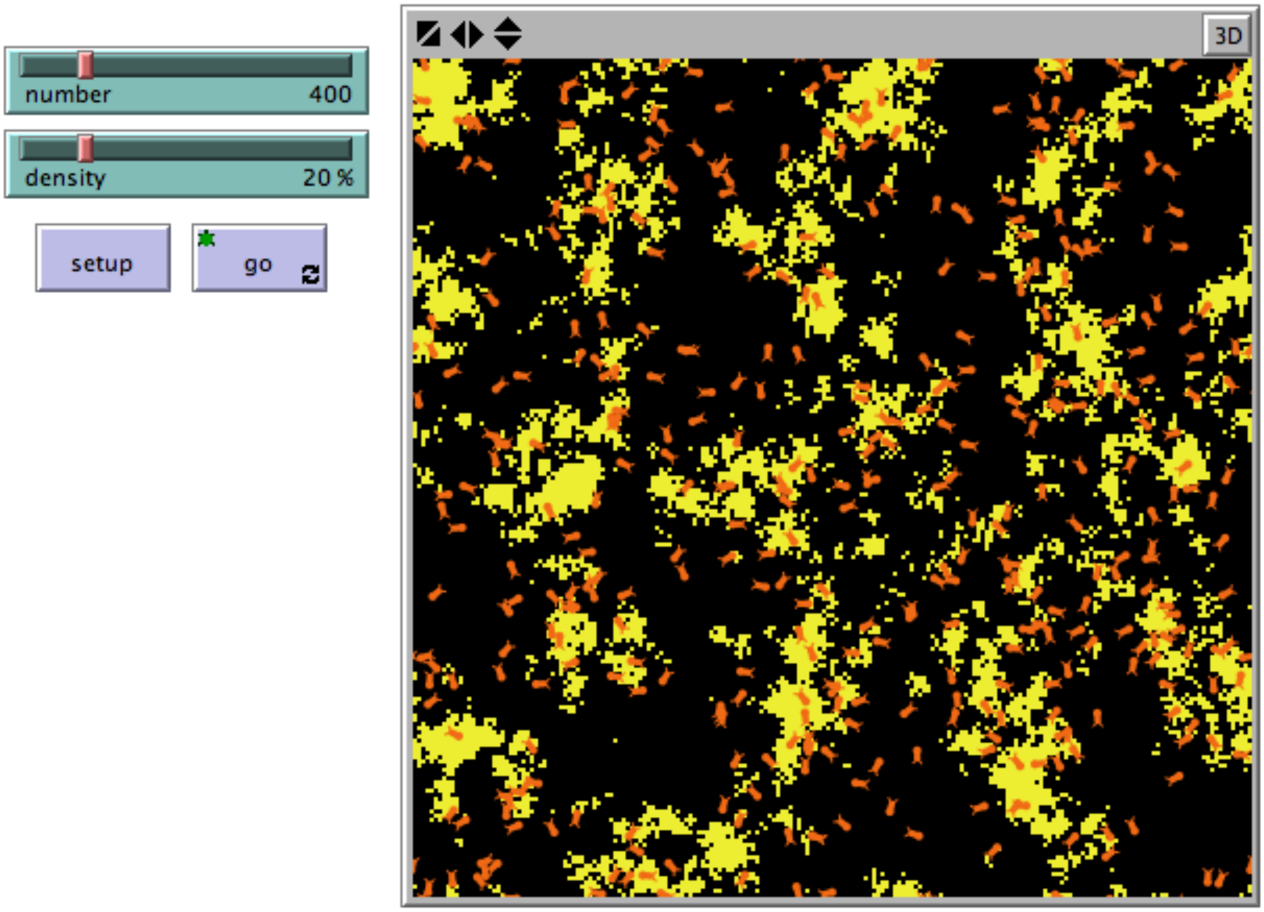
Adventures of Jasper Woodbury

Jasper Woodbury is the name of a character in a series of adventure stories that the Cognition and Technology Group at Vanderbilt University (CTGV) use as the basis for “anchored instruction”. The stories, presented on videodisc or CD-ROM are carefully crafted mysteries that present problems to be solved by groups of learners. Since the video can be randomly accessed, learners are encouraged to re-explore parts of the story in order to gather clues and develop theories about the problem to be solved. The Jasper series first appeared in the 1980s and there are now 12 stories (CTGV 1997).

CSILE / Knowledge Forum

CSILE—Computer Supported Intentional Learning Environment—was developed by Marlene Scardamalia and Carl Bereiter at the Ontario Institute for Studies in Education (OISE) in the 1980s. CSILE is a collaborative, problem-based, knowledge-building environment. Learners can collaborate on data collection, analysis of findings, constructing and presenting conclusions by exchanging structured "notes," and attaching further questions, contributions, and so on to pre-existing notes. CSILE was originally conceived to provide a dynamic scaffold for knowledge construction—one that would let the learners themselves direct the inquiry process (Scardamalia & Bereiter, 1991). CSILE is now commercially developed and licensed as *Knowledge Forum*. See

StarLogo & NetLogo



StarLogo and NetLogo are parallel-computing versions of Logo. By manipulating multiple (thousands), distributed “turtles,” learners can work with interactive models of complex interactions, population dynamics, and other decentralized systems. Developed by Mitchel Resnick, Uri Wilensky and a team of researchers at MIT, StarLogo was conceived as a tool to move learners' thinking “beyond the centralized mindset” and to study how people make sense of complex systems (Resnick 1991; 1994; Wilensky & Resnick, 1999). NetLogo— an environment developed by Wilensky at the Center for Connected Learning and Computer-Based Modeling at Northwestern University is in widespread use both in education and research. Both of these are freely available on the internet. See http://ccl.northwestern.edu/netlogo/ and http://www.media.mit.edu/starlogo.

MaMaMedia / World Wide Workshop

> The World Wide Workshop is a global foundation for developing open-source applications of social media technology and game production, to enhance learning, innovation, entrepreneurship, and an understanding of the world in economically disadvantaged and technologically under-served communities. (http://www.worldwideworkshop.org)

An organization founded in 2004 by MIT Media Lab graduate and entrepreneur Idit Harel, World Wide Workshop addresses the problem of closing the digital divide and transforming education by reaching low socio-economic youth in low-performing schools with learning networks and by taking a systemic approach to education innovation and reform. In 2006, the World Wide Workshop launched the Globaloria Learning Network www.Globaloria.org). The Globaloria Learning Network (www.Globaloria.org) is a "blended learning lab" that provides a year-long digital curriculum, tools, resources, student and educator data tracking, and professional development for educators to engage, motivate and advance students' STEM learning through game design. Young people in middle school and high school ages are immersed in blended learning (combining online and onsite), becoming game designers and mastering creative computational skills and core content knowledge. Academic researchers from several countries work with the World Wide Workshop to study constructionist digital literacy, motivation and engagement, and how new technology innovation can inform, engage and transform students, teachers, schools and communities.

The underlying constructionist digital literacy approach stems from her MIT Media Lab research and was also present in an earlier company Harel founded in the 90's called MaMaMedia. The rationale of MaMaMedia was to enable kids and their parents to participate in web experiences that are creative, safe, constructionist by nature, and educational. Harel's book, *Children Designers* (Harel 1991), lays the foundation for MaMaMedia, and for research in understanding how children in rich online environments construct software and design math games with representations of their thinking. MaMaMedia enabled girls and boys to be online playing games, learning how participate in the vast MaMaMedia community.

MOOSE Crossing

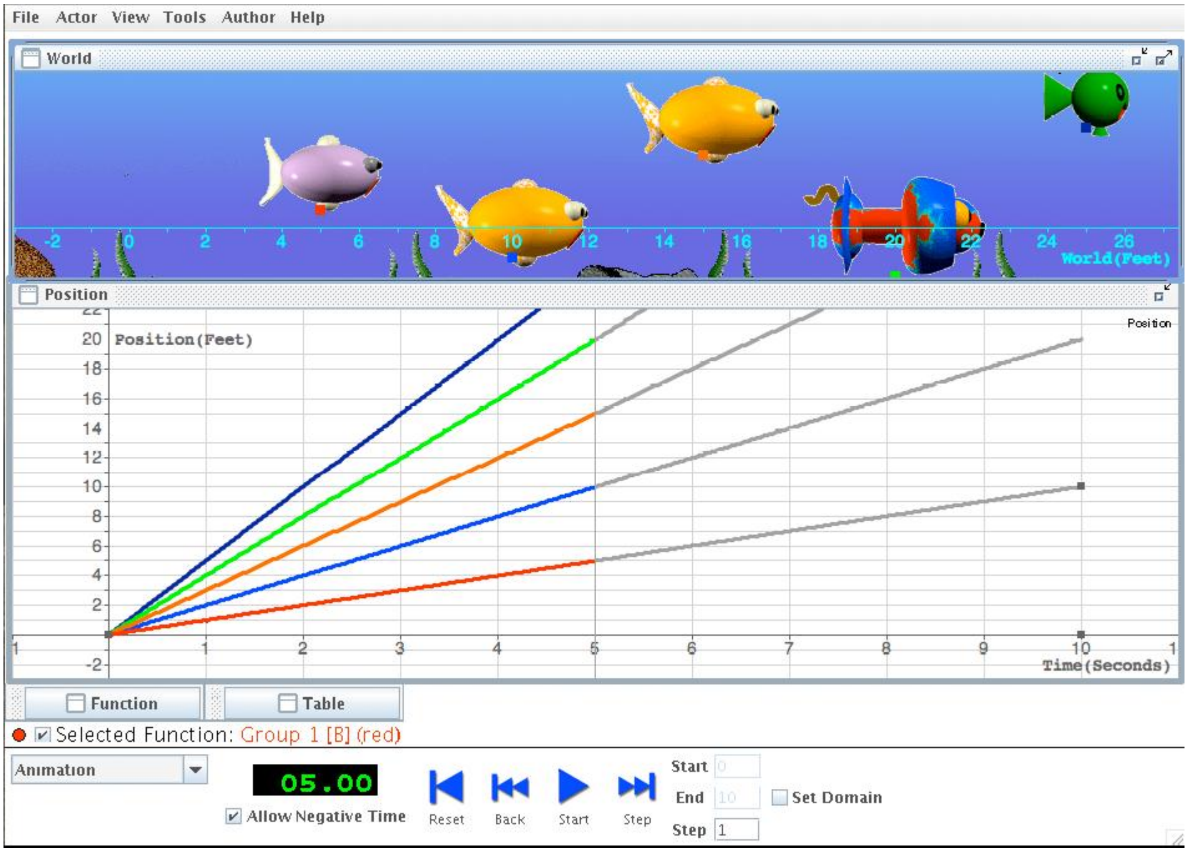
The MacMOOSE client interface showing editing, browsing, and main interaction windows.

Georgia Tech researcher Amy Bruckman created *MOOSE Crossing* as part of her doctoral work at the MIT Media Lab. MOOSE Crossing can be characterized as an break-through combination of Papert's Logo/ microworlds, the "mutable media" notions of Alan Kay (Kay 1996), and a MOO (Haynes and Holmevik 1998)—a real-time, collaborative, immersive virtual environment. MOOSE Crossing is a microworld that learners can themselves enter, designing and programming the virtual environment from within. It becomes a lived-in text that one shares with other readers/writers/designers. Bruckman (1998) stated that this early innovation, MOOSE Crossing, was "community support for constructionist learning." Indeed, it was.

Calling a software system a place gives users a radically different set of expectations. People are familiar with a wide variety of types of places, and have a sense of what to do there... Instead of asking What do I do with this software?, people ask themselves, What do I do in this place? The second question has a very different set of answers than the first. (Bruckman, 1998 p. 49)

Bruckman's thesis is that community and constructionist learning go hand in hand. Her ethnographic accounts of learners inside the environment reveals very close, very personal bonds emerging between children in the process of designing and building their world in MOOSE Crossing. "The emotional support," she writes, "is inseparable from the technical support. Receiving help from someone you would tell your secret nickname to is clearly very different from receiving help from a computer program or a schoolteacher" (p. 128).

SimCalc



SimCalc's features animation and real-time graphs.

SimCalc's tag-line is "Democratizing Access to the Mathematics of Change," and the goal is to make the understanding of change accessible to more learners than the small minority who take calculus classes. SimCalc, a project at the University of Massachusetts under James Kaput working with Jeremy Roschelle, and Ricardo Nemirovky, is a simulation and visualization system for learners to explore calculus concepts in a problem-based model, one that avoids traditional problems with mathematical representation (Kaput, Roschelle, & Stroup, 1998). The core software, called *MathWorlds* (echoing Papert's "Mathland" idea) allows learners to manipulate variables and see results via real- time visualizations with both animated characters and more traditional graphs. SimCalc is freely available on the Internet. See http://www.simcalc.umassd.edu/

Participatory Sims

Participatory Sims, a project overseen by Uri Wilensky and Walter Stroup at Northwestern University, is a distributed computing environment built on the foundations of LOGO that encourages learners to collaboratively explore complex simulations. The Participatory Sims project centres around HubNet, a "Classroom-based Network of Handheld Devices and Up-front Computer" which allows learners to participate in models of dynamic systems (Resnick 1996) in a live, classroom environment. "The emergent behavior (see Figure 1) of the system and its relation to individual participant actions and strategies can then become the object of collective discussion and analysis." (Wilensky & Stroup, 1999) See http://www.ccl.sesp.northwestern.edu/ps/index.html

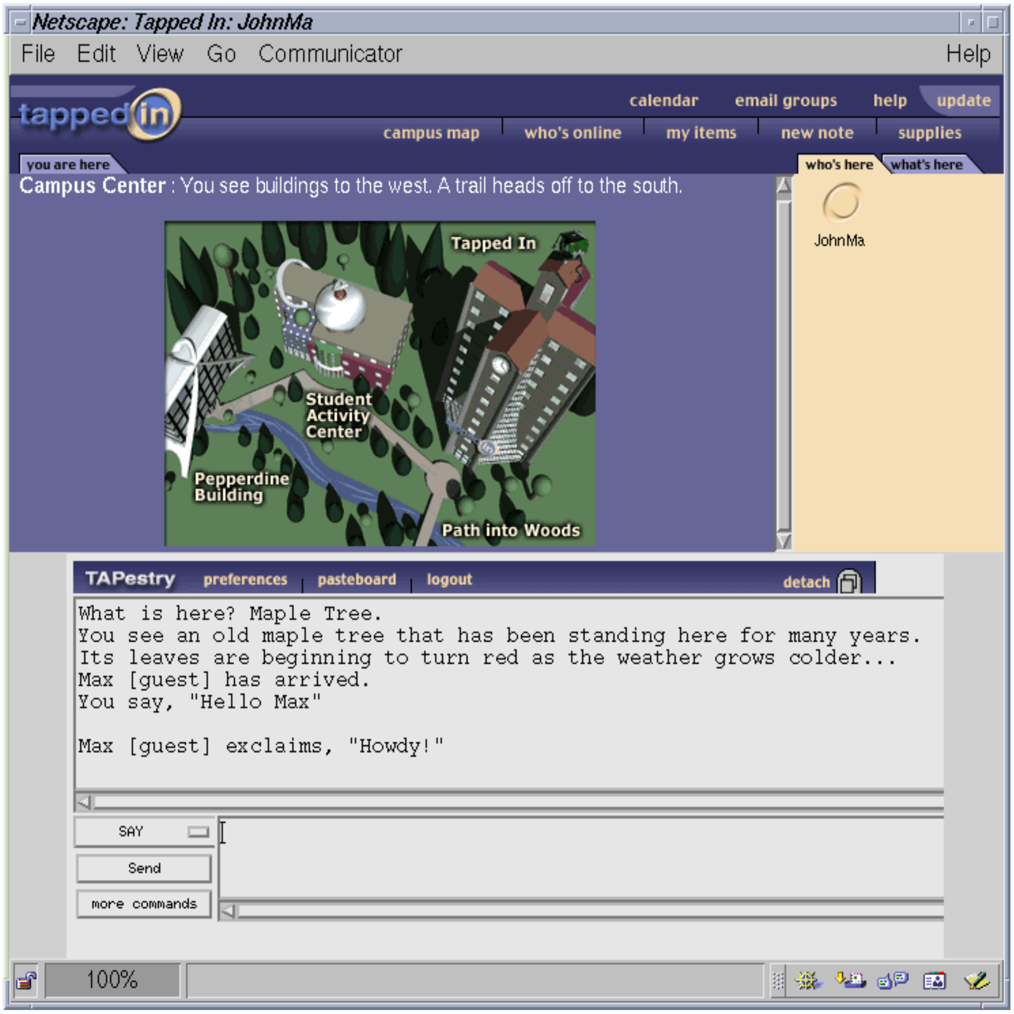
CoVis

CoVis—"Collaborative Visualization"—a project that ran from Northwestern University in the 1990s, was clearly a strong predictor of what was to follow in education. It focused on science learning through projects using a telecommunications infrastructure, scientific visualization tools, and software to support collaboration between diverse schools in distributed locations (Edelson, Pea, & Gomez, 1996). Much of learners' investigation centred on atmospheric and environmental studies, allowing wide-scale (across the USA) data sharing. Learners could then use sophisticated data analysis tools to visualize and draw conclusions. CoVis made use of a variety of networked software: collaborative "notebooks," distributed databases, system visualization tools, as well as the WWW and electronic mail. The goal in the CoVis project was for young people to study topics in much the same way as professional scientists do.

National Geographic Kids Network

Another example of an early perspectivity environment in the late 1980s and 1990s was the National Geographic Kids Network. A number of very large-scale research projects explored the possibilities of connecting multiple classrooms across the United States for data sharing and collaborative inquiry (Feldman, Konold, & Coulter, 2000). Programs like *National Geographic Kids Network* (NGKNet), an NSF-funded collaboration between the National Geographic Society and educational technology research center TERC reached thousands of classrooms and tens of thousands of students (p. 30). TERC's NGKNet provided curriculum plans and resources around issues like acid rain, and tools which facilitated large-scale data collection, sharing, and analysis of results. Other projects, like *Classroom BirdWatch* and *EnergyNet* focused on issues with comparable global significance and local implications, turning large numbers of learners into a community of practice doing distributed scientific investigation. Feldman, Konold, and Coulter note that these large scale projects question the notion of the individual child as scientist, pointing instead toward interesting models of collaborative engagement in science, technology, and society issues (pp.142–143). Needless to say this work still continues to impress. See http://kids.nationalgeographic.com/kids/

Tapped In



The "TAPestry" interface to the Tapped In environment.

Tapped In was a Multi-user Online Educational Workspace (MEOW) for teachers and education professionals. The Tapped In project, led by Mark Schlager at SRI, began in the late 1990s as a MOO (textual VR) environment for synchronous collaboration and has since grown into a sophisticated (Web + MOO) multimedia environment for both synchronous and asynchronous work, with a large and very active user population (Schlager 1997). Tapped In uses similar technological infrastructure to MOOSE Crossing, but has a different kind of community of practice at work within it; Tapped In functions more like an ongoing teaching conference, with many weekly or monthly events, workshops, and happenings.Tapped In is an exemplary model of a multi-mode collaborative environment. See http://www.tappedin.sri.com/

CoWeb

At Georgia Tech, Mark Guzdial and colleagues at the Collaborative Software Laboratory (CSL) created a variety of software environments building on the original educational computing vision of Alan Kay in the 1970s (Kay 1996); the computer can be a tool for composing and experiencing dynamic media. Growing from Guzdial's previous work on the *CaMILE* project (Guzdial 1997)—a web-based "anchored collaboration" environment, CSL's *CoWeb* project explores possibilities in designing and using collaborative media tools online (Guzdial 1999). CoWeb and other CSL work is largely based on the *Squeak* environment, a direct descendant of Alan Kay's research at Xerox PARC in the 1970s.

WebGuide

WebGuide, a web-based, collaborative knowledge-construction tool, was created by Gerry Stahl and colleagues at the University of Colorado (Stahl 1999). WebGuide is designed to facilitate personal and collaborative understanding through mediating perspectivity via cultural artifacts. WebGuide acts as a scaffold for group understanding. WebGuide is a structured conferencing system supporting rich interlinking and information re-use/re-contextualization, as well as multiple views on the structure of the information set. Learners contribute information from individual perspectives, but this information can later be negotiated and re-collected in multiple contexts construct.

Challenging Questions

Models of Mind or Culture Creation?

From the vantage point of the mid-1990s, Jerome Bruner looked back on the cognitive revolution of the late 1950s, which he helped to shape, and reflected on a lost opportunity. Bruner had imagined that the new cognitive paradigm would bring the search for meaning to the fore, distinguishing it from the behaviorism that preceded it (Bruner 1990, p. 2). And yet, Bruner writes, the revolution went awry, not because it failed, but because it succeeded:

Very early on, for example, emphasis began shifting from "meaning" to "information," from the *construction* of meaning to the *processing* of information. These are profoundly different matters. The key factor in the shift was the introduction of computation as the ruling metaphor and computability as a necessary criterion of a good theoretical model. (p. 4)

The information processing model of cognition became so dominant, Bruner argues, and the role of meaning and meaning-making ended up as much in disfavor as it had been in behaviorism. "In place of stimuli and responses, there was input and output," and hard empiricism ruled again, with a new vocabulary, but with the same disdain for mentalism (p. 7). Bruner's career as a theorist is itself instructive. Heralded by Gardner and others as one of the leading lights of 1950s cognitivism, Bruner has since the 1980s been one of a small but vocal group calling for a return to the role of culture in understanding the mind. This movement has been tangled up closely with the evolution of educational technology over the same period, perhaps illuminated in a pair of titles that bookend one researcher's decade-long trajectory: Etienne Wenger's (1987) *Artificial Intelligence and Tutoring Systems: Computational and Cognitive Approaches to the Communication of Knowledge* and his (1998) *Communities of Practice: Learning, Meaning, and Identity.*

Paradigm Shift with Digital Media or Incremental Changes?

In his 1996 article, "Paradigm Shifts and Instructional Technology: An Introduction," Timothy Koschmann began by identifying four defining paradigms of technology in education. In roughly chronological (but certainly overlapping) order, these are: Computer-Aided Instruction (CAI), characterized by drill-and-practice and programmed instruction systems; Intelligent Tutoring Systems (ITS), which drew on artificial intelligence (AI) research in order to create automated systems which could evaluate a learner's progress and tailor instruction accordingly; the Logo-as-Latin paradigm, led by Seymour Papert's "microworld" and children-as- programmers efforts; and finally, Computer-Supported Collaborative Learning (CSCL), a "socially-oriented, constructivist" approach that focuses on learners in practice, in groups. Koschmann invoked Thomas Kuhn's (1996) controversial notion of the *incommensurability* of competing paradigms:

Kuhn held that the effect of a paradigm shift is to produce a divided community of researchers no longer able to debate their respective positions, owing to fundamental differences in terminology, conceptual frameworks, and views on what constitutes the legitimate questions of science. (Koschmann 1996, p.2)

Koschmann's analysis may well be accurate. The literature surrounding the effects learning technology produces certainly displays examples of this incommensurability, even within the writings of individual theorists.

A counter perspective to Kuhn's view of paradigmatic shifts in scientific understanding was offered by Stephen Toulmin (1972), who argued that conceptual change must not be understood as a globally unified, systematic shift in attitudes in beliefs about science; rather, it was a fragmented process which was highly contextualized and dependent upon local scientific practices. According to Toulmin, knowledge develops in a more piecemeal fashion rather than through seismic leaps; 'competing' paradigms continue to exert considerable influence on our understanding. Andrea diSessa (2006), arguing for a reappraisal Toulmin's neglected work on conceptual change, applied it to how the "intuitive ideas" which young learners brought to a physics lesson were crucial resources for developing "knowledge in pieces," or the weaving of various threads of ideas into a "different, stronger, and more normative conceptual fabric" (diSessa, 2006, p.273). The application of these ideas to learning technologies casts doubt upon the notions of internal coherence of individual paradigms and their representative designers, as well as their impermeability to each other.

As mentioned earlier, Papert's work with teaching children to program in Logo was originally concerned with bridging the gap between Piaget's concrete and formal thinking stages, particularly with respect to mathematics and geometry. But over time, Papert's work with children and Logo began to be talked about as "computer cultures" (Papert 1980, p. 22– 23): Logo gave its practitioners a vocabulary, a framework, and a set of tools for a particular kind of learning through exploration. Papert envisaged a computer culture where children could express themselves as epistemologists, challenging the nature of established knowledge. But while Papert's ideas and the practice of Logo learning in classrooms contributed significantly to the *esprit de temps* of the 1980s, it was difficult for many mainstream educational researchers and practitioners to adopt the mindset he believed would revolutionize learning. A large scale research project to evaluate the claims of Logo in classrooms was undertaken by researcher Roy Pea (when he was at Bank Street College) and his colleagues in the mid-1980s. The Bank Street studies came to some critical conclusions about the work Papert and his colleagues were doing (Pea and Kurland 1987 [1984]; Pea, Kurland, and Hawkins 1987). Basically, the Bank Street studies concluded with a cautious note: they concluded that no significant effects on cognitive development could be confirmed, and called for much more extensive and rigorous research amid the excitement and hype. The wider effect of the Bank Street publications fed into something of a popular backlash against Logo in the schools. A 1984 article in the magazine, *Popular Psychology* summarized the Bank Street studies, and suggested bluntly that Logo hadn't delivered on Papert's promises.

Papert responded to this critique (Papert 1987 [1985]), arguing that the framing of research questions was overly simplistic. Papert chided his critics for looking for cognitive effects by isolating variables as if classrooms were "treatment" studies. Rather than asking "technocentric" questions like "What is THE effect of THE computer?" (p 23), Papert called for an examination of the culture-building implications of Logo practice, and for something he called "computer criticism," which he proposed as akin to literary criticism.

Pea and others responded (Pea 1987b), claiming that Papert had unfairly characterized the Bank Street research (Papert had responded only to the *Psychology Today* article, not to the original literature), and arguing that as researchers they had a responsibility to adhere to accepted scientific methods for evaluating the claims of new technology. The effect of this exchange was to illuminate the vastly different perspectives of these researchers. Where Papert was talking about the open-ended promise of computer cultures, Pea and his colleagues, developmental psychologists, were evaluating the work from the standpoint of demonstrable changes in cognition (Pea and Kurland 1987 [1984]). While Papert accused his critics of reductionism, Davy (1985) likened Papert to the proverbial man who looks for his keys under the streetlight "because the light is better there."

Gavriel Salomon and Howard Gardner responded to this debate with an article that searched for middle ground (Salomon and Gardner 1986): an analogy, they pointed out, could be drawn from research into television and mass media, a much older pursuit than educational computing, and one in which Salomon was an acclaimed scholar. Salomon and Gardner argued that one could not search for independent variables in such a complex area; instead, they called for a more holistic, exploratory research program, one that took more than the overt *effects of* the technology into account.

Indeed, in 1991, Salomon and colleagues David Perkins and Tamar Globerson published a groundbreaking article that shed more light on the issue (Salomon, Perkins, and Globerson 1991). To consider the "effects of" a technology, one had to consider what was changed after a learner had used a technology—but in the absence of it. The questions that arise from this are whether there is any "cognitive residue" from the prior experience, and whether there is transfer between tasks. This is a different set of questions than arise from investigating the "effects with" technology, which demand a more decentered, system-wide approach, looking at the learner in *partnership* with technology.

While it contributed important new constructs and vocabulary to the issue, the Salomon, Perkins, and Globerson article is still deeply rooted in a traditional cognitive science perspective, like much of Pea's research, taking first and foremost the individual mind as the site of cognition. Salomon, Perkins, and Globerson, all trained in cognitive psychology, warn against taking the "effects with" approach too far, noting that computers in education are still far from ubiquitous, and that the search for the "effects of" is still key. From the perspective of today's ubiquitous computing technologies, which have taken the "effects with" study of technology "out of the lab," and into countless informal settings, a less rigid cognitive orientation is now the norm for understanding technology's diffuse, yet constitutive effects on human interaction and community building. The most visible example is the revolution in online social networks, online game play, and social media in general.

In a 1993 article, Pea responded to Salomon et. al, from yet a different angle. Pea, now Dean at Northwestern and working closely with his Learning Sciences colleagues, wrote on "distributed intelligence," and argued against taking the individual mind as the locus of cognition, criticizing Salomon and colleagues' individualist notions of cognitive residue:

The language used by Salomon et al. (1991) to characterize the concepts involved in how they think about distributed intelligence is, by contrast, entity-oriented—a language of containers holding things. (Pea 1993, p. 79)

Pea, reviewing recent literature on situated learning and distributed cognition (Winograd and Flores 1986; Lave 1988; Brown, Collins, and Duguid 1996[1989]), had changed his individualist framework of cognitive science for a more "situative perspective" (Greeno 1997) while Salomon (1993) argued that cognition still must reside in the individual mind. Interestingly, neither Salomon nor Pea in this exchange seemed completely comfortable at this point with the notion of culture-making beyond its influence as a "contributing factor" to mind, artifacts, and such empirically identifiable constructs.

The question needs to be asked, are these advances made with the introduction of digital media technologies representative of a paradigm shift or are they merely a conversation among differing points of viewing, based on different measures and methods of studying the problem. Indeed, it seems that the proof is in the pudding. A cultural shift has occcurred. The next step it to harness the scholarship to create a vision for seriously changing how learning can be re-created with more engagement and involvement with all the stakeholders. To be able to find the patterns in current research so that less time is spent on debates and more on reaching agreements.

Developmental or Narrative Appoaches to Learning Theory?

Understanding the nature of technology-based learning systems greatly depends upon one's conceptualization of how learning occurs; is learning linear and developmental, or a more fluid and even random "system" of making meaning of experience?

Proponents of stage theory have tried to show how maturation takes place in logical causal sequences or stages according to observable stages in growth patterns—the final stage being the highest and most coveted. Developmental theories, such as Freud's oral, anal and genital (Freud, 1952), Erikson's eight stages of psychological growth from basic trust to generativity (Erikson, 1950), or Piaget's stages from sensori-motor to formal operational thinking (see Grubner and Voneche 1977), are based on the belief that the human organism must pass through these stages at critical periods in its development in order to reach full healthy integrated maturation, be it psychological, physical, spiritual, or intellectual.

Strict adherence to developmentalism, and particularly its unidirectional conception, has been significantly challenged by Gilligan (1982), Gardner (1985), Fox Keller (1985), Papert (1986), and Illich and Sanders (1989)—not to mention a wave of postmodern theorists—proposing theories which address the fundamental issues underlying how we come to terms with understanding our thinking. One such challenge, raised by Ivan Illich and Barry Sanders (1989), reflects upon the prehistorical significance of the narrative voice. Thinking about thinking as essentially evolving stages of development requires the kind of calibration only possible in a world of static rules and universal truths. Illich and Sanders point out that narrative thinking is rather a weaving of different layers or versions of stories which are never fixed in time or place. Before the written word and

[p]rior to history...there is a narrative that unfolds, not in accordance with the rules of art and knowledge, but out of divine enthusiasm and deep emotion. Corresponding to this prior time is a different truth—namely, myth. In this truly oral culture, before phonetic writing, there can be no words and therefore no text, no original, to which tradition can refer, no subject matter that can be passed on. A new rendering is never just a new version, but always a new song. (Illich and Sanders 1984, p.4.)

Illich and Sanders contend that the prehistoric mode of thinking was a relativistic experience; that what was expressed at any given moment in time changed from the previous time it was expressed. There could be no fixed recall, nor "truth." as we define it today. This concept of knowledge as a continually changing truth, dependent upon both communal interpretation and storytellers' innovation, dramatically changed with the introduction of writing. The moment a story could be written down, it could be referred to. Memory changed from being an image of a former indivisible time to being a method of retrieving a fixed, repeatable piece or section of an experience.

The development of prehistoric thinking (with image and imagination) through historical thinking (with writing and conceptual schemes) has also been called posthistorical thinking (Flusser 2004). Beginning with photography and on through networked computing devices, new image-based media, while born in conceptual thought, has enabled learners to tap into their "imaginal capacity" to reflect on their own learning processes and redefine the world through multiple representations of knowledge, also changing the notion of a fixed truth.

Another notion to Illich and Sanders emerges in Carol Gilligan's research on gender and moral development (1982). Gilligan makes the case that the "different voice" women bring includes an ethic of care, a tie between relationship and responsibility (1982, p.173). Gilligan set the stage for a new mode of research which includes intimacy and relationship rather than separation and objectivity, the tenets of of traditional empiricism.

Evelyn Fox Keller, a leading critic of the masculinization of science, heralded the relational model as a legitimate alternative for doing science. She pointed out that science is a deeply personal as well as a social activity (1985), historically preferential to a male and objectivist manner of thinking. Combining Thomas Kuhn's ideas about the nature of scientific thinking with Freud's analysis of the different relationship between young boys and their mothers and between girls and their mothers, Fox Keller analyzed underlying reasons for scientific objectivism. She claimed that boys are encouraged to separate from their mothers, and, girls to maintain attachments, influencing the manner in which the two genders relate to physical objects. The young boy, in competition with his father for his mother's attentions, learns to compete in order to succeed. Girls, not having to separate from their mothers, find that becoming personally involved—getting *a feeling for the organism*, as Barbara McClintock (Fox Keller 1985) would say—is a preferred mode of making sense of their relationship with the physical world. As a result, girls may do science in a more connected style, seeking relationships with, rather than dissecting, what they investigate. Girls seek to understand meaning through these personal attachments.

Just as science is not the purely cognitive endeavor we once thought it, neither is it as impersonal as we thought: science is a deeply personal as well as a social activity. (1985, p.7)

Obviously, we will never know if a scientific discipline would really be different if it had been driven by more relational or narrative influences. Yet we may want to ask how people with a tendency toward relational or narrative thinking can be both invited into the study of the sciences and be encouraged to contribute to its theoretical foundations. And, we may want to ask how new media and technologies expand how we study what we study, thereby inviting a range of epistemologically diverse thinkers into the mainstream of intellectual pursuits.

Bricolage and the Ecology of Digital Media Technologies or

In her first book, *The Second Self: Computers and the Human Spirit* (1984), Sherry Turkle explored the different styles of mastery that she observed in boys and girls in Logo classrooms. Returning to this topic, Turkle and Papert, in their 1991 article, "Epistemological Pluralism and the Revaluation of the Concrete," outline two poles of technological mastery: hard and soft. Hard mastery, identified with top-down, rationalist thinking, was observed in a majority of boys. Soft mastery, identified with relational thinking and Claude Lévi-Strauss's notion of *bricolage*, was observed in a majority of girls working with computers in a Boston elementary school (Turkle and Papert 1991, pp. 167-168). The identification of soft mastery and *bricolage* in programming was a turning point which led to a deeper examination of "the concrete," a subject woefully undervalued in contemporary life, and especially in math and science education.

Stanford scholar, Brigid Barron (2006) found that "learners use strategies consistent with the bricoleur image described by Turkle, building on the concept introduced by Levi-Strauss [1966] where information is flexibly gathered and put together for new purposes." Barron revisited the role of the *bricoleur* to expand upon what Nardi & O'Day (1999) call *information ecologies*. Not only are information ecologies a product of both relational and material resources as Nardi and ODay suggest, but also, according to Barron, dynamic learning systems include a range of multiple influences that are dovetail well with understanding learning in formal and informal learning settings. She concludes with a call for changes.

> The reports from the young learners shared … suggest that we should expect interest in learning to originate within and outside school and that adolescents have a significant role to play in sustaining their own development. As researchers interested in human development, we are in a vital position to help envision what self-sustaining learning ecologies might look like and investigate how resourcefulness might be nurtured. (Barron, 2006, p. 221)

Turkle and Papert's use the terms bricoleur and the notion of *hard* and *soft* to explain different approaches to computation, extends to other important domains: ecological stances, feminism, and ethnography of science and computation (1991, p. 372). They propose that hard and soft styles of creating knowledge and understanding systems as equally significant to concrete thinking will gain respectability in the scientific community by attending more to the softer concrete way of thinking.

> The development of a new computer culture would require more than technological progress and more than environments where there is permission to work with highly personal approaches. It would require a new and softer construction of the technological, with a new set of intellectual and emotional values more like those we apply to harpsichords than hammers. (Ibid, p. 184)

Goldman-Segall offered a dynamic and flexible conceptualization of diversity of thinking called *thinking attitudes* (Goldman-Segall, 2008). These attitudes imply positionality and orientation, and are situated in time and place. She defined thinking attitudes as a transitional position held for a shorter period of time, one that is fluid and flexible (Ibid., p. 245) This notion of *thinking attitudes* includes: meta/physical, historical, ethical and pedagogical attitudes. Meta/physical attitudes address the question, "What's the story?" They explore how children address causality, intention, existence, and truth. The meta/physical attitudes in adolescents are turning points, referring to the worlds of invention and imagination — attitudes that are rooted in the physical situatedness of their interactions with the world. Historical attitudes address how things began. They encompass learning from the past and making sense of it. Ethical attitudes include our actions in relation to desire and external norms. Balancing right and wrong is particularly challenging. These attitudes address questions such as: "What is fair?" To a great extent, pedagogical (or activist) attitudes overlap with ethical attitudes. Pedagogical attitudes are concerned with such questions as "What can we do? How do we change? How do we teach others to learn from what we did?" Video excerpts available on the web: http://www.pointsofviewing.com.

This dynamic epistemological theory of learning led to ways of knowing that include *genderflexing*: boys may take on *thinking attitudes* that are traditionally associated with those of girls, and vice versa (Goldman-Segall, 1996b &1998b). The underlying theme here is the primacy of situated points of viewing, rather than essential qualities. Learners become ethnographers, observing and engaging with the cultural environments in which they participate. She also recommends *knowledge framing* (1998). Framing is rooted in several diverse but interwoven contexts: Frames—in contrast to the more essentialist notion of styles—include the context set by the framer, what is framed, as well as what is left out of the frame. In other words, for learning, it is more important to have flexible thinking attitudes about the content knowledge so that the frames that are applied to that cluster of knowledge are appropriate and useful in understanding the domain under investigation. Related uses of framing can be found in the work by Marvin Minsky's on artificial intelligence (1986), Howard Gardner on multiple intelligences (1985b), Erving Goffman on everyday sociology (1986), and Trinh Minh T. Ha on cinematography (1992).

Distributed Cognition and Situated Learning

In the 1990s, the focus had already changed from understanding the mind of one child to understanding the situated minds of learners in collaborative teams. Simultaneously, learning moved from learning modules, to open-ended constructionism, to problem-based learning (PBL) environments and rich-media cases of teaching practices.

> *Our memories are in families and libraries as well as inside our skins; our perceptions are extended and fragmented by technologies of every sort.* – *Susan Leigh Star*

The 1989 article by John Seely Brown, Alan Collins, and Paul Duguid called "Situated Cognition and the Culture of Learning" (1996 [1989]) is generally credited with introducing the concepts and vocabulary of situated cognition to the educational community. This influential article, drawing on research at Xerox PARC and at the Institute for Research on Learning (IRL), expressed the authors' concern with the limits to which conceptual knowledge can be abstracted from the situations in which it is situated and learned (p. 19), as is common practice in classrooms. Building upon the experiential emphasis of pragmatist thinkers like John Dewey and on the social contexts of learning of Russian activity theorists like Vygotsky and Leontiev, Brown and his colleagues proposed the notion of *cognitive apprenticeship*. In a cognitive apprenticeship model, knowledge and learning are seen as situated in practice: "Situations might be said to co-produce knowledge through activity. Learning and cognition, it is now possible to argue, are fundamentally situated (p. 20)." This idea is carried forward to an examination of tools and the way in which they are learned and used:

Learning how to use a tool involves far more than can be accounted for in any set of explicit rules. The occasions and conditions for use arise directly out of the context of activities of each community that uses the tool, framed by the way members of each community see the world. The community and its viewpoint, quite as much as the tool itself, determine how a tool is used. (Brown, et al, p. 23)

The work that brings the situated perspective firmly home to the learning environment is Jean Lave and Etienne Wenger's *Situated Learning: Legitimate Peripheral Participation* (1991), which goes significantly beyond Brown's cognitive apprenticeship model. Core to Lave and Wenger's work is the idea of knowledge as distributed or stretched across a community of practice—what Salomon later called the "radical situated perspective" (Salomon 1993).

In our view, learning is not merely situated in practice—as if it were some independently reifiable process that just happened to be located somewhere; learning is an integral part of generative social practice in the lived-in world... Legitimate peripheral participation is proposed as a descriptor of engagement in social practice that entails learning as an integral constituent (Lave and Wenger 1991, p. 35).

This perspective flips the argument over: it is not that learning happens best when it is situated (as if there were learning settings that aren't situated), but rather, learning is an integral part of all situated practice. So, rather than asking—as Bransford and colleagues at Vanderbilt had—"how can we create authentic learning situations?" they ask "what is the nature of communities of practice?" and "how do newcomers and old-timers relate and interact within communities of practice?" Lave and Wenger answer these questions through elaborating the nature of communities of practice in what they term *legitimate peripheral participation*.

By this we mean to draw attention to the point that learners inevitably participate in communities of practitioners and that mastery of knowledge and skill requires newcomers to move toward full participation in the sociocultural practices of a community. (p. 29)

Lave and Wenger also elaborate on the involvement of cultural artifacts and technologies within communities of practice. As knowledge is stretched over a community of practice, it is also embodied in the material culture of that community, both in the mechanisms of practice and in the shared history of the community:

Participation involving technology is especially significant because the artifacts used within a cultural practice carry a substantial portion of that practices heritage... Thus, understanding the technology of practice is more than learning to use tools; it is a way to connect with the history of the practice and to participate more directly in cultural life. (p. 101)

Artifacts and technology are not just instrumental in embodying practice; they also help constitute the structure of the community. As Goldman-Segall (1998) reminds us,

They are not just tools used by our culture; they are tools used for making culture. They are partners that have their own contribution to make with regard to how we build a cultural understanding of the world around us. (pp. 268-269)

Situated cognition, then, becomes perspectival knowledge, and the tools and artifacts we create become what Goldman coined “perspectivity technologies:” viewpoints, frames, lenses, and filters; reflections of selves with others. To understand the significance of perspectivity in the role of learning, one has to turn to recent studies on the other side of the coin—perception.

This renewed interest in perceptually-grounded research, or emodiment, encompasses the continually interacting parts of making meaning.

Conclusion

In this chapter, the Points of Viewing Theory was applied to an already rich understanding of the use of computers, the Internet, and digital media. The range of possible contributors was so broad that we decided to focus only on those theories and tools which were directly connected with the notion of perspectival knowledge construction and perspectivity technologies. To those researchers whose work is not described in this chapter, we regret that we did not find the opportunity to include your work.

Perspectivity technologies (Goldman, 2007) represent the next phase of thinking with our technology partners. Not only will we build them, shape them, and use them. They will also affect, influence, and shape us. They will become, if some researchers have their way, part of our bodies, not only augmenting our relationships but becoming members in their own right. As robotic objects become *robotic subjects*, we will have to consider how Steven Spielberg's robot in the movie AI felt when interacting with humans—and hopefully we will be kinder to ourselves and to our robots.

Thus, a perspectivity technology is not only a technology which enables us to better see each other's viewpoints and make decisions based on multiple points of viewing. It is also concerned with the creation and design of technologies that add perspectives. Technologies have built-in filters. To explain this briefly, one need only think of how recording an event with pen and paper, an audio-tape recorder, and a digital video recorder each provide different perspectives of the same event. The technology provides an important filter or lens. A viewpoint, one could say. And while that viewpoint is deeply influenced by who the filmmaker is, or who the reporter is, there is a perspective that is contributed by the technology. A camera tells a different story than the audio or text tool.

As we use new media as communication devices, they affect how we communicate; they participate by being what they are, having a capacity to shape the story. Beyond the *media is the message* theme of Marshall McLuhan (1964), we are now deeply entrenched in a participatory relationship with our new media technologies because they have become part of our perspective, our consciousnes, and our way of life. The level of interaction with our virtual creatures (technologies) transforms our relationships. We are never completely alone. We are connected through media devices even if we can't see them. They see us.

That said, what has changed in learning? It might seem we have moved a long way from believing that learning is putting certain curriculum inside of students' heads and then testing them for how well they have learned that material. Yet, instructionism is still alive and well. From kindergarten to higher education, students are still being trained to be able to pass tests that will provide them with entrance into higher education. In spite of learning theories moving from behaviorism to cognitivism to distributed and situated cogntion, educators are caught in the quagmire of preparing students for their future education instead of trying to make the present educational, engaging, and challenging fun. Teachers are caught in an entangled web of uncertainty as they scramble to learn the new tools of the trade (the Internet, distance learning environments, etc), learn the content they have to teach, and then organize the learning into modules that will fit into the next set of learning modules.

The irony is that when we think of who our best teachers were, they were the teachers who were able to elicit something within us and help us connect our lives to others' lives. Not a technology thing! The lives of poets, mathematicians, physicists, and the fisher down at the docks. These teachers created a sense of community in the classroom. We became part of a discovery process that had no end. Oakeshott here It was not knowledge that was already known that we craved. It was putting ideas together that had not yet been put together—at least in our own minds. We felt we invented something new. And indeed we and others within these learning environments did invent new ideas in our minds. Yet, people say that this cannot happen to most students in most classes and the best we can do is to teach the curriculum, provide a safe learning environment, and test people for what we wanted them to learn. This is not good enough. And if students do not become partners in their learning now, technologies will create islands of despair as more and more students stop learning how to be creative citizens interested in each other, in difference, and in understanding complexity. And technology could open up a gulf between people as well as lack of boundaries between work and play. In Sherry Turkle's book, *Alone Together* (2011) she explores these problematics of computer use reminding us about a serious problem facing a technologically seduced society. She argues that we are losing our sense of community, that being together in online environments, such as Facebook™ for example, can create more aloneness.

> Connectivity technologies once promised to give us more boundaries between work and leisure. But as the cell phone and smartphone eroded the bounndaries between work and leisure, all the time in the world was not enough. Even when we are not "at work," we experience ourselves "on call"; presssed, we want to edit out complexity and "cut to the chase." (Turkle, 2001, p. 12)

These comment have raised some online readers to "push-back," to use a common vernacular. In an online discussion, Włodzimierz Sobkowiak, a professor of English philology at the Adam Mickiewicz University in Poland asks:

> Why should communities of necessity be 'constituted by physical proximity' only is beyond me, frankly, so I'll not even try to analyze this claim. … I can assure the reader that the shared concerns, real consequences, and common responsibilities' present in those environments are felt as not a bit less real than in the so-called Real Life. (Retrieved on August 15, 2011 from http://grou.ps/zajek/blogs/item/sherry-turkle-alone-together)

While technologies have become many things for many people, they can be designed for the creative sharing of perspectives and viewpoints that lead to building better communities of practice in our schools and in our societies.

Since the attack on the World Trade Center more than a decade ago on September 11, 2001, we have come to realize that the world is not what we thought it was. We know so little about each other. We know so little about the world. Our educational lenses have focused too long on educational goals which acted as blinders to the world around us. We thought we didn't need to understand each other and out diverse perspectives on the world. That one view of knowledge was enough. Yet, what we know and what we make is always a reflection of our beliefs and assumptions about the world. And we need to build new bridges in a socially constructed interconnected world where people have access to each other's customs, languages, and world views. And, we must rely on our technologies to build connections with peoples we do not know so that the gulf between us lessens.

Perspectival knowledge, the ability to stand up and view unknown territory, enables students, educators, and the public at large to take a second and third look at the many lenses which make up the human experience, even if from a distance. The purpose is not to always approve of what we see, but to learn how to put different world views into a new configuration and uncover paths we might not yet see. And we might, if we are brave enough, respect students not only for what has been taught them after they have taken prescribed courses and completed assignments, but also respect them the moment they walk through the door—or through the online portal as they engage in the formal or informal *learning habitat*.

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