

Planning for “Neomillennial” Learning Styles: Implications for Investments in Technology and Faculty

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Abstract

The evolution of higher education is shaped by changes in the characteristics of entering students, by development of new methods of teaching and learning, and by shifts in the knowledge that society values. Rapid advances in information technology are influencing each of these factors, as the standard interface for computers and telecommunications that brings distant experts and archives to one’s desktop is increasingly complemented by “Alice in Wonderland” interfaces to virtual environments and “Ubiquitous Computing” infusions of digital information into real world settings (Dede, 2002). Higher education institutions can prosper by basing their strategic investments on using these emerging educational technologies to match the increasingly “neomillennial” learning styles of their students. Based on “mediated immersion” in “distributed-learning communities,” these emerging learning styles include:

- fluency in multiple media and in simulation-based virtual settings;
- communal learning involving diverse, tacit, situated experience, with knowledge distributed across a community and a context as well as within an individual;
- a balance among experiential learning, guided mentoring, and collective reflection;
- expression through non-linear, associational webs of representations; and
- co-design of learning experiences personalized to individual needs and preferences.

Implications for higher education are presented, with particular emphasis on strategic investments in physical plant, technical infrastructure, and professional development. The implications for physical and technical infrastructure include:

- infusing wireless networking and mobile wireless devices throughout the campus,
- creating multi-purpose habitats personalizable by students (rather than specialized locations such as computer labs), and
- experimenting with virtual versions of physical environments and with “augmented realities” based on ubiquitous computing.

The implications for professional development include helping faculty develop capabilities in:

- *Co-Design*: Developing learning experiences students can personalize
- *Co-Instruction*: Utilizing knowledge sharing among students as a major source of content and pedagogy
- *Guided Social Constructivist and Situated Learning Pedagogies*: Infusing case-based participatory simulations into presentational/assimilative instruction
- *Assessment Beyond Tests and Papers*: Evaluating collaborative, non-linear, associational webs of representations; utilizing peer-developed and peer-rated forms of assessment; student assessments provide formative feedback on faculty effectiveness.

Many faculty will find these shifts difficult, but they must themselves experience mediated immersion and develop “neomillennial” learning styles to continue effective teaching as the nature of students alters.

Information Technology's Influence on Learning Styles

The evolution of higher education is shaped by changes in the characteristics of entering students, by development of new methods of teaching and learning, and by shifts in the knowledge society values. Focusing initially on the first of these dimensions, descriptions about the influence of technology on student learning styles tend to contrast various generations who grew up with different technologies (Tapscott, 1998; Howe & Strauss, 2000; Oblinger, 2003). Each framework clusters and names generational cohorts somewhat differently, but typically television is portrayed as the dominant medium in shaping Baby Boomers' characteristics (born 1946-1964): how they learn, play, create, work, consume, and participate in communities. In contrast, computers and the Internet are depicted as the crucial technological force determining the characteristics of Millennials (born after 1982), and those born between those two generations are represented as influenced by both types of media.

From the generational learning styles perspective, television-shaped learners are described as passive observers, assimilating a single version of "truth" (e.g., the evening newscast), while Internet-shaped learners are portrayed as active seekers of information, judging among competing opinions (for example, synthesizing inconsistent information from various websites). Television-generation learners are represented as more subservient to hierarchical authority than Internet-generation learners, who in contrast are seen as more independent, intellectually open, innovative, curious, and self-reliant.

This portrayal of generational learning styles is oversimplified. Certainly, the media used by children and the events that occur in society during their formative years influence how they learn. For example, the window of opportunity for readily learning to speak multiple languages, which often closes after childhood, illustrates how experiences during early neurodevelopmental

stages shape a person's adult capabilities. However, just as some adults retain an ability to readily master other languages, and all adults with immersive practice can learn another language, so formative experiences with media do not inexorably determine individuals' characteristics throughout their lifetimes.

Moreover, for almost all types of personal attributes, differences among individuals are greater than dissimilarities between groups. For example, men and women do not fall neatly into "Mars" and "Venus" depictions. Also, age cohorts that span decades distinguished primarily by shifts in birth rates do not have consistent internal formative experiences across, say, 1946-64. In addition, as discussed later, computers and the Internet are not a uniform medium, in contrast to television, radio, and books (Dede, Brown-L'Bahy, Ketelhut, & Whitehouse, 2004).

The bottom line is that many Baby Boomers exhibit "Millennial" learning styles, and—to a lesser extent—vice versa. Demographically and technologically determined differences among generations, while fun to discuss at a superficial level and as typical characteristics of large groups, are a poor foundation for decision-making about the learning needs of individual students. These generalizations break down even further when applied to the diverse, cross-age mixtures of people found in many college and university courses.

So, can any useful conclusions be reached about trends in learning styles? If one discards the hype about generational determinism, the learning preferences ascribed to "Millennials" are increasingly true for many students across a wide range of ages, driven only by the technologies they grew up with, but also by the tools and media they use everyday. For example, by its nature, the Web rewards comparing multiple sources of information, individually incomplete and collectively inconsistent. This induces learning based on seeking, sieving, and synthesizing,

rather than on assimilating a single “validated” source of knowledge as from books, television, or a professor lecturing.

Similarly, digital media and interfaces encourage multi-tasking: my teenage daughter “does her homework” by simultaneously reading her textbook, listening to her MP3 player, receiving and sending email, utilizing her web browser, and dialoguing with six of her classmates via instant messaging! Some of these behaviors are off-task, but others are helpful (e.g., forming a virtual think-tank with her friends to collaboratively tackle homework). Whether multi-tasking results in a superficial, easily distracted style of gaining information or a sophisticated form of synthesizing new insights depends on the ways in which this learning strategy is used. Certainly, at some number of simultaneous tasks, this strategy results in cognitive overload and concomitant loss of effectiveness.

As another of many possible examples illustrating media’s influence on learning styles for people of any age, textual, auditory, and video presentations of content are linear and serial, while Web representations are often non-linear and more closely mirror the associational network of human long-term memory. Potentially, this can result in a more effective style of learning, since rich associations among chunks of data are as important a part of knowledge as the information itself. In practice, research indicates that how “hypermedia” is designed by its originators and traversed by its users has much to do with the degree to which learning is enabled (Ashman, 2002). For example, poorly designed hypermedia can cause cognitive overload in its users as they determine which of many paths to follow, while well designed hypermedia offers a small number of links labeled to indicate how the interrelationships among these chunks of information are part of the knowledge presented.

A final illustration of “millennial” learning styles fostered by current media is “Napsterism”: the recombining of others’ designs to individual, personally tailored configurations (Mitchell, 2003). This is evident in how people of all ages have shifted from purchasing music pre-packaged into albums to instead mixing/tailoring their own sequences of artists and songs. Business is increasingly catering to and reinforcing this shift by data-mining the choices individuals make, then providing customized services based on patterns of individual characteristics and behaviors (e.g., a person who buys dog-food at the supermarket will receive unsought mail relating to pet care). Increasingly, people want educational products and services tailored to their individual needs rather than one-size-fits-all courses of fixed length, content, and pedagogy. Whether this individualization of educational products is effective or ineffective depends both on the insight with which learners assess their needs and desires and on the degree to which institutions provide quality customized services rather than Frankenstein-like mixtures of learning modules.

Different Kinds of Internet-Based Media Foster Various Types of Learning Styles

Another oversimplification of the generational frameworks for learning styles is seeing computers and telecommunications as a single medium that fosters a particular approach to learning. On the contrary, the Internet is an infrastructure that supports many media, including such disparate applications as “groupware” for virtual collaboration, asynchronous threaded discussions, multi-user virtual environments, videoconferencing, and mobile, location-aware wireless devices (e.g., personal digital assistants with embedded global positioning system [GPS] capabilities). Research indicates that each of these media, when designed for education, fosters particular types of interactions that enable – and undercut – various learning styles (Dede, Whitehouse, & Brown-L’Bahy, 2002).

In particular, university students have a wide range of preferences among Internet-based instructional media, depending on their individual learning style. For example, at the end of a course I teach each year on “Learning Media that Bridge Distance and Time,” students rank the eight different media in which they worked during the semester: face-to-face, experiential websites for informal learning, groupware, a multi-user virtual environment, wireless handheld devices, videoconferencing, asynchronous threaded discussions, and the course instructional shell. Year after year, face-to-face interactions are ranked by all students in either first or second place. This replicates the results of many distance education studies that show students often feel that something important to their learning is missing when all interactions are mediated, whether asynchronous or synchronous.

“Distributed learning” is a term used to describe educational experiences that combine the use of face-to-face teaching with synchronous and asynchronous mediated interaction. This instructional strategy distributes learning across a variety of geographic settings, across time, and across various interactive media. Our research provides a strong rationale for instructional designs based on distributed learning. For example, over fifty percent of the students consistently rank asynchronous threaded discussions as their first or second most effective learning medium. Our case studies indicate that often these learners think deeply about a topic before formulating a question or a stance; value collective reflection; appreciate the convenience of posting anyplace, anytime; or are English language learners who welcome the opportunity to assimilate and compose at their own pace—all independent of their generational demographic characteristics. In addition, almost half the students typically rank a multi-user virtual environment as their third or fourth choice of learning medium. These students often describe themselves as shy and reluctant to participate in face-to-face dialogue, as valuing intellectual

interchanges most when coupled with psychosocial interactions, or as feeling more “authentic” in communications where their physical characteristics are masked by the medium.

Both types of student preferences make a strong argument for using highly ranked multimedia tools to complement face-to-face instruction, based on both cognitive and psychosocial dimensions of learning style. Further, of particular note is that less than half of my students typically rank face-to-face interaction as their first choice of learning medium, even though these students have no predisposition toward distance learning and experience excellent classroom teaching. Cumulatively, findings from this and similar research (Harlen & Altobello, 2003) indicates that the full range of students' learning styles is undercut when interaction is limited to classroom settings. As discussed later, neither homogenizing instruction to a “generic” learning style nor customizing teaching to each individual’s learning style is an adequate response to this challenge.

Clearly, adults who did not grow up with a certain medium nonetheless frequently evolve their learning style to take advantage of its capabilities, just as many who did not grow up with word processors now write more effectively via word processing than with a typewriter. Numerous studies document the ways that mature Internet-based educational media, such as those described above, enable students to learn in a manner well suited for them (Dede, Brown-L’Bahy, Ketelhut, & Whitehouse, op cit). Students often are surprised to “find their voice” in media whose characteristics differ substantially from face-to-face interaction, which is increasingly less seen as the “gold standard” that completely satisfies educational needs. As computers and telecommunications continue to evolve, what new forms of learning styles may emerging media enable, and how can higher education prepare for this shift?

How Emerging Media are Fostering “Neomillennial” Learning Styles

Over the next decade, three complementary interfaces will shape how people learn (Dede, 2002):

- *The familiar “world to the desktop” interface*, providing access to distant experts and archives, enabling collaborations, mentoring relationships, and virtual communities-of-practice. This interface is evolving through initiatives such as Internet2.
- *“Alice-in-Wonderland” multi-user virtual environments (MUVE) interfaces*, in which participants’ avatars interact with computer-based agents and digital artifacts in virtual contexts. The initial stages of studies on shared virtual environments are characterized by advances in Internet games and work in virtual reality.
- *Interfaces for “ubiquitous computing,”* in which mobile wireless devices infuse virtual resources as we move through the real world. The early stages of “augmented reality” interfaces are characterized by research on the role of “smart objects” and “intelligent contexts” in learning and doing.

The “millennial” learning styles discussed thus far stem primarily from the world-to-the-desktop interface; however, the growing prevalence of interfaces to virtual environments and augmented realities is beginning to foster “neomillennial” learning styles. The crucial factor leading to the augmentation of “millennial” learning styles with “neomillennial” characteristics is that the “world-to-the-desktop” interface is not psychologically immersive, while in contrast virtual environments and augmented realities induce a strong sense of “presence.” This immersion in virtual environments and augmented realities shapes participants’ learning styles beyond what using sophisticated computers and telecommunications has fostered thus far, with multiple implications for higher education.

How Immersive Presence Enhances Learning

“Immersion” is the subjective impression that one is participating in a comprehensive, realistic experience (Heeter, 1992; Witmer & Singer, 1994). Immersion in a mediated, simulated experience (such as a virtual environment or an augmented reality) involves the willing suspension of disbelief. As a weak example, when watching a Harry Potter movie on an IMAX screen, the plot and characters coupled with visual and auditory input produce a sense of psychological immersion: the audience does not focus on the sensations of sitting in a theatre seat, but instead on being present in a wizarding “world,” observing a fascinating series of events. The example is weak because the experience is passive, as opposed to the stronger immersion induced when one is a participant shaping an experience rather than an observer watching.

The design of mediated-immersion simulated learning experiences depends on actional, symbolic, and sensory factors (Dede, Salzman, Loftin, & Ash, 2000). Inducing actional immersion involves empowering the participant in an experience to initiate actions that have novel, intriguing consequences. For example, when a baby is learning to walk, the degree of concentration this activity creates in the child is extraordinary. Discovering new capabilities to shape one's environment is highly motivating and sharply focuses attention.

Inducing a participant's symbolic immersion involves triggering powerful semantic associations via the content of an experience. As an illustration, reading a horror novel at midnight in a strange house builds a mounting sense of terror, even though one's physical context is unchanging and rationally safe. Invoking intellectual, emotional, and normative archetypes deepens one's experience by imposing a complex overlay of associative mental models.

Beyond actional and symbolic immersion, advances in interface technology are now creating virtual environments and augmented realities that induce a psychological sense of sensory and physical immersion. Sensory immersion is relatively easy to foster in augmented realities, which are set in physical environments. Psychological immersion is achievable in MUVES by design strategies that combine actional, symbolic and sensory factors in manipulating one's avatar to further the suspension of disbelief that one is "inside" a virtual environment: the equivalent of diving rather than riding in a glass-bottomed boat.

For example, one design strategy to induce psychological immersion in virtual environments is using egocentric rather than exocentric frames of reference. As Salzman (2000) describes:

The exocentric frame of reference (FOR) provides a view of an object, space, or phenomena from the outside, while the egocentric FOR provides a view of the object, space, or phenomena from within. Imagine a dollhouse. As a human, you can peer at the house from a number of angles, you can reach into it to feel the rugs and furniture with your fingers, and you may even be able to stick your head inside; but you can only imagine what it would be like to be a doll living inside that house. You experience the dollhouse from the exocentric FOR. If you were the doll inside the house, you would experience the house and its furnishings from within - walking on the rugs, sitting in the chairs, and sleeping in the bed; but you would only be able to imagine what it would be like to be the human on the outside looking in. You would experience the dollhouse from the egocentric FOR. Each FOR would give you different kinds of information about the dollhouse and it might shape what you come to know about that house.

The research on virtual reality Salzman and I conducted on frames of reference found that the exocentric and the egocentric FORs have different strengths for learning. Our studies established that learning ideally involves a "bicentric" perspective alternating between egocentric and exocentric FORs.

We also researched how each of these three perspectives—the egocentric, the exocentric, and the bicentric—influenced participants' motivation and learning styles (Salzman, Dede, & Loftin, 1999). One major advantage of egocentric perspectives is that they enable participants'

actional immersion and motivation more strongly than exocentric FORs, which are better suited for dispassionate observer roles. Another advantage of the egocentric FOR is that this perspective enables “situated” learning, while exocentric perspectives foster insights gained from distancing oneself from the context (seeing the forest rather than the trees). Bicentric FORs combine the strengths of each perspective.

Situated Learning and Transfer via Psychological Immersion

The capability of computer interfaces to foster psychological immersion enables technology-intensive educational experiences that draw on a powerful pedagogy: situated learning. Reports such as the National Research Council’s study, *How People Learn: Extended Edition* (2000), delineate theoretical constructs for understanding teaching and learning. The major schools of thought cited are *behaviorist* theories of learning (presentational instruction), *cognitivist* theories of learning (e.g., tutoring, guided learning-by-doing), and *situated* theories of learning (mentoring and apprenticeships in communities of practice). Situated learning requires authentic contexts, activities, and assessment coupled with guidance from expert modeling, mentoring, and “legitimate peripheral participation” (Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004). As an example of legitimate peripheral participation, graduate students work within the laboratories of expert researchers, who model the practice of scholarship. These students will interact with experts in research as well as with other members of the research team who understand the complex processes of scholarship to varying degrees. While in these laboratories, students gradually move from novice researchers to more advanced roles, with the skills and expectations for them evolving.

Potentially quite powerful, situated learning is much less utilized for instruction than behaviorist or cognitivist approaches. This is largely because creating tacit, relatively

unstructured learning in complex real-world settings is difficult. However, virtual environments and ubiquitous computing can draw on the power of situated learning by creating immersive, extended experiences with problems and contexts similar to the real world (Dede, 2004). In particular, multi-user virtual environments and real-world settings augmented with virtual information provide the capability to create problem-solving communities in which participants can gain knowledge and skills through interacting with other participants who have varied levels of skills, enabling legitimate peripheral participation driven by intrinsic sociocultural forces.

Situated learning is important in part because of the crucial issue of transfer. “Transfer” is defined as the application of knowledge learned in one situation to another situation and is demonstrated if instruction on a learning task leads to improved performance on a transfer task, typically a skilled performance in a real world setting (Mestre, 2002). One of the major criticisms of instruction today is the low rate of transfer generated by conventional instruction. Even students who excel in schooling or training settings often are unable to apply what they have learned to similar real world contexts. Situated learning addresses this challenge by making the setting in which learning takes place similar to the real world context for performance in work or personal life (Dede, Brown-L’Bahy, Ketelhut, & Whitehouse, 2004). Learning in well-designed digital contexts can lead to the replication in the real world of behaviors successful in simulated environments (Murray, 1997).

Moreover, the evolution of an individual’s or group’s identity is an important type of learning for which simulated experiences situated in virtual environments or augmented realities are well suited. Reflecting on and refining one’s individual identity is often an significant issue for higher education students of all ages, and learning to evolve group and organizational identity is a crucial skill in enabling innovation and in adaptation to shifting contexts. The social

sciences see both the self and the organization as often fragmented, with complementary parts, rather than centralized and unitary. Identity “play” through trying on various representations of the self and the group in virtual environments provides a means for different sides of a person or team to find common ground and the opportunity for synthesis and evolution.

Immersion is important in this process of identity exploration because virtual identity is unfettered by physical attributes such as gender, race and disabilities. Virtual environments based on games (e.g., Everquest [<http://eqlive.station.sony.com/>]) and simulations (such as Whyville [<http://www.whyville.net>]) illustrate how participants take advantage of fluidity in the identities they present. Simulations in virtual environments and augmented realities increase the value of these explorations by providing realistic feedback on how the real world responds to various patterns of individual and group behavior (Turkle, 1995).

But what is so special about the egocentric perspectives and situated learning now enabled by emerging media? After all, each of us lives with an egocentric perspective in the real world and has many opportunities for situated learning without using technology. One attribute that makes mediated immersion different and powerful is the ability to access information resources and psychosocial community distributed across distance and time, broadening and deepening experience. A second important attribute is the ability to create interactions and activities in mediated experience not possible in the real world, such as teleporting within a virtual environment, enabling a distant person to see a real-time image of your local environment, or interacting with a (simulated) chemical spill in a busy public setting. Both of these attributes are actualized in the Alice-in-Wonderland interface.

Immersion in Virtual Educational Environments

Most students now using multi-player virtual environments (MUVES) do so in the context of gaming. As Steinkuehler (2004) notes:

Massively multiplayer online games (MMOGs) are highly graphical 2- or 3-D videogames played online, allowing individuals, through their self-created digital characters or “avatars,” to interact not only with the gaming software (the designed environment of the game and the computer-controlled characters within it) but with other players’ avatars as well. These virtual worlds are persistent social and material worlds, loosely structured by openended (fantasy) narratives, where players are largely free to do as they please – slay ogres, siege castles, barter goods in town, or shake the fruit out of trees... Thanks to out-of-game trading of in-game items, Norrath, the virtual setting of the MMOG EverQuest, is the seventy-seventh largest economy in the real world, with a GNP per capita between that of Russia and Bulgaria. One platinum piece, the unit of currency in Norrath, trades on real world exchange markets higher than both the Yen and the Lira (Castronova, 2001).

Players of all ages are involved in many different MMOGs and in ancillary activities such as fanfiction websites, where people enamored with a particular game or book can add to its genre with their own writing (Black, 2004). (These fanfiction archives are substantial; Black documents a multi-fandom archive that contains hundreds of thousands works of original fanfiction, including over twenty thousand Final Fantasy videogame-related fictions and approximately one hundred and twenty-seven thousand Harry Potter-based texts.) While the content of these games and activities often does not lead to knowledge useful in the real world, rich types of learning and identity formation do take place in these environments, fostering “neomillennial” learning styles based on characteristics of immersive mediated interaction. Our research on MUVES crafted for educating young people about higher order inquiry skills illustrates this.

With National Science Foundation funding, my colleagues and I are creating and studying graphical MUVES that use digitized museum resources to enhance middle school students' motivation and learning about science and society (Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004). Our goal is to promote learning for all students, particularly those unengaged

or low performing; our studies include assessing the various types of learning styles we see emerging and reinforced by egocentric and bicentric situated learning through mediated interaction. Today's middle school pupils will enter college in about five to seven years, and older enrollees with learning styles shaped by virtual environments are a growing part of current students in higher education.

Our "River City" MUVE is centered on skills of hypothesis formation and experimental design, as well as on content related to national standards and assessments in biology and ecology. We are demonstrating how students can gain this knowledge through immersive simulations, interactive virtual museum exhibits, and "participatory" historical situations. Students learn to behave as scientists while they collaboratively identify problems through observation and inference, form and test hypotheses, and deduce evidence-based conclusions about underlying causes.

The River City virtual "world" consists of a city with a river running through it; different forms of terrain that influence water runoff; and various neighborhoods, industries, and institutions, such as a hospital and a university (<http://muve.gse.harvard.edu/muvees2003/>). Through egocentric perspectives, the learners themselves populate the city, along with computer-based agents, digital objects that can include audio or video clips, and the avatars of instructors (Figure 1). River City is typical of the United States in the late nineteenth century; the right hand window in Figure 1 depicts how we use museum artifacts to illustrate building exteriors and street scenes from that period in history. In addition, throughout the world, students encounter residents of River City and "overhear" their conversations with one another. These computer-based "agents" disclose information and provide indirect clues about what is going on in River City.

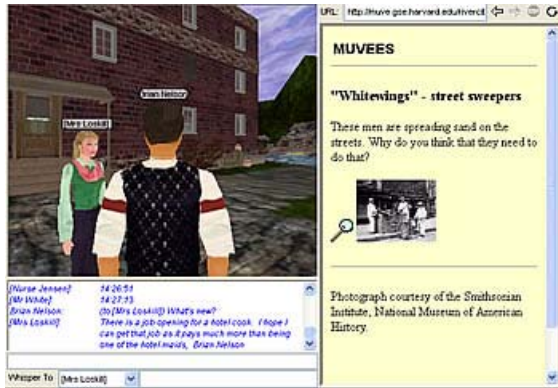


Figure 1: Talking with an Agent

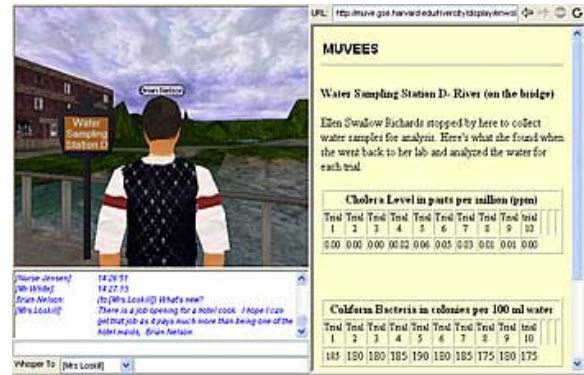


Figure 2: Collecting Water Quality Data

Content in the right-hand interface-window shifts based on what the participant encounters or activates in the virtual environment (Figure 2). In this case, the right hand window presents water quality data from one of eleven water-sampling stations in River City. Through data gathering, students observe the patterns that emerge and wrestle with questions such as “Why are many more poor people getting sick than rich people?” Multiple causal factors are involved, including polluted water runoff to low-lying areas, insect vectors in swampy areas, overcrowding, and the cost of access to medical care.

Dialogue is shown in the text box below these two windows. To aid their interactions, participants also have access to one-click interface features that enable the avatar to express (through stylized postures and gestures) emotions such as happiness, sadness, and anger. These interface features also allow looking upward or downward, as well as seeing the world from a first-person perspective or from behind one's own body in a third-person viewpoint. In addition, learners can interact with digital artifacts and tools, such as a virtual microscope in which the image from the microscope slide appears in the right-hand interface-window.

Multiple teams of students can access the MUVE simultaneously, each individual manipulating an avatar which is "sent back in time" to this virtual environment. Students must

collaborate to share the data each team collects. Beyond textual conversation, students can project to each other "snapshots" of their current individual point of view (when someone has discovered an item of general interest) and also can "teleport" to join anyone on their team for joint investigation. Each time a team reenters the world, several months of time have passed in River City, so that learners can track the dynamic evolution of local problems.

Three strands of illness in River City (water-borne, air-borne, and insect-borne) are integrated with historical, social and geographical content to allow students to experience the realities of disentangling multi-causal problems embedded within a complex environment. In our research on this educational MUVE based on situated learning, we are studying usability, student motivation, student learning, and classroom implementation issues. The results thus far are promising:

- all learners are highly motivated, including students typically unengaged in classroom settings;
- all students build fluency in distributed modes of communication and expression and value using multiple media because each empowers different types of communication, activities, experiences, and expressions;
- even typically low-performing students can master complex inquiry skills and sophisticated content; and
- shifts in the pedagogy within the MUVE alter the pattern of which students do best.

We are now conducting large-scale studies to assess the strengths and limits of this educational approach, in particular how MUVES shape students' learning styles (Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004). Other researchers who study educational MUVES designed for young people, such as Quest Atlantis (<http://atlantis.crlt.indiana.edu/start/index.html>) and

Whyville (<http://www.whyville.net>), also are assessing how immersive virtual environments influence their participants' learning styles (Barab, Thomas, Dodge, Carteaux, and Tuzun, in press; Dede & Palombo, 2004). These studies are documenting how storyline and players' progression through various levels of capability/power enhance motivation and integrate content and skills, as well as how identity play complements and extends learning. Research indicates that active learning based on experience (real and simulated) that includes frequent opportunities for reflection via bicentric frames of reference is both engaging and powerful for a broad spectrum of students.

Immersion in Educational Augmented Realities

An emerging interface that complements the Alice-in-Wonderland immersion of MUVES is augmented reality via ubiquitous computing, in which mobile wireless devices immerse participants in virtual resources as they move through the real world. As one example, Hsi and her colleagues have developed a device called 'eXspot' intended to support, record, and extend exhibit-based, informal science learning at the Exploratorium, an interactive hands-on museum of art, science, and perception located in San Francisco (Hsi, Semper, Brunette, Rhea, & Boriello, to be published). eXspot participants visiting the Exploratorium carry a card with a radio frequency interference device (RFID) "tag" embedded. As various exhibits are viewed, these visitors can swipe the card on a RFID reader at the exhibit. At anytime later, participants can view a museum-generated personal Web page listing the dates the museum was visited and specific exhibits swiped that day. Personal photos taken at the exhibits and online content about exhibits are also available. Research shows that many participants value this functionality and choose to access the webpage after leaving the museum.

As another illustration of ubiquitous computing for learning, Klopfer and his colleagues are developing augmented reality (AR) handheld-computer simulations that embed students inside lifelike problem-solving situations to help them understand complex scientific and social dynamics (<http://education.mit.edu/ar>). Participants in these distributed simulations use location-aware handheld computers (with Global Positioning Systems [GPS] technology), allowing users to physically move throughout a real world location while collecting place-dependent simulated field data, interviewing virtual characters, and collaboratively investigating simulated scenarios.



Figure 3: Students in Augmented Reality

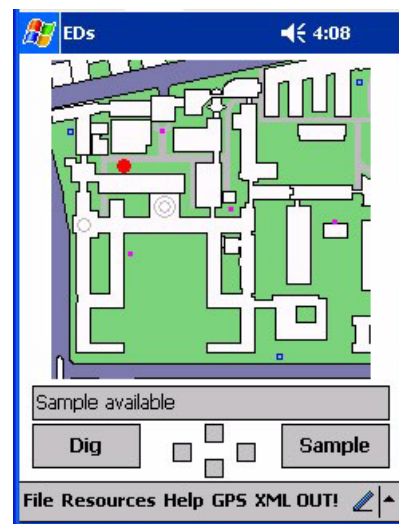


Figure 4: Handheld Location on Campus

For example, their “Environmental Detectives” Augmented Reality simulation engages high school and university students in a real world environmental consulting scenario not possible to implement in a classroom setting (Klopfer, & Squire, in press). Students role-play environmental scientists investigating a rash of health concerns on the MIT campus linked to the release of toxins in the water supply. Working in teams (Figure 3), players attempt to identify the contaminant, chart its path through the environment, and devise possible plans for remediation. As participants physically move about campus, their handheld devices respond to their location (Figure 4), allowing them to collect simulated field data from the water and soil,

interview virtual characters, and perform desktop research using mini-webs of data. At the end of the exercise, teams compile their data using peer-to-peer communication, and synthesize their findings.

Initial research on Environmental Detectives and other AR-based educational simulations demonstrates that this type of immersive, situated learning can effectively engage students in critical thinking about authentic scenarios (Klopfer, Squire, & Jenkins, 2003). Students participating in these simulations indicated that they felt invested in the situations and were motivated to solve the problem. They moved nearly seamlessly between the real world and the information that was being presented to them on their handheld computers as they collected data from virtual scientific instruments and accounts from virtual experts and witnesses. Students were most effective in learning and problem-solving when they collectively sought, sieved, and synthesized experiences, rather than individually locating and absorbing information from some single best source. Klopfer and I are planning to initiate studies on how bicentric immersion in MUVes complement that in augmented realities, and how each type of mediated situated learning affects participants' learning styles.

How Emerging Media are Fostering Mediated Immersion Throughout Life

Quite apart from educational innovation based on emerging media, people's daily use of new devices is shifting their lifestyles toward frequent mediated immersion, which in turn is shaping their learning styles towards "neomillennial" characteristics. Prognosticators such as Howard Rheingold (2002) and William Mitchell (2003) speculate about the impacts on individuals and civilization as new digital media pervade every aspect of life. For example, Rheingold depicts a future based on distributed networks of information, communication, and activity – as contrasted to the historic pattern of lifestyles centered on face-to-face groups

interacting with local resources. Members of the same physical group may have very different personal communities as their major sources of sociability, support, information, a sense of belonging, and social identity. He sees these distributed communities, created through mediated immersion, as far-flung, loosely bounded, sparsely knit, and fragmentary.

Rheingold's forecasts draw on lifestyles seen at present among young people who are high-end users of new media, as well as the visions of researchers and businesses developing products and services based on virtual environments and ubiquitous computing. In a world composed of these high-end users with access to these new products and services, the following types of experiences would pervade people's lifestyles:

- Mobile wireless devices (MWDs) – such as gaming devices, cellphones, digital music players, personal digital assistants -- would access media that are virtually connected to locations (such as street signs linked to online maps), objects (such as books linked to online reviews), and services (such as restaurants linked to ratings by their customers).
- MWDs would access every type of data service anywhere (e.g., banking and stock market information, weather, tickets and reservations, transport schedules)
- MWDs would locate strangers nearby who have identified themselves as having common interests (e.g., people interested in dating and matched on desired attributes, friends of friends, fellow gamers, fans of a certain team, actor, or author).
- Rather than having core identities defined through a primarily local set of roles and relationships, people would express varied aspects of their multi-faceted identities through alternate extended experiences in distributed virtual environments and augmented realities.

Rheingold paints a largely positive picture of this “social revolution,” while articulating some concerns about privacy, quality of life, and loss of humanity.

The technology infrastructure necessary for these lifestyles is emerging. As Baker & Green (2004) note, one-third of U.S. households now have broadband access to the Internet. In the past three years, 14 million U.S. families have linked their computers with wireless home networks. Some 55% of Americans now carry cell phones, and the first data services--radio, photos, and short videoclips--are starting to take off.

Mitchell's forecasts (2003) are similar to Rheingold's in many respects. He too envisions largely tribal lifestyles distributed across dispersed, fragmented, fluctuating habitats: electronic nomads wandering among virtual campfires. People's senses and physical agency are extended outward and into the intangible, at considerable cost to individual privacy. Individual identity is continuously reformed via an ever-shifting series of networking with others and with tools. People express themselves through non-linear, associational webs of representations rather than linear "stories" and co-design services rather than selecting a pre-customized variant from a menu of possibilities.

Whether these forecasts of major shifts in society are accurate is uncertain. Probably, some people will choose the distributed immersive lifestyles Rheingold and Mitchell portray, while others will have less intensive interactions with new media that do not lead to dramatic changes in their activities or identity. More and more, though, people of all ages will have lifestyles involving frequent immersion in both virtual and augmented reality. How might distributed, immersive media be designed specifically for education, and what "neomillennial" learning styles might they induce?

“Neomillennial” Learning Styles Based on Mediated Immersion

Emerging devices, tools, media, and virtual environments offer opportunities for creating new types of “learning communities” for students and teachers. Bielaczyc & Collins (1999) indicate that:

“The defining quality of a learning community is that there is a culture of learning, in which everyone is involved in a collective effort of understanding. There are four characteristics that such a culture must have: (1) diversity of expertise among its members, who are valued for their contributions and given support to develop, (2) a shared objective of continually advancing the collective knowledge and skills, (3) an emphasis on learning how to learn, and (4) mechanisms for sharing what is learned. If a learning community is presented with a problem, then the learning community can bring its collective knowledge to bear on the problem. It is not necessary that each member assimilate everything that the community knows, but each should know who within the community has relevant expertise to address any problem. This is a radical departure from the traditional view of schooling, with its emphasis on individual knowledge and performance, and the expectation that students will acquire the same body of knowledge at the same time.”

Mediated immersion creates “distributed-learning communities,” which have different strengths and limits than location-bound learning communities confined to classroom settings and centered on the teacher and archival materials (Dede, 2004). In particular, distributed-learning communities infuse education throughout students’ lives, orchestrating the contributions of many knowledge sources embedded in real world settings outside of schooling and fostering “neomillennial” learning styles.

In my research and in synthesizing the work discussed in this article, learning styles enhanced by mediated immersion in distributed-learning communities include:

- Fluency in multiple media, valuing each for the types of communication, activities, experiences, and expressions it empowers. *This goes beyond “millennial” learning styles, which center on working within a single medium best suited to one’s style and preferences.*
- Learning based on collectively seeking, sieving, and synthesizing experiences, rather than individually locating and absorbing information from some single best source. *This goes*

beyond “millennial” learning styles in preferring communal learning in diverse, tacit, situated experiences over solo integration of divergent, explicit information sources and in valuing knowledge distributed across a community and a context as well as within an individual.

- Active learning based on experience (real and simulated) that includes frequent opportunities for reflection (for example, infusing experiences in the Virtual University simulation [<http://www.virtual-u.org/>] in a course on university leadership). *This goes beyond “millennial” learning styles in valuing bicentric, immersive frames of reference that begin with direct participation, then infuse guidance.*
- Expression through non-linear, associational webs of representations rather than linear “stories” (e.g., authoring a simulation and a webpage to express understanding, rather than a paper). *This goes beyond “millennial” learning styles in using representations involving richly associated, situated simulations rather than branching, but largely hierarchical multimedia.*
- Co-design of learning experiences personalized to individual needs and preferences. *This goes beyond “millennial” learning styles, which emphasize selecting a pre-customized variant from a range of services offered.*

Mediated immersion likely has other influences on learning style yet to be discovered, but these initial findings have a variety of implications for strategic planning and investment in higher education.

Implications of Neomillennial Learning for Higher Education’s Strategic Investments

The table below presents speculations about how the emergence of “neomillennial” learning styles may influence higher education. Emphasis is placed on implications for strategic investments in physical plant, technology infrastructure, and professional development.

Table 1: Speculations about Higher Education Now and in the Future

<i>Dimension</i>	<i>Now</i>	<i>Future</i>
Location and Physical Infrastructure	<p>Locations and physical infrastructures configured to accomplish specialized forms of activity (e.g., dorm room or apartment; classrooms; student center; library; computer lab)</p> <p>Direct physical manipulation of equipment in science lab</p>	<p>Wearable devices and universal wireless coverage mean access, information, computational power no longer tied to physical space (such as a computer lab)</p> <p>Most activities are distributed across space and time, so tailoring space to particular purposes (such as library reading rooms) often no longer necessary</p> <p>Notion of place is layered/blended/multiple. Mobility and nomadicity prevalent among dispersed, fragmented, fluctuating habitats (e.g., coffeehouses near campus)</p> <p>Virtual simulations complement equipment-based science labs</p>
Smart Objects and Intelligent Contexts	<p>Inert objects and contexts with information available only via signage</p> <p>Physical presence on campus only way of “being there”</p>	<p>Information is virtually connected to locations (such as campus buildings linked to online maps) and objects (such as textbooks linked to course ratings by students).</p> <p>“Mirroring”: Immersive virtual environments provide replicas of distant physical settings</p>
Social Group	<p>Roommates, members of dorm or apartment, classmates</p>	<p>Far-flung, loosely bounded, sparsely knit, and fragmentary communities (independent of cohabitation, common course schedules, or enrollment at a particular campus)</p>

Collaboration	Collaboration dependent on shared physical presence or cumbersome virtual mechanisms	Middleware, interoperability, open content, and open source enable seamless information sharing, collaborative virtual manipulation of tools and media, shared authoring and design, collective critiquing
Personal Customization	Little or none	<p>“Napsterism”: recombining others’ designs to personally tailored configurations (Mitchell, 2003)</p> <p>Customized services based on data-mining for patterns of personal characteristics and behaviors</p>
Cognition	<p>Finding information</p> <p>Sequential assimilation of linear information stream</p>	<p>Seeking, sieving, synthesizing disparate sources of data</p> <p>Multi-tasking among disparate experiences and information sources</p> <p>Focus on associative interconnections among chunks of information</p> <p>Constant reflection on and sharing of experience</p> <p>Mind extended via distributed cognition, sensation, memory</p>
Identity	Identity expressed in the context of face-to-face groups interacting with local resources	<p>Virtual identity unfettered by physical attributes such as gender, race, disabilities...</p> <p>The self continuously reformed via an ever-shifting series of distributed networking with others and with tools</p> <p>Self as an electronic nomad wandering among virtual campfires, no longer needing a local physical infrastructure to articulate identity</p>
Instruction	Instructor designs and delivers “one size fits all” content, pedagogy, and assessment	Learners influence design of content, pedagogy, and assessment based on individual preferences and needs

	Students are passive recipients	<p>Knowledge sharing among students as a major source of content</p> <p>Guided social constructivism and situated learning as major forms of pedagogy</p> <p>Case-based participatory simulations complement presentational/assimilative instruction</p>
Assessment	<p>Student products generally tests or papers</p> <p>Grading centers on individual performance</p> <p>Students provide summative feedback on instructional effectiveness</p>	<p>Student products often involve non-linear, associational webs of representations (e.g., authoring a simulation and a webpage to express understanding of an internship, rather than authoring a paper that synthesizes expert opinions)</p> <p>Peer-developed and peer-rated forms of assessment complement faculty grading, which is often based on individual accomplishment in a team performance context</p> <p>Assessments provide formative feedback on instructional effectiveness</p>

These ideas are admittedly speculative rather than based on detailed evidence and are presented to stimulate reaction and dialogue about these trends.

If one accepts much of the analysis above, four implications for investments in physical and technological infrastructure are apparent:

- *Wireless Everywhere*: provide total coverage of the campus; subsidize uniform mobile wireless devices offering convergence of media (phone, PDA, gaming, Internet)
- *Multi-purpose Habitats*: Creating layered/blended/personalizable places rather than specialized locations (such as computer labs)

- *Augmented Reality*: Experiment with “smart objects” and “intelligent contexts” (via GPS and radio-frequency-interference-device [RFID] tags and transceivers)
- *“Mirroring”*: Experiment with virtual environments that replicate physical settings, but “magical” capabilities for immersive experience

This is not to imply that campuses should immediately undertake massive shifts toward these four themes, but rather to suggest that students of all ages with increasingly “neomillennial” learning styles will be drawn to colleges and universities who have the capabilities above.

Four implications for investments in professional development also are apparent. Faculty will increasingly need capabilities in:

- *Co-Design*: Developing learning experiences students can personalize
- *Co-Instruction*: Utilizing knowledge sharing among students as a major source of content and pedagogy
- *Guided Social Constructivist and Situated Learning Pedagogies*: Infusing case-based participatory simulations into presentational/assimilative instruction
- *Assessment Beyond Tests and Papers*: Evaluating collaborative, non-linear, associational webs of representations; utilizing peer-developed and peer-rated forms of assessment; student assessments provide formative feedback on faculty effectiveness

Some of these shifts are controversial for many faculty, and all involve “unlearning” almost unconscious beliefs, assumptions, and values about the nature of teaching, learning, and the academy. Professional development that requires unlearning necessitates high levels of emotional/social support in addition to mastering the intellectual/technical dimensions involved. The ideal form for this type of professional development is distributed-learning communities, so that the learning process is consistent with the knowledge and culture to be acquired. In other

words, faculty must themselves experience mediated immersion and develop “neomillennial” learning styles to continue effective teaching as the nature of students alters.

Conclusion

All the caveats about generalizing learning style findings delineated earlier certainly apply to the discussion above. Differences among individuals are greater than dissimilarities between groups, so students in any age cohort will present a mixture of “neomillennial”, “millennial,” and traditional learning styles. The technologies discussed are emerging rather than mature, so their final form and their influences on users are not fully understood. A substantial number of faculty and administrators will likely dismiss and resist some of the ideas and recommendations presented in this article.

However, widespread discussion among members of the academy about the trends delineated above is important, whether at the end of that dialogue those involved agree with my speculative conclusions or not. Further, to the extent that some of these ideas about “neomillennial” learning styles are accurate, campuses that make strategic investments in physical plant, technical infrastructure, and professional development along the dimensions suggested will gain a considerable competitive advantage in both recruiting top students and teaching them effectively.

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