CHAPTER 1

THE PEDAGOGY OF THINGS

Ubiquitous Learning, Student Culture, and Constructivist Pedagogical Practice

C. Edward Watson and William O. Plymale

ABSTRACT

This chapter explores the interdisciplinary symbiosis that is emerging between constructivism, student culture, and ubiquitous computing technologies and trends. Recent research regarding students highlights the value and need for constructivist pedagogies that utilize u-learning strategies. Constructivist theory is summarized and described in frameworks that show its relevancy to u-learning. Key u-learning technologies and exemplary practices that support today and tomorrow's students are described and explored in depth. This chapter ultimately provides a vision for the future of u-learning that is grounded in emerging technologies, learning theory, and relevancy to the rising generation of students.

Ubiquitous Learning, pages 3–15

INTRODUCTION

In 1991, Mark Weiser introduced the idea of ubiquitous computing: a world in which computers and associated technologies become invisible and thus indistinguishable from everyday life. This invisible computing is accomplished by means of "embodied virtuality," the process of drawing computers into the physical world (Weiser, 1991). Almost 20 years later, our technologies are redefining Weiser's impression of physical juxtaposition. Advances in sensing, computation, storage, and communications bring new meaning to terms like nearness and presence, and this evolution offers a range of pedagogical promise in an age where students are increasingly carrying devices that can interact with this emerging ubiquitous network of computing. This chapter explores current and future trends associated with the key components of these developments within the context of teaching and learning.

Providing a foundation for this exploration is a long-standing school of thought in educational psychology that argues, in short, that the student who talks, reflects, interacts, and engages the most, learns the most. This simplification of constructivist theory rings true with the intuition of most teachers and faculty, regardless of teaching philosophy and pedagogical approach, and is especially useful for those developing pedagogies employing these tools.

In concert with the emergence of research-informed ubiquitous learning strategies are ongoing narratives regarding today's millennial students. While much of the literature regarding today's youth is based upon generalizations, empirical data does exist that provides guidance for those engaged in learner analysis as a component of their larger instructional design. We know that the numbers of students using emerging technology (Web 2.0, convergence devices, etc.) are increasing, and today's students often use technology for social purposes. This chapter includes an examination of the literature surrounding millennials and offers clarity regarding how to incorporate our understanding of students into the development of u-learning strategies.

Emerging technologies provide the foundation for these strategies, and the most relevant of those will be explored. People-centric mobile applications, physical mobile interactions, and cross-reality are among the new ubiquitous computing trends that take advantage of the aforementioned synergy and will dramatically extend the capabilities of u-learning in the coming decade. Foundational among these is the cell phone, which now functions as a wireless sensor node. This omnipresent technology provides one of the keys behind an emerging people-centric global mobile sensing network, which is resulting in new application areas, such as personal, public, and social sensing, which enable different ways to sense, visualize, and share information about ourselves, friends, communities, the way we live, and the way we learn (Campbell, Eisenman, Lane, Miluzzo, & Peterson, 2006).

Just as the people-based global network is forming, so also is the Internet of Things. Tagging physical objects with RFID and Near Field Communication (NFC) extends these objects as digital resources associated with digital information or services. Physical Mobile Interaction (PMI) explores convenient and intuitive ways mobile devices can be used to interact with tagged physical objects. Cross-reality (x-reality) is the union of ubiquitous sensor/actuator networks and shared online virtual worlds. With x-reality, events in the real world drive phenomena in a virtual environment that is unconstrained by time, space, or physics. These technologies, applied with a clear understanding of today's students and relevant learning theory, provide an unambiguous path forward for u-learning.

BACKGROUND

Around the turn of the century, much was written concerning the then-current generation of students and their relationship with and usage of technologies (e.g., Arafeh & Levin, 2002; Duderstadt, 2000; Frand, 2000; Howe & Strauss, 2000; Oblinger, 2003; Prensky, 2001a, 2001b). A core theme within this scholarship was that learners were developing new learning styles and learning preferences as a result of their immersion in a variety of technologies throughout their formative years. Prensky (2001b) is likely the most well-known, as he coined the term *digital natives* and chronicled the technological immersion of students at that time. He estimated that children were being socialized by

> 10,000 hours playing video games; over 200,000 emails and instant messages sent and received; over 10,000 hours talking on digital cell phones; over 20,000 hours watching TV (a high percentage fast speed MTV); over 500,000 commercials seen—all before the kids leave college. (p. 1)

He posited that today's youth are so markedly different from past generations that our educational systems are a mismatch for these learners (Prensky, 2001a). This echoes similar calls for change in education around this time (e.g., Duderstadt, 2000; Tapscott, 1998); however, Prensky firmly rooted his call for change in issues of technology and student culture.

Around the same time, Frand (2000) provided a view of what he called the information-age mindset and argued that a growing number of students possessed these values and behaviors. He stated that this mindset reflected student self-perceptions and included their view of themselves as multitaskers, mistrustful of information, and so accustomed to computers that they did not perceive of them as technology. Oblinger (2003) echoed these observations and suggested instructional approaches that might best reach this new generation of students.

A second round of debate regarding student culture, digital natives, and learning emerged later that decade. Pletka (2007) echoed Prensky and framed the key issues in education as resulting from the digital technologies that have created a new generation of learners who have adapted to the new demands, tools, values, and expectations of an information age. Jenkins (2009), Palfrey and Gasser (2008), and Tapscott (2009) described a variety of student behaviors that they suggested provide evidence of significant generational differences, including youth using technology to meet people, create and exchange media content, engage in textual content creation (wikis, blogs, etc.), and stay connected. The rise of mobile convergence devices is a key emerging tool in these narratives. While these descriptions typically provide a positive view of today's students, concurrently, there are others who have provided less-flattering narratives.

In *The Dumbest Generation*, Bauerlein (2008) described today's youth as being challenged by a number of life's facets. He cites a variety of reports and research studies that suggest young adults have difficulty with memorization and understanding basic academic concepts. Neuroscientists Small and Vorgan (2008) provided related points, and frame high-tech immersion as contributing to increased social isolation, negatively impacting ADD, and resulting in Internet addiction for some young adults. Consistent with this view, Bauerlein (2008) framed the usage of social networking as a compulsive activity characteristic of today's youth.

In short, technology is being cited as the reason for a number of ills as well as many accomplishments associated with today's students, resulting in compelling arguments for new pedagogical practices associated with applications of technologies that students are believed to already be using. There is a perception that students are so immersed in technology in their private and day-to-day lives that any application of technology in the classroom will be well received. This argument resonates with faculty today because so many have had anecdotal experiences that are consistent with the aforementioned literature. Faculty see students with white ear buds, which are synonymous with the iPod. They observe students with cell phones. They have experienced students texting and Facebooking in class. Some students ask for notes to be placed online or for specific technologies to be used for course activities. Descriptive studies of student computer ownership and usage seem to provide further evidence in support of the ubiquitous digital native learner. The Educause Center for Applied Research (ECAR) completes a yearly study of college undergraduates and found that 87.8 percent of respondents owned a laptop, 51.2 percent carried an Internet-capable handheld device, 86.6 percent used social networking and spent an average of 21.3 hours online each week (Smith, Salaway, & Caruso, 2009).

Anecdotal personal observations, classroom experiences, and supporting descriptive data make the broad generalizations found in the literature regarding student culture all that more believable; however, a recent exhaustive review of this literature and the underlying data in support of the digital native claims call into question most of these assumptions. Bennett, Maton, and Kervin (2008) analyzed the educational research and the sociology behind these arguments to determine the efficacy of the current conception of students as digital natives. They found that the research evidence demonstrates that a number of young people are highly adept with a range of technologies; however, "a significant proportion of young people do not have the levels of access or technology skills predicted by proponents of the digital natives idea" (p. 779). They point out the lack of empirical evidence in support of new learning styles or learning preferences. They also conclude that "there is no evidence that multitasking is a new phenomenon exclusive to digital natives" (p. 779). Further, the latest empirical evidence regarding multitasking concludes that humans are unable to accurately perform more than two concurrent tasks at one time (Charron & Koechlin, 2010). This provides clear limitations on the reality of multitasking in practice. Bennett et al. (2008) conclude that the "digital natives literature demonstrates a clear mismatch between the confidence with which claims are made and the evidence for such claims" (p. 783). The evidence does support a view of students as incredibly diverse, and it is a mistake to select technologies and pedagogies based upon broad stereotypes fostered by digital natives mythologies. With that said, there is guidance regarding students for teachers and faculty planning to employ ubiquitous technologies in course settings.

The 2009 ECAR study reveals that less than half of students (45.9%) feel their instructors have "adequate IT skills for carrying out course instruction" (Smith et al., 2009, p. 17). As a broad strategy, faculty would be more successful with u-learning and instructional technology, in general, if they ensured a higher level of personal competency with the technologies in question before attempting to use them in course settings. This might require faculty to use fewer technologies to ensure greater success with a smaller set of approaches and technologies. Additionally, two thirds of students in this study reported that most or all of their instructors inadequately trained them to use the information technology employed in their courses. The assumption that all students have broad computing skills is clearly refuted by this finding and illustrates one of the dangers of progressing with that assumption. A more helpful practice would be for faculty to assume their students have a sparse understanding of the required technology. Faculty should be encouraged to provide copious guidance to ensure that students are able to focus on the learning goals of the activity without being distracted and frustrated by the technologies that are intended to facilitate learning.

While broad generational stereotypes are a problematic foundation on which to build u-learning pedagogy, the literature does provide guidance regarding students' cognitive development, which should inform choices when designing instruction. For instance, it was empirically determined that short-term memory capacity is different in different age groups (Cowan, Nugent, Elliott, Ponomarev, & Saults, 1999). Perry (1970) as well as Baxter Magolda and Porterfield (1988) identified intellectual development stages through which college students predictably pass. Knowles, Holton, and Swanson (1998) examined adult learners and found that they are quite self-directed, require clear relevancy in the instructional content, prefer experiential learning, and approach learning from a life-centered perspective. They also found that as adults age, the differences between them as learners increases (p. 40). This sampling of what we know about learners at different ages suggests a best practice wherein differentiated activities are employed based upon characteristics of learners at different stages of cognitive development. Contemporary learning theory, which leans heavily upon constructivist principles, provides additional guidance for those creating instruction for today's students. Fortuitously, the attributes of many u-learning technologies facilitate students' interactions as they actively participate in authentic learning environments, evoking many of the concepts and practices offered by constructivism.

While constructivism as a learning theory has a lengthy history, pedagogical practice associated with this theory has gained popularity only over the last 20 years (Richardson, 2003). Constructivism can be viewed as a philosophy associated with how we come to know or understand (Savery & Duffy, 1996), but it is also a multidimensional concept that has been applied to theory and teaching (Doolittle & Hicks, 2003). It is sometimes misunderstood due to a number of related perspectives that share the same name. They primarily include radical constructivism, social constructivism, and cognitive constructivism.

Foundationally, these schools of constructivism share several philosophical tenets, including a belief that the individual plays an active role in the construction of knowledge, social and individual experiences are key to the learning process, and that the accuracy of the knowledge obtained may vary when compared with an external reality (Doolittle & Hicks, 2003). Briefly summarized, philosophically, radical constructivism believes that reality is unknowable and is subjective to the individual (Piaget, 1973). As its name implies, social constructivism, emphasizes the role social interaction plays in the development of knowledge (Doolittle & Hicks, 2003). Web 2.0 technologies, such as wikis, u-learning concepts, and information residue, provide examples of social constructivism in practice. Unlike radical and social

constructivism, cognitive constructivism, "embraces the notion that one can come to know reality, or truth, as it exists external to the individual" (Doolittle & Hicks, 2003, p. 80). The work of Russian psychologist Lev Vygotsky (1896–1934) has been significantly influential in the development of constructivist theory and practice, and his scholarship provides a framework for a learning theory for u-learning based primarily upon the social constructivist perspective.

Vygotsky posited a zone of proximal development for students as they learn. At the bottom of this zone is what an individual can learn or accomplish by him/herself. At the top of the zone is what an individual can learn or accomplish if aided by an instructor, peer, or classmate (Vygotsky, 1978). The emphasis on interaction in this educational model is clear; however, Vygotsky also states that the use of whole, authentic activities is required as well as an emphasis on processes to encourage individual change (Doolittle & Hicks, 2003; Moll, 1990). Let's now consider constructivism within the context of u-learning.

U-LEARNING PEDAGOGY

Ubiquitous learning (u-learning) is a learning paradigm offering the promise of support for teaching anything at any time in any place by using ubiquitous computing devices, software, and services. While this claim is unrealistic at this time, given the limitations of current implementing technologies (computational, networking, and storage), some have revised the definition of u-learning to that of teaching the right thing, at the right time, in the right place. Po-Sheng, Yen-Hung, Yueh-Ming, & Tzung-Shi (2008) developed the following list of u-learning characteristics after reviewing and synthesizing similar projects by other researchers (e.g., Chen, Kao, Sheu, & Chiang, 2002; Chen, Chang, & Wang, 2008; Hwang, 2006; Ogata & Yano, 2004; Yang, 2006). Note that these characteristics are presented in the framework of u-learning environments, though they have applications across many instructional contexts:

- *Urgency of learning need*—u-learning environment can be used for an urgent learning need. On-demand or just-in-time learning is an interpretation of this u-learning characteristic.
- *Initiative of knowledge acquisition*—u-learning system can provide information to a learner's request in a timely fashion.
- *Interactivity of learning process*—u-learning interfaces facilitate effective communications between learners and peers, teachers, and experts.

- *Situation of instructional activity*—u-learning involves situated interaction. Learning process is embedded deeply into the natural flow of everyday activities.
- *Context-awareness*—learners' interaction with u-learning environment is controlled by context—user, location, time, activity, etc.
- *Activity provides personalized services*—learners are provided personalized learning activities by the u-learning system based on surrounding context.
- *Self-regulated learning*—u-learning environment allows learner to actively control their learning progress and captures this behavior as learner context for future use.
- *Seamless learning*—learning activities can progress seamlessly as learners move from place to place.
- *Adapt the subject contents*—learner interaction with the u-learning environment can take place using various learning devices.
- *Learning community*—u-learning system can access networked content and services to enhance the learning interaction between learners and teachers.

These characteristics provide a current description of u-learning capabilities and evoke a variety of social constructivist instructional practices. For instance, like teachers and peers, u-learning technologies can provide guidance and information to learners as they progress through a learning activity. Vygotsky's emphasis on authentic activities mirrors the direction of u-learning technologies that are components within the physical world. Additionally, social interaction with other learners can be mediated by the technology, either through overt communications between learners or through information and data left behind by those who communicated with the technologies in question. Authenticity and interaction are key components of constructivist pedagogical practice and are, by the nature of the technologies under consideration, inherent to u-learning activities. As more u-learning technologies become available, the clear link to constructivist practice will play a key role in the development of pedagogy in this arena.

Current and Future Trends

There are a variety of technologies that will expand u-learning options in the future, and current research trends in ubiquitous computing are driven by related factors. One is the continuing refinement and convergence of personal mobile devices. Cell phones, like Apple's iPhone, Nokia's N900, and Google's Nexus One now run sophisticated operating systems and applications, contain fast CPUs, connect with multiple wireless interfaces, and

incorporate numerous hardware sensors capable of collecting contextual information about the user and their environment. Another factor is the infusion of emerging computational and networking technologies that shape perceptions of reality. Earlier ubiquitous computing studies focused on augmented reality—a view of reality overlaid with various forms of additional computer-generated information. Essentially, this offers a combination of real and virtual elements to users. Current augmented reality research is in the area of cross-reality (x-reality). X-reality is the union of ubiquitous sensor/actuator networks positioned in the real world and in shared online virtual worlds. Millions of mobile wireless sensor nodes composed of people and their smartphones along with converging hardware applications like Intel Research's Wireless Identification and Sensing Platform (WISP) will impact x-reality studies and applications (Philipose et al., 2005).

A third contributing factor, in some ways related to augmented reality but far more significant, is the evolving Internet of Things. Embedding sensor, computational, and network hardware in everyday objects allows them to communicate with people as well as each other. In the Internet of Things, real-world objects have individual digital presences. These objects include people, places, things, and services uniquely identified, and defined in a standardized manner and capable of interacting with each other (Siorpaes et al., 2006). Implementation of a robust Internet of Things will be based on an infrastructure of ubiquitously networked sensors and actuators coupled with low-cost microcontrollers, wireless technologies, cloud services, and PMI interfaces. Environmental conditions and context data will further influence these exchanges. Next generation cross-reality environments are emerging as a result of the integration between Internet of Things technologies and the technology of massively shared online virtual worlds like Second Life (Paradiso & Landay, 2009). In cross-reality environments such as this, virtual worlds can be infused with real-world, real-time information provided by sensor networks. In addition, participants in virtual environments will be able to manifest their actions in the real world through a vast network of actuators and displays.

When considering these ubiquitous computing trends with respect to constructivist pedagogy, the number of opportunities for students to interact and engage with their environment and each other increase tremendously. Researchers at the University of Munich and Lancaster University are investigating ways to facilitate mobile interactions with the Internet of Things (Brollet al., 2009). Physical Mobile Interaction (PMI) is the use of mobile devices to physically interact with physical objects and places in a given context so as to facilitate access to associated information and services. At its simplest, for example, students visiting the La Brea Tar Pits could read the QR code affixed near their assignment, let's say the study of Pit 91, with their cell phones (Kato & Tan, 2007). This action would invoke a Web browser and connect it to the Pit 91 Web site, offering students additional detailed information related to the completion of their project. PMI actions include pointing as described, touching of RFID or NFC elements, or scanning a tagged object via Bluetooth. In addition to Web browsing, other types of services invoked through PMI could include context management, personalization, service discovery and composition, session management and migration, and privacy and security features.

CONCLUSION

As time passes, interaction and computation will become deeply embedded into the natural flow of everyday tasks, activities, and collaborations. Futurists predict 100 billion devices will be connected within the next 5–10 years, rising to trillions in the near future (Lucas, 1999). As more and more "things" become enabled in this fashion, new instructional opportunities and capabilities will emerge. Although it is unclear as to exactly how students and teachers will use and interact with the Internet of Things and cross-realities, it is certain that advances in technologies and access to computing devices will ensure this new ecology. Researchers in education, sociology, computer engineering, computer science, and other fields continue to be drawn to the study of u-learning and u-learning environments; however, a consensus opinion on a defining set of u-learning environmental criteria, functions, services, and implementations is far from clear. When comparing the above u-learning characteristics with traits of ubiquitous and pervasive computing, a number of commonalities emerge. They include collaborative interaction, user mobility, context awareness, ambient information, adaptive interfaces, event notification, and invisibility. These parallels should not be surprising as these fields are inextricably linked. In the future, those researching u-learning must have an eye toward emerging trends in ubiquitous computing, as those developments will ultimately impact the range of instructional options that become available. With that said, learning theory should ultimately guide practitioners as they implement these technologies in real-world instructional settings.

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ABOUT THE AUTHORS

C. Edward Watson, PhD, received his doctorate in Curriculum and Instruction in 2007 from Virginia Tech. He is the associate director for the Center for Instructional Development and Educational Research at Virginia Tech. Dr. Watson teaches courses on change agency and visual media. His book, *Self-Efficacy and Diffusion Theory: Implications for Faculty Development*, was published in 2008. His research interests include the scholarship of teaching and learning, interdisciplinary pedagogy, social learning theory, learner motivation, and emerging technologies. Dr. Watson serves on Cengage Learning's advisory board, is the managing editor for the *International Journal of Teaching and Learning in Higher Education*, and is the co-executive editor of the *International Journal of ePorfolio.*

William O. Plymale, is the Director of Technology Applications for Research and Collaboration in Virginia Tech's Learning Technologies Division. He supports the university's research initiatives by coordinating and associating university research faculty and their projects with appropriate Learning Technologies areas. His current research interests include cross-reality and augmented physical environments, and tangible, presence-based messaging systems. He is also a PhD student in Virginia Tech's Bradley Department of Electrical and Computer Engineering. One of his responsibilities each semester is the supervision of an ECE undergraduate research project entitled "Application of Pervasive Computing Concepts to Teaching and Learning."