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Facilitating Engaged Learning in the Interaction Age Taking a Pedagogically-Disciplined Approach to Innovation with Emergent Technologies

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The purposes of this paper are to explore emerging technologies, engaged learning, and features and students of the Interaction Age and to identify connections across these three realms for future research and practice. We begin by highlighting those elements of the Interaction Age that suggest a shift in the affordances and applications of digital content. The Interaction Age, as an extension of the Information Age, distinguishes digital content as not just content accessed by students but as content around which they engage and construct knowledge in a social manner. Second, we review technologies emerging on college campuses as well as categorize and compare newer technologies including mobile learning, Augmented Reality, Virtual Reality, and ubiquitous learning. These technologies are among those at the leading edge of innovation and hold promise for educational application. However, in light of the Interaction Age, we argue that these technologies must contribute to student learning, and in particular, student *engagement* in learning. Thus, we present the outcomes of a literature review regarding engagement and engaged learning. Finally, we explore prominent connections between emerging technologies, engaged learning, and students and devices of the Interaction Age, offering examples of these linkages to stimulate future research and practice.

The application of a variety of technologies for learning and teaching is influenced by two significant forces: the realm of technological innovation (especially, today, in regard to hardware and software) and the realm of learning theory. In consideration of the technological trajectory, learning has evolved from textbooks to television to computers, and now to mobile digital devices, in a relatively short time. In respect to the theoretical trajectory, expansions in ontological and epistemological thought have provoked a broadening of learning paradigms (e.g., behaviorism, cognitivism, and constructivism) suggesting moves toward more self-directed, contextualized, and engaged learning environments and approaches. Developments in ways of knowing and ways of learning have evolved against a backdrop of society's evolution from an Industrial and Information Age to an Interaction Age.

Often, the technology force and the learning force develop along two separate trajectories in the less socially complex confines of "the lab" or "the mind." Yet, experience reveals, that they must be woven closely in practice. That is, whenever new technologies are introduced, researchers attempt to apply those technologies for educational purposes, often hoping to demonstrate, through empirical evidence, a better quality of education to result. Instructional personnel (teachers, instructional designers, etc.), mindful of the real-world needs of learners and constraints faced in the learning context, strive to apply sound learning theories and instructional design approaches to integrate new technologies as they arrive on the scene with increasing rapidity, abundance, and complexity. An ongoing challenge and opportunity for educational researchers and practitioners is to apply new technologies as a means toward improved learning rather than as an end in and of itself; that is, to take a pedagogically-disciplined approach to teaching and learning innovation.

In this paper, we, as instructional designers engaged in preparing today's learning environments and experiences, take a present-day look at aligning the two trajectories of technology and theory. Specifically, we inquire into emerging technologies which may support more engaged learning for students in today's Interaction Age. The specific questions under consideration are as follows:

- What do the characteristics of the Interaction Age and its students suggest for future educational practice?
- What technologies are emerging as potentially useful learning technologies?
- What factors impact engaged learning?
- To better support engaged learning, what aspects and attributes of emerging technologies might educational researchers and practitioners focus on?

Current and Future Students in the Interaction Age

According to Milne (2007), our society is extending from the Information Age into the Interaction Age. In the Information Age, the focus has been on delivering and accessing digital content, while in the Interaction Age, the role of digital content is broadened as something around which people engage and interact. In

Table 1, we provide a summary of Milne's analysis regarding the shift from Information Age to Interaction Age in terms of networks, devices, interfaces, and user focus.

To summarize briefly, "digital networks have evolved from carrying data in a purely transactional sense to facilitating social interaction" (Milne, 2007, p. 14). Rather than just deliver a document to an individual's inbox, sender and receiver might use a network to conference real-time about that document. Second, students in the Information Age typically have at least one portable computing device such as a mobile phone, laptop, or even handheld gaming device. In the Interaction Age, we witness an extension of these individually-owned devices through augmented work and play spaces that enable individuals to plug in portable devices to share and engage with one another, say through a large screen interface, upon entering the environment. Third, the ever-increasing focus on Web technologies is moving today's learners from a graphical user interface (GUI) to tangible interfaces that allow for a greater range of interaction modalities. Interactive smart boards, gesture-based gaming, digital pens, or even Han's (2006) cutting edge multi-touch interfaces all allow for greater flexibility and fidelity in terms of supporting the human response. Fourth, increasingly more jobs require human engagement in group settings rather than individual performance. Many learning environments have already begun to reflect this shift by embedding more group or team work. Emergent technologies, too, are beginning to break new ground toward true multi-user interfaces; although retrofitted or adapted single-user interfaces still seem to predominate. The shift from an Information Age to an Interaction Age underlies the importance of understanding learning and learning environments as increasingly social and contextualized (Moore, Fowler, & Watson, 2007).In such a changing age, today's students are already different from students of the past in terms of how they have grown up with and use technologies (McGee & Diaz, 2007). Prensky (2001a) is one to argue the uniqueness of who he terms today's "digital native" students. As Prensky (2001b) puts it,

> Our children today are being socialized in a way that is vastly different…over 10,000 hours of videogames, 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, over 500,000 commercials seen – all before the kids leave college. And, maybe, at the very most, 5,000 hours of book reading. (p. 1)

A series of empirical studies sponsored by the Pew Internet and American Life Project (Jones & Madden, 2002; Lenhart, Madden, & Hitlin, 2005; Levin & Arafeh, 2002) support the notion of today's students as digital natives.

In similar fashion, Oblinger (2006) points out several characteristics of today's university students to consider in designing new learning spaces for them including: a penchant for highly active and participatory experiences both face-to-face and digitally and often at the same time; technological adeptness and ubiquity, using mobile phones, digital cameras, MP3 players, and wireless Internet to browse, download, and message; and multiple priorities, including school, work, sports, volunteer activities, that make time a precious commodity. In fact, Oblinger makes a case for the diverse and open spaces in which and through which today's students move through life as an impetus for changing spaces in classrooms and on campuses. Moore, Fowler, and Watson (2007) concur but also speak to such innovative spaces as still rare and isolated.

Finally, evidence suggests that thinking patterns, in addition to behavioral patterns, are changing with today's students in part, at least, to their native environment of ubiquitous digital technologies and considerable levels, since birth, of interaction within it. Prensky (2001b) points to evidence that today's digital native students think about and process information fundamentally differently from their predecessors - thinking in parallel and linear patterns and reading visual images as one might read text.

TABLE 1
Shift from Information Age to Interaction Age

	Information Age	→ Interaction Age
Networks	Transport data	Provide for social interaction
Devices	Portable devices	Augmented environments
Interfaces	Graphic interface	Tangible interface
User focus	Individual work	Group work

Note. Summarized from Milne (2007).

It is the case that individuals born since the early 1980s have grown up in a digital age. However, as Bennett, Maton, and Kervin (2008) argue, it is short-sighted to assume that all digital native students are technologically sophisticated or even technologically inclined. We agree that applying digital native as a global generalization is problematic and that individual learners remain as complex and varied and they have always proved to be. At the very least, digital natives of the Interaction Age offer an opportunity for teachers and instructional designers who prepare and facilitate learning experiences and environments to reconsider how to teach and design instruction that complements their lived experience as engaged and social digital consumers from a young age. Changes in instructional designs and teaching practices must not be based solely on an influx of digital native students but rather on empirical evidence that integrates sound pedagogy with identified learner traits.

Emerging Technologies

Once thing to count on is that today's technologies will continue to evolve as new ones continue to emerge. According to recent editions of *The Horizon Report*, a publication produced through a collaboration between the New Media Consortium (NMC) and the EDUCAUSE Learning Initiative (ELI) (2006, 2007, 2008), emerging technologies to watch and consider in regards to the learning frontier in higher education include those listed in Table 2.

In each report year, six top technologies were identified and categorized in terms of expected widespread presence on university campuses according to three timeframes- one year or less, two to three years, and four to five years. As explained by the 2008 report authors (NMC & ELI, 2008):

> The two technologies placed on the first adoption horizon, grassroots video and collaboration webs, are already in use on many campuses. Examples of these are not difficult to find. Applications of mobile broadband and data mashups, both on the mid-term horizon, are evident in organizations at the leading edge of technology adoption, and are beginning to appear at many institutions. Educational uses of the two topics on the far-term horizon, collective intelligence and social operating systems, are understandably rarer; however, there are examples in the world of commerce, industry and entertainment that hint at coming use in academia within four to five years. (p. 3)

Beyond the fact that *The Horizon Report* documents newer technologies that already show some degree of application in higher education research, learning, and creative practice, it is interesting and noteworthy that the identified emerging technologies are largely consistent with social trending from an information focus to an interaction focus and behavioral changes from passive to active and engaged learners. Such trending is reflected by a recent review by McGee and Diaz (2007) of the collaborative and communicative functions of many Web 2.0 technologies, including blogs, IM-type tools, wikis, and social bookmarking.

Although the technologies ranked in recent *Horizon Reports* (NMC & ELI, 2006, 2007, 2008) vary somewhat in name and foci, an extended review of the literature reveals several categories of emergent technologies to consider for teaching and learning, including the following: Mobile Learning (m-learning), Augmented Reality (AR), Virtual Reality (VR), and Ubiquitous Learning (u-learning). It is challenging to define these categories clearly and distinctly for a number of reasons. Researchers sometimes use the terms differently or, may even combine them. Winters (2006) pointed out that communities may define mobile learning based on their own specific set of experiences and backgrounds. For example, cases can be categorized and studied as mobile learning with AR technology or ubiquitous learning mainly using mobile devices. Challenges aside, we attempt to define these four categories and highlight those characteristics that may serve to engage learners in interesting and effective ways.

When considered as a subset of e-learning, m-learning can be defined as learning that takes place via wireless, portable devices such as mobile phones, personal digital assistants, and laptop computers (Brown, 2005; O'Malley, Vavoula, Glew, Taylor, Sharples, & Lefrere, 2003). Klopfer and colleagues (Klopfer & Squire, 2008; Klopfer, Squire, & Jenkins, 2002) identify five affordances of such m-learning devices that may support learning: portability, social interactivity, connectivity, context sensitivity, and individuality. Perhaps less apparent than the first three, context sensitivity concerns the ability to gather data unique to the current circumstance (location, time, etc.) and individuality relates to flexibility for each individual to follow a self-directed, custom learning path. Handheld data collection devices, such as handheld water testing meters or GPS/GIS receivers, are popular examples in science of context sensitive mobile technologies that can be applied for learning purposes.

TABLE 2
Technologies to Watch on University Campuses

Years to University Campus Widespread Adoption	*The Horizon Report*, 2006 Edition	*The Horizon Report*, 2007 Edition	*The Horizon Report*, 2008 Edition
One or Less	• social computing • personal broadcasting (e.g., podcasting, video blogging)	• user-created content (blogs, wikis, etc.) • social networking	• grassroots video • collaboration webs
Two to Three	• mobile phones receiving educational content • educational gaming	• mobile phones with broadening functionality (e.g., GIS, video) • virtual worlds	• mobile broadband • data mashups
Four to Five	• augmented reality and enhanced visualization (e.g., 3D representations of data) • context-aware environments and devices responding to voice, motion, etc.	• new scholarship and emerging publication forms • massively multiplayer educational gaming	• collective intelligence • social operating systems

Note. Summarized and compiled from *The Horizon Report* (NMC & ELI, 2006, 2007, 2008).

The next two emergent technology categories, augmented reality (AR) and virtual reality (VR), can be conceived of as sitting along a continuum that ranges by the degree of reality present in the experiential system (Milgram & Kishino, 1994). On one end of the continuum is the real environment, followed by AR, then VR, and lastly on the other end, the fully virtual environment. Such a continuum is useful in suggesting the many shades of gray in mixed reality systems, each being somewhat more or less real.

Augmented Reality is described commonly as blending computer-generated virtual objects/ environments with real objects/environments, often to enhance or annotate what can be discerned by the human user. Azuma (1997) offers further definition by characterizing AR as bringing together the real and the virtual, allowing for interactivity in real time, and manifesting in three dimensions (3-D). Within the context of environmental design education, Blalock and Carringer (2006) identify five AR system affordances supportive of human inquiry: rapid and accurate object identification (especially in stripped down environments), invisible feature identification and exploration; the layering of multiple information sources; readily apparent object relationships; and easy manipulation of perspectives. Whether designing a new landscape or practicing a surgical procedure, these AR affordances not only offer alternatives to real experiences but even offer opportunities to expand on what is possible in a real-world learning environment.

Virtual reality can be distinguished from AR in that an individual is immersed in a completely synthetic environment (Milgram & Kishino, 1994) where natural laws (e.g., gravity, time, etc.) likely do not apply. Second Life (2007) is an example of a Web-based VR world growing in popularity and grabbing the attention of researchers interested in its educational potential. In such a VR setting, individuals can assume varied roles and manipulate variables to explore impact (Chen & Hung, 2004). Many VR environments pose well- to ill-structured problems or challenges (e.g., through simulation or gaming scenarios) that present the opportunity to experiment with solutions (de Jong & van Joolingen, 1998) in potentially less costly ways than in a real environment. Such problems can be readily situated in single or multiple subject domains such as science and math (Brill, 2007; Hung & Chen, 2006). The lack of real-world constraints can pose potential challenges in terms of acquiring and transferring high fidelity knowledge and skills in the real world. What can be accomplished in a VR environment may not be relevant, useful, or even desirable in a real context.

The final category of emerging technologies is ubiquitous learning or u-learning. U-learning is an extension of ubiquitous computing (UC) which is characterized as the availability of many computers in the physical world that are, essentially, invisible to the individuals using them (Weiser & Brown, 1996). As Weiser and Brown put it, UC is characterized by

> lots of computers sharing each of us…the hundreds we may access in the course of a few minutes of Internet browsing…[those] imbedded in walls, chairs, clothing, light switches, cars - in everything…Fundamentally, the connection of things in the world with computation. (para. 9)

UC affords "calm technology" that extends our reach in our lived world without disrupting our center. It is digital technology going eventually the way of the pen; once an emergent technology itself that has been, for some time now, ubiquitous and supportive without being distracting or disruptive. At the leading edge of digital technological innovation, we know the least regarding educational applications of ubiquitous computing. Yet, reflecting on much older and more mature technologies (once again, the pen), ubiquity, ready-to-handedness, and embeddedness in context (Dourish, 2001, 2004; van't Hooft, Swan, Cook, & Lin, 2007) are traits that certainly have potential to support all human activity, including learning, in a manner that is situated in lived experience.

Looking across m-learning, AR, VR, and u-learning and their unique affordances, all four categories seem to offer learners, whether as individuals or as members of a group, the opportunity to develop new knowledge and skills by exploring issues/problems within richly complex, high fidelity contexts.

Engaged Learning

Although emergent digital technologies such as virtual reality tend to grab our attention, educators and researchers must balance the inclination to jump on board with cutting-edge technologies with the discipline of sound pedagogical theory; that is, what is known and continues to be discovered regarding how humans learn and improve their performance. Engagement is a theoretical construct evident in the literature as an essential condition of meaningful learning. Certainly, emergent technologies such as those just described may offer opportunities for students of the Interaction Age to experience heightened and sustained engagement in learning. First, engagement must be considered more closely.

The concept of engaged learning has roots in well-established and researched learning constructs such as interest (Dewey, 1913), effort (Brophy, Rashid, Rohrkemper, & Goldberger, 1983; Meece & Blumenfeld, 1998), motivation (Pintrich & De Groot, 1990; Skinner & Belmont, 1993), and time on task (Berliner, 1990; Lentz, 1998). Bulger, Mayer, & Almeroth (2006) characterized engaged learning as having high levels of active learner participation designed into the plan for learning. In the edited book *Engaged Learning with Emerging Technologies*, Hung, Tan, and Koh (2006) described active learning as learners taking responsibility for their own learning during which they are "actively developing thinking/learning strategies and constantly formulating new ideas and refining them through their conversational exchanges with others" (p. 30). In this same book, Jonassen and Strobel (2006) asserted that active learners "interact with their environment and manipulate the objects in that environment, observing the effects of their interventions and constructing their own interpretations of the phenomena and the results of the manipulation and sharing those interpretations with others" (p. 1). Already, these descriptions suggest connections back to previously identified traits of the Interaction Age and emergent technologies.

In their study of engaged learning design, Bulger, Mayer, and Almeroth (2006) demonstrated that an intentionally engaged learning design resulted in higher levels of learner attention and on-task behavior. Taking a closer look, one can ascertain that their engaged learning design included: a real-world task and environment presented via simulation, directed interactive activities, collaborative group work, an in-class deliverable, a facilitative teacher, role-modeling, and a requirement to reference and integrate resources from beyond the boundaries of the classroom; components certainly illustrative of the aforementioned descriptions of active learning and active learning environments.

A number of scholarly groups have articulated indicators of engaged learning. We discuss three here for comparison and synthesis. Jones, Valdez, Nowakowski, & Rasmussen (1994) provided a set of eight indicators of engaged learning related to vision, tasks, assessment, instructional model, learning context, grouping, teacher roles, and student roles. First, teachers and students share a vision for engaged learning in which students take responsibility for learning, feel motivated to learn and energized by learning, and are strategic in their learning. In engaged learning, tasks are authentic, challenging, and multidisciplinary and assessments are based in authentic performance, ongoing, numerous, varied, and equitable. Assessment data are used by students and teachers to evaluate and advance learning in an iterative manner. The model and context for learning is characterized by interactive modes of instruction with an emphasis on the co-construction of knowledge. Students explore collaboratively in heterogeneous and flexible groupings with the teacher serving as an informed guide and facilitator. Students shift among varied roles including inquirer, teacher, apprentice, and producer. Jones et al. based their refined and expanded work on the seven indicators identified by Means and her colleagues (1993) which were grounded in observations of successful teaching/learning practice. Unique to their framework are the addition of the shared vision for engaged learning as well as significantly expanded conceptions of assessment, teacher roles, and student roles.

Hung, Tan, and Koh (2006) offered an engaged learning framework emphasizing problem and process which, they argue, are both necessary for authentic learning. The framework includes six indicators: ill-structured, multidisciplinary problems; student ownership of learning goals, inquiry processes and strategies (such as problem deconstruction); student collaboration with shared, flexible roles and accountability; self-monitoring and evaluation of the learning process; the use of teachers and experts to provide tools, techniques, and support; and real-world tools that allow for open communication and sharing among students, teachers, and experts. The work of Hung and colleagues is derived from a rather robust review of contemporary ideas in learning spanning constructivism, situated cognition, authenticity in learning, self-regulated learning, and problem-based learning. Notably, the indicator of student collaboration and accountability is supported empirically (Abrami, Lou, Chambers, Poulsen, & Spence, 2000).

A third and rather different view into engaged learning comes in the work of Wang and Kang (2006) who have grouped indicators of engagement into three domains: the cognitive, the emotional, and the social. In the cognitive domain, engaged learning is hallmarked by knowledge construction and emergence as well as student ownership and self-regulation. In the emotional domain, engaged learning is indicated by learners who feel curious yet secure and confident. In the social realm, there are indicators of information/resource-sharing and group cohesion and acceptance within the context of collaboration. Each of these domains and related indicators are considered in light of both learning and assessment for learning. This third literature-based framework offers a readily consumable guide to important elements in the high engagement teaching/learning environment. However, as Wang and Kang point out, it must be researched.

Three themes are quite evident across the three frameworks for engaged learning. Student responsibility for and ownership of learning is clearly manifest in a variety of ways including setting learning goals, co-constructing and representing knowledge, assuming varied roles and tasks, and participating in self-monitoring and assessment. Second, flexible collaboration in groups is also emphasized. Third, the use of varied and relevant human and non-human resources (teacher, expert, tools, processes, techniques, etc.) to support learning is consistent across frameworks.

Frameworks for engaged learning, such as those discussed here, offer means for understanding, designing for, and evaluating engagement in learning. They may also shed light on how to integrate emergent digital technologies that resonate with today's digital native students in informed and pedagogically sound ways.

Linking Emerging Technologies and Engaged Learning

In this paper, we have explored traits and students of the Interaction Age, emerging digital technologies, and the concept of engagement in learning. Each one of these three areas, in itself, is a challenging area to comprehend fully with a great deal of landscape to cover. Yet, each of these areas offers only one piece of the puzzle when designing for meaningful learning. The opportunity lies in understanding more clearly, through both conceptual and empirical work, the intersection of these three areas for improved teaching and learning. Our position, and one shared by other education professionals (McGee & Diaz, 2007; Moore et al., 2007), is that sound teaching and learning approaches should remain at the forefront of such a scholarly agenda. Further, we perceive engagement in learning as a pedagogical opportunity area for inquiry. If engaged learning is the goal and certain indicators appear to support enhanced engagement, the question becomes: What are the digital technologies that best facilitate engaged learning and speak to the digital native student? Moore, Fowler, and Watson (2007) point out that the design and study of such pedagogically-grounded, integrative research is challenging in that it does not quite have the lure of emergent technology research and is time- and labor-intensive, requiring significant resources toward instructional design. Further, it requires an inquiry approach that is systemic in nature. Challenges aside for a moment.

Table 3 offers several examples of the types of connections that could be further explored and researched across these individual landscapes. For example, given that the literature reveals student ownership as a common indicator of engaged learning and given that mobile learning devices can provide for individuality through unique scaffolding, this category of technologies may be an appropriate choice for a learning environment aimed at enhancing individual ownership in learning. Mobile devices certainly align with the digital native learner's way of being in the world, even if these devices have only been used to-date to achieve personal goals (e.g., using an iPod™ and Nike™ smart sneakers to support an exercise regimen). The critical aspect of such a strategy is that the mobile device is not simply dropped into the learning environment or dropped in the hands of its user as has

TABLE 3
Connecting Engaged Learning with Emergent Technologies and the Digital Native

Common Indicator of Engaged Learning	Emerging Digital Technologies Supporting Engagement Indicator	Alignment with the Digital Native Student
Ownership of and responsibility for learning goals	Mobile learning devices with unique, individual scaffolding designed for and built in	Capitalizes on their early access to and frequent use of mobile devices to achieve personal goals
Interactive, collaborative, and generative approach to learning within the context of solving authentic problems	Virtual worlds and game-based learning designed as realistic learning spaces which enable learners to manipulate a variety of variables	Connects with their pervasive habits to interact and stay in touch via digital means (e.g., mobile phone, Web spaces, email, etc.)
Facilitative role of experts, teachers, and "expert" resources	Mobile device or pervasive learning space where expert learning content is designed for and embedded	Speaks to their use of widely available digital information resources to move through the world and achieve personal goals

been done, for example, with recent laptop requirement initiatives. Rather, individual scaffolding (such as electronic goal setting, monitoring, reporting, and adjustment) must be designed intentionally into the device and, more largely, into the learning.

Table 3 presents only three examples which connect engaged learning with emergent technologies and the digital native learner. There are many more potential applications to explore across K-12, higher education, and even informal learning environments. Work to identify and research more of these types of connections continues. Developmental research, a model for research that investigates the design, development, and implementation of specific learning interventions (Richey, Klein, & Nelson, 2004), may be a particularly useful method for empirical studies. Notably, the underlying principle of this work must be that research with emerging technologies be conducted in a disciplined manner, grounded in sound pedagogical theory that is designed for in the learning experience.

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