Learning style and digital activity: An ecological study

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In order to understand student engagement in higher education through the use of digital technologies, it is necessary to appreciate the broader use of differing technologies. Forty-eight first-year university students completed an online survey that queried patterns of digital activity across home, school and community contexts and that included rating scale items that measured learning style (i.e., active-reflective, sensing-intuitive, visual-verbal, sequential-global). Results suggest that students vary widely in digital activities and that such variation is related to differences in learning style. For example, active learners were more likely than reflective learners to engage in digital activities in the community and users of some specific application, as opposed to non-users, were more likely to be verbal than visual learners. Implications for instructional applications of digital technology in higher education are presented.

Keywords: technology; digital technology; learning style; techno-microsystem; ecological model

Introduction

The use of digital technologies to engage higher education students has been a topic of debate for some time. A preliminary understanding of the ways that students use technology, in all aspects of their life, is paramount to such debate. Previous studies have been conducted to investigate the impact of digital technologies on student engagement (Chen, Lambert & Guidry, 2009) and the effect of student engagement on learning outcomes (Carini, Kuh & Klein, 2006). This study, conducted in a first-year undergraduate course, aims to contribute to the understanding of learning styles and digital technology use.

Literature Review

The use of emerging technologies by undergraduate university and college students is well documented for two reasons. First, "college students have been at the forefront of social change since the end of World War II" (Jones & Madden, 2002, p. 5). They were among the first to use the internet for communication, file sharing and playing games and to have regular broadband access. Second, universities develop and implement technological instructional innovation (Dede, 2005; Nagler & Ebner, 2009). Currently, the implementation of instructional applications of digital technologies is fundamental in all universities and online university learning is increasing exponentially (Margaryan, Littlejohn, & Vojt, 2011). In this regard, junior university students provide a metric of pending social and educational trends (Johnson, 2007a). The Australian Bureau of Statistics (2009) organises demographic generations by using birthdates, share characteristics and significant world events. These demographic generations include 18-19 year olds referred to as the *iGeneration* or *Netgeneration*, 20-39 year olds referred to as *Gen X* and *Gen Y*, 40-59 year olds are *Baby Boomers* and individuals 60-79 years of age are referred to as *Lucky*. Such classification reveals the extent to which digital technology defines first-year university students who are most commonly 18-19 years of age.

Current description of patterns of digital technology use among first-year university students is often atheoretical and lacks the comprehensive approach necessary given the ubiquitous nature of young people's use of technology. Johnson (2010a) recently proposed the *Ecological Techno-Microsystem*, a theoretical model that considers diverse uses of digital technology (e.g., information, communication and recreation) across environments (home, school and community) and the relationship of such use to all aspects of human learning and development. As presented in Figure 1, human learning is conceptualized as the consequence of ongoing reciprocal interactions between individual characteristics and environmental experience which increasingly includes digital experiences, particularly for junior undergraduate students frequently referred to as *digital natives* (Bennett, Maton, & Kervin, 2008). Indeed, approximately 96% of Australian first-year university students report owning a mobile phone, 89.5% report owning a desktop computer, 76% a digital camera, 72.5% a memory stick, 68.9% an MP4 player, 63.2% a laptop computer and 47.4% a digital game console (Kennedy, Judd, Churchward, Gray, & Krause, 2008).

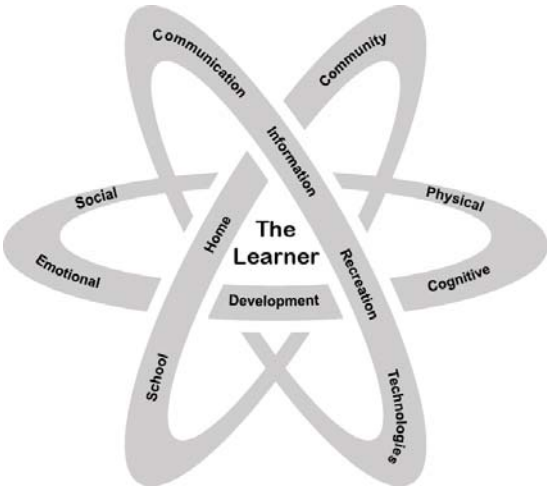

Figure 1: The Ecological Techno-Microsystem (Adapted from Johnson, 2010a)

Student characteristics and use of digital technology

Considerable research has established associations between patterns of digital technology use and university student cognitive, emotional, social and physical characteristics (Johnson 2005, 2006, 2008). Chen and Peng (2008) defined heavy internet users as junior university students in their sample who used the internet for more than 34 hours per week (one standard deviation above the mean). The study found that non-heavy users (≤ 17 hours per week) had better academic grades than heavy users and that heavy users were more likely than non-heavy users to be lonely, physically ill and depressed. Lanthier and Windham (2004) reported that social use of the internet was positively associated with male students' academic, social and emotional adjustment to university.

Dede (2005) described the learning style of digital natives as characterized by "fluency in multiple media, valuing each for the types of communication, activities, experiences, and expressions it empowers; learning based on collectively seeking, sieving, and synthesizing experiences rather than individually locating and absorbing information from a single best source; active learning based on experience that includes frequent opportunities for reflection; expression through non-linear associational webs of representations rather than linear stories; and co-design of learning experiences personalized to individual needs and preferences" (p. 10). Learning style, however, has been found to vary widely across university students (Johnson, 2007b). A review of the literature identified 71 theoretical approaches to learning style, many associated with tests of individual differences in style (Coffield, Moseley, Hall, & Ecclestone, 2004). Such tests require students to rate items in terms of their learning behaviour and preferences. Subsets of test items typically assess elements of a proposed taxonomy of learning style dimensions or continua. For example, the Paragon Learning Style Inventory provides an indication of learning style and cognitive preference in terms of introversion-extroversion, intuition-sensation, thinking-feeling and judging-perceiving (Shindler & Yang, 2003). The Index of Learning Styles (ILS) developed by Felder and Silverman (1988) specifically for university students has established reliability and validity (Felder & Spurlin, 2005) particularly for education students (Johnson, 2007b). The ILS classifies students along four continua or dimensions:

1. *active* (e.g., learns by doing and enjoys working with others) versus *reflective* (e.g., learns by thinking and prefers working alone)
2. *sensing* (e.g., practical, concrete thinker, oriented toward facts) versus *intuitive* (e.g., innovative, abstract thinker, oriented toward theory)
3. *visual* (e.g., prefers to learn with pictures, diagrams, and charts) versus *verbal* (e.g., prefers written and spoken explanations)
4. *sequential* (e.g., linear thinking, learns in small steps) versus *global* (e.g., holistic thinking, learns in leaps)

Saeed, Yang and Sinna (2009) reported that active learners prefer social bookmarks; reflective, sequential and verbal learners prefer podcasts; sensing learners prefer email; intuitive and global learners prefer blogs; and visual learners prefer vodcasts. In this regard, blended and online university courses should provide a range of instructional applications of digital technologies to ensure all learning styles are accommodated. Johnson (2007b) concluded that university students were aware of their learning styles and understood the conditions that facilitate their mastery of course content. Traditional post-secondary instructional contexts are not necessarily amenable to accommodating variation in student learning style. Large class sizes, limited resources and over-burdened teaching faculty are not conducive to active student involvement in learning processes and stimulating visual presentation of course content. "Instructional applications of web-based technology may provide mechanisms to accommodate student learning style more consistently in higher education" (p. 629).

Research issues and questions

The following research questions were developed to guide the study:

1. What are the ecological patterns of digital activity for junior university students (iGeneration)?
2. Are patterns of digital activity differentially associated with aspects of student learning style?
3. What are the instructional implications of such patterns and associations (or lack thereof)?

Methods

A questionnaire was developed specifically for this study. The questionnaire included demographic items necessary to describe the sample, forty rating scales items from the ILS (Felder & Silverman, 1988), specifically, ten items for each of the four learning styles and 19 digital technology uses (e.g., instant messaging) adapted from the list generated by Kennedy and colleagues (2008). Students were instructed to select all digital technology activities which they used. All students enrolled in an introductory educational psychology course (n = 123) at a university in Western Australia were invited, via email, to complete the questionnaire using Qualtrics an anonymous online survey application. Forty-eight students responded to the survey. Of these respondents, 56.3% were aged 18-19 years (iGeneration), 37.5% were 20-39 years of age (Gen X and Gen Y), 6.3% were aged 40-59 years (Baby Boomers) and there were no participants aged 60-79 years (Lucky). One respondent indicated part-time enrolment status while the remainder indicated full-time enrolment status. Thirty-six participants were female which is consistent with the gender distribution trends in the participating university. The proportion of students reporting each digital activity across each ecological context was tallied. T-tests compared mean learning style scores for students who did and those who did not report engaging in each digital activity.

Results

Table 1 presents the proportion of students indicating that they engaged in each of the digital activities listed in the online survey. Variation across students and across contexts was apparent. For example, less than one-third of students indicated that they read or contributed to blogs at home. Downloading/streaming music from the internet was common at home (80.4%) but rare at university (4.5%). Approximately one-quarter of students reported web conferencing from home while none reported the same digital activity at university. Using the internet to buy and sell was common at home (73.9%) but extremely rare at university (2.3%) and relatively rare in the community (12.2%). Some students conducted personal business while online at university (9.1%) but none reported watching television online at university, although 11.4% reported downloading and watching videos while at university. Blackboard was a common activity among participating first-year university students both at home (95.7%) and at university (90.9%), although a significant proportion (41.5%) also reported using Blackboard in the community. Approximately one-third of participating students reported downloading and playing games online while at home, 19.5% reported the same activity in the community, while only 2.3% reported playing online games while at university.

Table 2 summarises significant differences in learning styles between students who did and those who did not report engaging in specific digital activities at home. Notwithstanding a sample of convenience, distribution of scores within each group was approximately normal. Students who reported reading or contributing to blogs while at home tended to be more reflective (e.g., thoughtful and cautious) than students that did not report that digital activity at home. In contrast, students who reported using the internet at home to access maps and make telephone calls were significantly less reflective and more active than students who did not report that online behaviour. Students who reported using Twitter, blogs, photo sites and playing online games at home tended to be more intuitive (e.g., abstract and hypothetical) than students who did not report such use of digital technology at home. Students who reported using Twitter and blogs at home tended to be more verbal than visual in their learning style than individuals that did not report such use of digital technology at home.

Significant differences in the sensing-intuitive dimension of learning style (e.g. pragmatic versus hypothetical) emerged between students who did and those who did not report specific online activities at university (Table 3). Students who reported using social networking, conducting personal business and buying and selling things online tended to have more intuitive (i.e., hypothetical, creative and unconventional) than students who did not report such use of digital technology at university. No significant differences in the other dimensions of learning styles (i.e., active-reflective, visual-verbal, sequential-global) emerged between students who did and those who

did not report specific uses of digital technology at university.

Table 1: Ecological patterns of digital activity among first-year university students (% indicating use)

Digital Technology Activity	Ecological Context		
	Home	University	Community
Instant message	71.7%	29.5%	41.5%
Email	93.5%	88.6%	73.2%
Use Twitter or similar application	8.7%	4.5%	9.8%
Use social networking sites (Facebook, Myspace etc.)	87.0%	70.5%	85.4%
Check information (news, weather, sports, facts etc.)	93.5%	70.5%	68.3%
Read or contribute to blogs	30.4%	9.1%	17.1%
Use maps (find places, get directions, plan routes)	91.3%	11.4%	56.1%
Conduct personal business	78.3%	9.1%	24.4%
Use Internet photo sites	43.5%	9.1%	12.2%
Watch TV	50.0%	0.0%	29.3%
Download/stream music	80.4%	4.5%	36.6%
Download or watch videos online	63.0%	11.4%	46.3%
Download or play games online	32.6%	2.3%	19.5%
Use the Internet for accessing Blackboard	95.7%	90.9%	41.5%
Use the Internet for accessing reference information for study	95.7%	81.8%	22.0%
Use the Internet for buying or selling things	73.9%	2.3%	12.2%
Use the Internet to build and maintain a website	10.9%	2.3%	2.4%
Use the Internet for making phones calls (e.g., VOIP using Skype)	41.3%	0.0%	4.9%
Use the Internet for web conferencing (e.g., Elluminate or webcam activity such as Skype)	26.1%	0.0%	7.3%

Table 2: Mean learning style differences between students who did and those who did not report digital activity at home

Digital Technology Activity at Home	Active-Reflective	Sensing-Intuitive	Visual-Verbal	Sequential-Global
Use Twitter or similar application: Yes No		17.0 14.1 t = -2.47*	15.8 13.2 t = -2.28*	
Read or contribute to blogs: Yes No	15.6 13.5 t = -2.96**	16.1 13.6 t = -3.34**	14.4 12.9 t = -2.13*	
Use maps (find places, get directions, plan routes): Yes No	14.0 17.0 t = 2.26*			
Use Internet photo sites: Yes No		15.3 13.7 t = -2.38*		
Download or play games online: Yes No		15.5 13.8 t = -2.49*		

Use the Internet for making phones calls (e.g., VOIP using Skype): Yes No	 13.3 14.8 t = 2.03*			

* p < .05 ** p < .01

Table 4 presents significant differences in dimensions of learning style between students who did and those who did not report engaging in specific digital activities in the community (e.g., at work, an internet cafe or a friend's house). Notwithstanding a sample of convenience, distribution of scores within each group was approximately normal. Students who reported using Twitter, making online telephone calls and web conferencing in the community tended to be more reflective (e.g., thoughtful and cautious) than active (e.g., social and impulsive). Students who reported using Twitter and maps on the internet for directions, tended to be more intuitive (e.g., abstract and hypothetical) than students who did not report engaging in such online activities while in the community. Students who reported using Twitter, blogs, photo sites and making online telephone calls tended to be more verbal than visual in their style of learning.

Table 3: Mean learning style differences between students who did and those who did not report digital activity at university

Digital Technology Activity at University	**Active-Reflective**	**Sensing-Intuitive**	**Visual-Verbal**	**Sequential -Global**
Use social networking sites (Facebook, Myspace etc.): Yes No		 14.9 13.2 t = -2.34*		
Conduct personal business: Yes No		 16.8 14.1 t = -2.20*		
Use the Internet for buying or selling things: Yes No		 19.0 14.3 t = -2.05*		

* p < .05

Table 4: Mean learning style differences between students who did and those who did not report digital activity in the community

Digital Technology Activity in Community	Active-Reflective	Sensing-Intuitive	Visual-Verbal	Sequential-Global
Use Twitter or similar application: Yes No	 16.5 13.9 t = -2.17*	 17.3 14.1 t = -2.74**	 17.8 13.0 t = -5.11***	
Read or contribute to blogs: Yes No			 15.0 13.1 t = -2.12*	
Use maps (find places, get directions, plan routes): Yes No		 15.2 13.6 t = -2.33*		
Use Internet photo sites: Yes No			 15.4 13.2 t = -2.19*	
Use the Internet for making phones calls (e.g., VOIP using Skype): Yes No	 19.0 14.0 t = -2.16*		 19.0 13.3 t = -2.69*	
Use the Internet for web conferencing (e.g., Elluminate or webcam activity such as Skype): Yes No	 18.0 14.0 t = -2.50*			

* p < .05 ** p < .01 *** p < .001

Discussion and implications for digital instructional practice

Results of the current investigation suggest that it is naive to consider all first-year university students (iGeneration) as identical in patterns of digital technology use. Jones, Ramanau, Cross and Healing (2010) concluded that while there were strong age-related variations, it was simplistic to describe first-year university students as a single generation. "The generation is not homogenous in its use and appreciation of new technologies and there are significant variations amongst students that lie within the Net generation age band" (p. 773). With respect to participating first-year university students, the extent of community based internet use was surprisingly high (e.g. social networking and checking email). University students may commonly use the internet while at work, at an internet cafe or at a friend's house confirming the ubiquitous nature of digital activity among the iGeneration. Virtually all university students surveyed reported using email, checking for information online, using Blackboard and accessing internet sites at home (Table 1). Nonetheless, results of the current investigation suggest considerable variability in other uses of digital technologies across ecological contexts.

Active leaners tend to retain and understand information best by doing, rather than simply listening or watching (Johnson, 2007b). Reflective learners, on the other hand, prefer to think prior to initiating action (Saeed et al., 2009). Active learners prefer to work in groups while reflective learners prefer to work alone. According to (Felder & Silverman, 1988), sitting through lectures without any form of active participation is particularly difficult for active learners. For the current investigation, the active-reflective dimension of learning style was differentially associated with digital activities at home versus in the community. Asynchronous communication technologies (e.g., Twitter and blogs) appeared well-suited to participating university students described as reflective learners. In contrast, participating active learners, characterised by pragmatism, reported using the internet to access maps and make telephone calls from home. Such practical uses of digital technology are consistent with the active learning style. Alternatively, synchronous applications of digital technology in the community (e.g., making telephone calls using Skype) were associated with more reflective, as opposed to active, learners. It may be that community use of digital technology allows for more processing time whilst, for example, students travel to work or to a friend's house. Indeed, community-based digital activities are less common and less spontaneous than digital activities at home and at school.

Students who score high on the sensing dimension of learning style tend to prefer learning factual information while intuitive learners prefer discovering possibilities and relationships (Johnson, 2007b). Sensors are most comfortable with well-established instructional methods and routines; intuitors prefer innovation and dislike repetition. Sensors tend to be patient with details and good at memorising; intuitors are better at grasping new concepts and are more comfortable than sensors with abstraction and hypothetical formulation. Sensors tend to be more practical and careful than intuitors (Saeed et al., 2009). Sensors prefer university courses that have connections to the real world (Felder & Silverman, 1988). For the current sample and across ecological contexts, the intuitive learning style, as opposed to the sensing style, was associated with use of innovative technologies. While early applications of digital technology focused on drill and practice (Barrow, Markman, & Rouse, 2008; Burton, Moore, & Magliaro, 2004; Efendiogla & Yelken, 2010) which are compatible with a sensing learning style, contemporary digital activities, by their very nature, reflect innovation and, consequently, are well-aligned with intuitive learners. It may be reasonable to suggest that a wide range of applications of digital technologies, from those that support rote memorisation to highly creative uses, are necessary to accommodate the full range of learning styles in any first-year university class.

Visual learners remember best what they see (e.g., pictures, diagrams, flow charts, timelines, video and demonstrations). Verbal learners prefer written and spoken explanations. In most university classes, little visual information is presented (Johnson, 2007b). Students mainly listen to lectures and read text. According to Felder and Silverman (1988), since most people are visual learners, many university students do not benefit from instruction that is compatible with their visual learning style. While digital technologies often include diagrams, photographs and icons, much of digital communication and information remains text-based (Johnson, 2010b). Language, whether verbal or written, is processed in the same part of the brain (Berninger et al., 2010). Unfortunately, it may be that online digital activity, as is generally the case with university teaching particularly in the social sciences, has failed to provide meaningful visual representation of information. As digital technologies emerge, student learning may be enhanced by increased use of pictures, diagrams, flow charts,

timelines, video and demonstrations.

Sequential learners tend to gain understanding in a linear fashion with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material without necessarily seeing connections. Sequential learns follow logical paths in finding solutions; global learners often solve problems quickly in novel ways once they ascertain the larger picture (Felder & Silverman, 1988). No significant differences in the sequential-global dimension of learning style emerged between students who reported and those who did not report any use of digital technologies across any ecological contexts. It may be that sample size (n = 48) was insufficient to detect significant group differences. It may also be the case that digital technologies do not favour linear versus holistic cognitive processing styles. Some digital applications (e.g., web 1.0 searches) are relatively linear and require sequential cognitive processing. In other cases, related visual images (e.g., social networking) provide connections that require global or holistic cognitive processing approaches (Johnson, 2008).

It may be worth noting that the fewest significant differences in learning style occurred in student reported use of digital activity at university. Unlike home or community-based digital activity, university online activities are often controlled by instructors and/or instructional context. Based on semi-structured focus group interviews with undergraduates, Bullen, Morgan, Belfer and Qayyum (2008) concluded that student use of digital technology at university was the consequence of "the student and instructor dynamic within a course or program, the technical requirements of the discipline, and the affordances that a tool provided within a given context*"* (p. 10). Margaryan and colleagues (2011) concluded that university students use a limited range of relatively well-established digital technologies. Use of collaborative knowledge creation tools, virtual worlds and social networking sites were uncommon. It may be that the iGeneration is being confined in their application of digital technology in university contexts. Individual difference in learning style may not be apparent due to the controlled nature of the digital environment at university. The question becomes, does this instructional control facilitate or impede student learning? Saeed and colleagues (2009) concluded that "today's learners are flexible in stretching their learning styles and are able to accommodate varying instructional strategies including the use of emerging web technologies" (p. 106).

Limitations and future research

A notable limitation of the current investigation is the narrow sample of first-year university students. All participating students were drawn from those enrolled in one required introductory education course offered at one university. Caution must be exercised in generalizing findings to first-year university students in other programs and other countries. For example, some universities have policies that restrict students from engaging in certain uses of the internet. Additionally, participating university students self-reported their learning style preferences and their use of digital technologies across ecological contexts. An enduring criticism of self-report measures is the potential of misrepresentation particularly to present oneself in a positive manner (Kreuter, Presser, & Tourangeau, 2008). Indeed, it is surprising that very few students (2.3%) reported playing online games while at university. Finally, the list of digital activities in the online survey was limited. Given that almost all junior university students own a mobile phone (Kennedy et al., 2008), use of mobile digital technologies should have been queried in the online survey. According to Pensky (2005), use of mobile "phones compliment the short-burst, casual, multi-tasking style of today's Digital Native learners" (p. 1). Reportedly, university students express excitement "about the opportunities afforded by the mobility and portability of mobile devices, in being able to learn anywhere and everywhere, and at their own convenience" (Litchfield, Dyson, Lawrence, & Zmijewska, 2007, p. 587). However, in a study by Loke and colleagues (2010), only 16% of participating undergraduate students made use of mobile learning infrastructure. Seemingly divergent and contradictory research findings may be reconciled by theoretical consideration of the diverse uses of digital technology (e.g., information, communication and recreation) across environments (home, school and community) and the opportunities and constraints that exist within those environments relative to specific patterns of use.

With respect to the Techno-Microsystem (Figure 1), the current investigation attempted to determine specific uses of communication, information and recreation digital technologies across all three environments in which such activity occurs (i.e., home, school and community). Consideration of learner characteristics, however, was limited to one aspect of cognitive development, -- learning style. Social, emotional and physical characteristics are associated with variation in digital behaviours (Chen & Peng, 2008; Johnson, 2006). For example, Lanthier and Windham (2004) reported that social use of the internet was positively associated with male students' academic, social and emotional adjustment to university. Similarly, numerous studies have linked various uses of the digital technology to university student health problems, depression and loneliness (Caplan, 2007 Engelberg & Sjoberg, 2004; Gordon, Juang, & Syed, 2007; Li & Chung, 2006). Chen and Tzeng (2010) concluded "that it is not how much time university students spend online but what they do online that is associated with academic grades and psychological adjustment" (p. 257). Subsequent comprehensive ecological research may examine the multitude of complex relationships proposed by the Techno-Microsystem, although the ecological contexts of digital activity are increasingly blurred by increasingly ubiquitous uses of digital technologies.

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