Teacher Thinking and Affordances of TouchPad Technology: An Ongoing Study of Teacher Adoption of iPads in Higher Education

Daniel CHURCHILL[*], Jie LU, & Tianchong WANG
The University of Hong Kong
*dchurch@hku.hk

Abstract: TouchPad mobile devices (e.g., iPads) are increasingly being used in educational contexts. Growing investment is planned by higher education institutions in Hong Kong and by the HKSAR Education Bureau in relation to educational uses of TouchPad technology. However, current research into educational applications of this technology is limited. This paper reports an ongoing qualitative study that investigates how higher education teachers use iPad technology to facilitate their practice. The emergent study results provide insight into both the educational affordances of iPad technology and the ways in which teachers' personal or private theories mediate these affordances and transform through the process. The study outcomes will contribute to theoretical understanding of higher education teacher changes through adoption of technology. Furthermore, the outcomes will provide a set of recommendations for applications of TouchPad technology in higher education and ways to support teachers to effectively adopt such technology in their   practices.

Keywords: mobile learning, iPad, affordances, teacher private theories

1. Introduction

TouchPad devices are increasing becoming dominant information technology in hands of people. Statistics from major sources, such as Nielsen.com, strongly suggest huge increase in consumer demand for this technology and related software, services and content. Murphy (2011) refers to this technology as the Post-PC devices. Most notable of these devices is the Apple iPad. It is expected that by 2015, global sales of iPad devices will reach 395 million (see Telecomasia, 2010). Majority of TouchPad devices sold globally in 2011 were iPads (Herald Sun, 2011), although devices from Samsung are increasingly challenge Apple's dominance. Hong Kong is leading the adoption of iPads in the World and with one of the fastest broadband connectivity in the World, native services, software and content are likely expand rapidly. According to recent press coverage, 17% of Hong Kong people own a TouchPad device, a rate that is six times higher than the global average (Herald Sun, 2011). Besides Apple and Samsung, other major hardware designers and manufactures are in pursuit of attracting a share of market place though own devices, e.g., the Dell Streak, ASUS EEE Pad, Blackberry Play Pad, Lenovo LePad, Cisco Cius and HP Slate.

The Horizon Report 2011 emphasizes the importance of mobile technology and adds that this technology coupled with cloud computing will have strong impact on education (New Media Consortium, 2011). In Hong Kong, the Education Bureau's Pilot Scheme on Textbooks and E-learning Resources in Schools emphasizes the importance of the design of educational content such as learning objects and e-books (see Education Bureau, 2010). The Hong Kong Government Research Agency, ASTRI, is investing in the development of TouchPad devices to deliver such e-learning resources (see ASTRI, 2010). Hong Kong universities are likely to be expected to follow what is established in the school system. Significant investment is taking place with very limited guidelines on effective integration of TouchPad technology in education at all levels. Although Liaw, Hatala and Huang (2010) suggest mobile technologies have the power to improve education, however, there is a lack of recommendations for educators as the current research is still in an embryonic stage.

We concur with Banister (2010), Klopfer and Squire (2005), and Ostashewski and Reid, 2010, that it is important to study teacher thinking and uses of this technology, explicate possible uses (affordances),

and articulate recommendations for successful educational applications and supporting intervention for teacher adoption in higher education. Our further effort concentrates of understanding features of effective design of Apps and systems for education. In this paper, we discuss a study that investigates teacher changes through adoption of iPads, kinds of tools they use and how such technology facilitates aspects of their practices.

2. Affordances of Mobile Technology and Education

The literature related to early adoption of mobile technology suggests that it might assist students to learn any time, anywhere, by empowering them "to access internet resources and run experiments in the field, capture, store and manage everyday events as images and sounds, and communicate and share the material with colleagues and experts throughout the world" (Sharples, Corlett & Westmancott, 2002, p. 222). For Luchini, Quintana and Soloway (2004), the key benefit of such mobile technology is that powerful personal devices can "provide access to tools and information within the context of learning activities" (p.135). For Hsieh, Jang, Hwang and Chen (2011) mobile technology has potential to support students' reflection leading to improved learning achievement when there is an appropriate match between a teacher's teaching style and students' learning style. Research on teachers' use of mobile technology to assist their teaching should provide ideas regarding uses of such technology in achieving learning outcomes. These early reports explored uses of handheld portable digital assistants (PDAs) had been used in education. Nowadays, The iPads can overcome the key limitations of PDAs and smart phones, identified in the education literature as (1) small screen real-estate with (2) limited interactivity (see Churchill, Kennedy, Flint & Cotton, 2010; Churchill & Hedberg, 2008; Song & Fox, 2008; Jones, Buchanan, & Thimbleby, 2003; Luchini, Quintana & Soloway, 2004). Apple iPads might be a "transformative technology" that can help to create flexible, collaborative, and inquiry-oriented learning environments, but only if appropriate models for their use are developed.

Affordance is a useful concept that can be applied to interpret how teachers engage technology in their practice. It includes actual uses, and those uses that emerge in their practice. How iPads will be used in higher education depends largely on teachers' understandings of affordances of this technology. Norman (1988) defines affordances as "the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (p.9).

For Barnes (2000), a teacher's use of new technology in teaching and learning is carried out with a belief that this technology will afford learning in some way. Klopfer and Squire (2005) describe five potential educational affordances of PDAs: (1) portability, as handhelds can be taken to different locations; (2) social interactivity, as handhelds can be used to collaborate with other people; (3) context sensitivity, as handhelds can be used to gather real or simulated data; (4) connectivity, as handhelds enable connection to data collection devices, other handhelds, and to a network; and (5) individuality, as handhelds can provide scaffolding to the learners. Patten, Sánches and Tangney (2006) present a framework that consists of the following affordances of PDA technology: administration, referential, interactive, microworld, data collection, location awareness, collaboration. Liaw, Hatala and Huang (2010) suggest five affordances of mobile technology for education: (a) educational content and knowledge delivery, (b) adaptive learning applications, (c) interactive applications, (d) individual applications, and (e) collaborative applications. Churchill and Churchill (2008) expanded upon these studies and examined a teacher's use of PDA technology. Their study articulated a number of affordances of PDA technology including as a multimedia access, connectivity, capture, representational and analytical tool. A summary of these studies is presented in Table 1. These affordances from the literature are sorted through our analysis into emerging groups that include: (a) resources tool, (b) connectivity tool, (c) collaborative tool, (d) capture tool, (e) analytic tool, (f) representational tool, and (g) administration tool. These groups are used as an analytical framework for understanding affordances that emerge in this study.

Table 1: Affordances of PDA technology across the relevant studies

Klopfer and Squire (2005)	Patten, Sánches and Tangney (2006)	Churchill and Churchill (2008)	Liaw, Hatala and Huang (2010)	Summary of affordances emerging from across the studies
• Portability • Social interactivity (3*) • Context sensitivity (4) • Connectivity (2, 3) • Individuality (1)	• Administration (7) • Referential (1) • Interactive resource (1) • Microworld environment (1) • Data collection (4) • Location awareness (4) • Collaboration (3)	• Multimedia access (1) • Connectivity tool (2) • Capture tool (4) • Representational tool (6) • Analytical tool (5)	• Educational content and knowledge delivery (1) • Adaptive learning applications (1) • Interactive applications (3) • Individual applications (6) • Collaborative applications (3)	1. Resources 2. Connectivity 3. Collaborative 4. Capture 5. Analytical 6. Representational 7. Administration

* Corresponds to an affordance listed in the summary (final column)

3. iPads in Education

There is a growing need for a more applicable framework to provide teachers, educational policy-makers and researchers with a better representation of the affordances of emerging TouchPad technology and how such technology influences and transforms people who adopt it. Current studies involving iPads in education provide some useful but limited suggestions.

The Catholic Education-Dioces of Paramatta in Australia experimented with iPads in eight primary and three secondary schools (Catholic Education-Dioces of Paramatta, 2010). This trial found that iPads were effective as: (a) support for learning in various settings due to portability and fit-for-task suitability, (b) support for student engagement and quick access to apps that students require for a particular learning task, and (c) students of all levels can use apps, especially for reinforcement and rote learning of basic concepts.

The 'Step Forward' pilot implementation of iPads at the Trinity College of the University of Melbourne suggests this technology supports different learning styles and allows students to achieve their goals faster (Jennings, Anderson, Dorset & Mitchell, 2011). Furthermore, it is suggested that iPads are more effective that other computing technology such as laptops, and using this technology resulted in reduced printing and paper use. A survey of student and teacher experiences at the Trinity College shows that iPads are overwhelmingly recommended for use (76.2 % of staff and 80% of students). For Jennings, Anderson, Dorset and Mitchell (2011) advantages of iPads include educational flexibility and value, low cost, size and weight, battery life, low maintenance need, and touch screen. Furthermore, Murphy and Williams (2011) suggest iPads are effective technology for presentation of class materials via multimedia systems. Other suggested advantages of iPads include size, battery life, instant on, transition between applications, multi-touch screen, cost, e-reader, multimedia support and playback, and connection to multimedia systems. Ostashewski and Reid (2010) add that the key advantage of iPad is that it can be used as a multimedia database. Other advantages suggested include ease of interaction via the touch screen, screen size, controllable multimedia playback, sound volume, and data collection capabilities.

Forty teachers from a number of faculties at the University of San Francisco used iPads over six months in 2011 (Bansavich, 2011). Implementation was monitored by the university's Center for Instruction and Technology. It was noted that the key advantage of iPads for higher education include

Table 2:
Summary of positive characteristics and educational uses of iPad devices from literature (Bansavich, 2011; Beebe, 2011; Catholic Education-Dioces of Paramatta, 2010; Jennings, Anderson, Dorset & Mitchell, 2011; Murphy & Williams, 2011; Ostashewski & Reid, 2010; Walters, 2011).

Positive characteristics of iPads	Educational uses of iPads
• Design of the device	• Presentation of class materials via multimedia systems (1)*
• Size and weight	• iPad provides access to multimedia databases and e-books (1)
• Multi-touch screen and interactivity	
• Long battery life	• Book in teachers pedagogical library (1)
• Speed of the device	• Provides quick access to Apps that students might require for a particular learning task (1 to 7)
• Relatively low cost	
• Low maintenance need	• Students of all levels can use Apps, especially for reinforcement and rote learning of basic concepts (1)
• Portability	
• Easy to use	• Teachers can easily collect assignments (2)
• Ease of connection to multimedia systems	• Tool that allows teachers to easily experiment with technology (5)
• Instant on	• A tool for creation, not just for consumption (6)
• Quick transition between applications	• iPad provides annotating and note taking features for meeting and classrooms (6, 7)
• E-reader and electronic textbook capabilities	• Supports learning engagement in variety of settings due to portability and fit-for-task suitability (1 to 7)
• Multimedia support and playback	• Supports different learning styles (1 to 6)
• Availability of Apps	• Kinesthetic and multi-touch interaction support students to develop visual and spatial skills (1 to 6)
	• Students can achieve their learning goals faster with appropriate use of iPads (1 to 6)
	• Students can achieve the level of "Create" at the peak of the Bloom's taxonomy with appropriate use of iPads (1 to 6)

* Related to an affordance listed in the last column of the Table 1

4. Teachers' Private Theories

One of the limitations of the studies of affordances of mobile technology is that they are explored apart from teachers' private theories that mediate adoption of this technology. Previous studies (e.g., Churchill, 2005) indicate that teachers' use of technology is guided by a set of private theories.

The literature generally suggests that teachers hold cognitive constructs, beliefs, guiding principles, preconceptions or private theories, which determine their instructional decisions and technology integration. A variety of issues relevant to teachers' private theories have been addressed in the literature, e.g., planning and teacher thinking when linking a curriculum to instruction (Clark & Peterson, 1984); teacher reflections and personal theories (Lloyd, 1999; Griffits & Tann, 1992); teacher pedagogical content knowledge (Wilson, Shulman & Richert, 1987); teacher schemata and decision-making (Borko & Shavelson, 1990); teacher epistemology (Howard, McGee, Schwartz & Pursel, 2000); teacher beliefs, social dynamics and institutional culture (Windschitl & Sahl, 2002); and teacher thinking and instructional design practice (Moallem, 1998). Researchers have only recently begun to explore teachers' use of technology and influences that shape their thinking and decisions (see Windschitl & Sahl, 2002; Churchill, 2005).

Previously, we conducted a study to investigate teachers' private theories and their instructional technology use (see Churchill, 2005). Six areas of teachers' private theories were identified to inform teachers' technology use (see Table 2):

Table 2: Areas of teachers' private theories (from Churchill, 2005)

• Area of private theories	• Description
• Students	• How students learn, their limitations, their ability to use technology for learning and collaboration
• Learning	• Knowledge and how is it acquired, useful teaching and learning strategies, ways learning can be evaluated
• Teacher	• Teachers' roles in learning in a classroom and a technology-based environment
• Technology	• Use of technology in a class, ways in which technology-based learning differs from traditional classroom learning, limitations and benefits of technology for learning
• Design	• Selection criteria for topics determining suitability for technology-supported learning, how to plan and design an instructional unit
• Educational Changes	• Changes in society and their implications for education, ways in which such changes impact teachers dend students and require uses of technology in education

5. The Study of Adoption of iPads

We are currently conducting a study that builds on the affordances of PDA technology and further explores iPad affordances as they emerge from classroom practitioners' efforts to understand and use this new technology in higher education. The following questions are central to the study:

- How are affordances of mobile technology utilized in context of uses of iPads?
- How teachers' private theories relate to adoption of affordances?
- How affordances lead to transformation in teachers' private theories?

The study utilizes the affordances summarized in Table 1 as an analytical framework for sorting data, and undergoes further analysis to understand adoption of affordances of mobile technology, and the ways in which the teachers' private theories (Table 2) mediate the use of this technology and transform through the process of adoption. The study is being conducted over an 18-month period. A group of nine teachers from different faculties from the University representing a range of disciplines from science, humanities and art is included in the study. A small sample of cases is sufficiently large for a qualitative study (see Savolainen, 1994; Small, 2009; Williams, 2000). Consistency technique is being used across the cases to allow comparability. The technique allows for limited uniqueness to be understood given that the participants are from a range of disciplines. The study employs multiple case study methodology to explicate affordances of TouchPads as they emerge from a sample of teachers from a single university and their efforts to use this technology. The study is an inductive, hypotheses-generating naturalistic inquiry, with the aim of accumulating an understanding and proposing recommendations relevant to the context of the study (Creswell, 1998; Flyvbjerg, 2006; Merriam, 1988; Yin, 1989). Its focus is on "the larger picture, the whole picture, and begins with a search for understanding of the whole" (Janesick, 2000, p.379), while allowing readers to draw their own conclusions (Stake, 2003).

The current stage of the study reveals certain patterns. The researchers developed patterns of private theories for each of the participants by interviewing them about a number of issues related to their teaching. Each of the participants has been provided by a new iPad device, giving them options to choose an iPad mini or a regular size device. All the participants opted to the regular device due to the size of a display area. Three sets of interviews were conducted up to this stage: one focusing on private theories upon beginning of the study, the second (group) interview, several months later after iPads have been received, focusing on initial impressions, apps downloaded and used, and the third interview at the beginning of current academic year focusing on the participants' plans for further uses, and any emerging issues. At the same time, effort has been made to collect any further data through a social networking site (Edmodo.com) set-up to allow reflections and sharing amongst the people involved in the research. The researchers examined Apps used by each of the participants, and developed a classification of these into emerging categories. The following group of tools emerged:

- Productivity Apps – These include tools such as word-processing, document annotation, creating of multimedia material tools. Specific Apps used include Mail, iAnnotate, Docs2PDF, Neu.Annotate , PDF Notes, Office2DH, iMovie and Dragon.
- Teaching Apps – These include tools that support classroom teaching, such as those that support connection to a projector, mark-book, presentation tools and classroom management tools. Examples of Apps used are Moodle, Clicker School, TeacherPal, Prezi Viewer, Slides Shark, LanSchool Teacher.
- Notes Apps – These are tools that enable note taking in combination with audio recording, drawing and typing. Examples of Apps are HansOn, Bamboo Paper, Penultimate, AudioNote, Draw Free and iPocketDraw.
- Communication Apps – These include tools that support communication and social networking. Some specific Apps include Facebook, Skype, Messages, FaceTime and MyPad.
- Drives – These include tools that allow connectivity to the Cloud, network drives and a computer. Some specific Apps include Air Shawing, FileBrowser, Dropbox, ZumoDrive, Air Drive and AirDisk.
- Blogging Apps – These tools allow convenient blogging via the iPad device. These Apps include Blogsy and Wordpress.
- Content Accessing Apps – These include tools such as e-books, multimedia material and video accessing tools. Some specific Apps include iBooks, Kindle, YouTube, Perfect Reader, iTunes and iTunesU.

Furthermore, attempt was made to link these categories of Apps to specific areas of private theories and affordances of mobile technology. This has been done by identifying links between the categories of Apps and categories of affordances through participant's private theories. Data from interviews and observations have been unitized and coded according to associations with three aspects: a Category of Apps, an Area of Private Theories, and an Affordance of Mobile Technology. The pattern of links presented in the Figure 1 was explicated in the study. The Figure shows links between areas private theories and Apps on one side, and the private theories and affordance of mobile technology on the other. The numbers on links between any two connections represents the number of participants whose data indicates such a link. For example, three participants associated 'Communication Apps' with their 'Private Theories about Students,' while seven participants associated 'Private Theories about Students' with 'Resources Environment' affordance. Purpose of opting for such summary statistics as a mean of cross-case analysis was to understand how adoption is taking place in general. Table 4 shows summary of connections between 'Categories of Apps used by the Participants,' 'Areas of the Participants' Private Theories,' and 'Affordances of Mobile Technology from Previous Studies.'
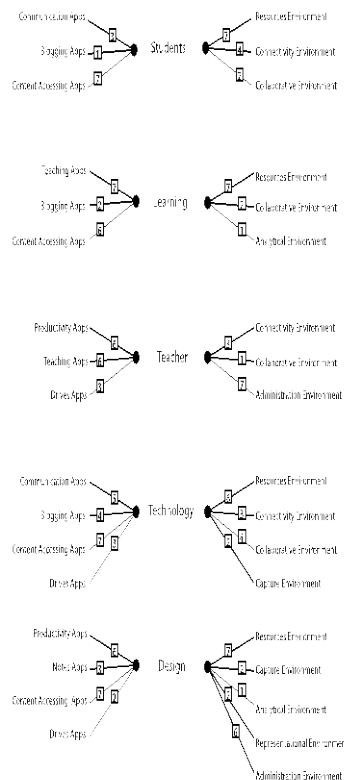

Figure 1. Connections between categories of Apps, private theories and affordances of mobile technology

Table 3: Summary of connections

Categories of Apps used by the Participants	No. of Connections	Areas of the Participants' Private Theories	No. of Connections	Affordances of Mobile Technology from Previous Studies	No. of Connections
Productivity Apps	6	Students	24	Resources Environment	34
Teaching Apps	13	Learning	25	Connectivity Environment	10
Notes Apps	3	Teacher	26	Collaborative Environment	9

Communication Apps	7	Technology	34	Capture Environment	4
Drives Apps	9	Design	36	Analytical Environment	2
Blogging Apps	6	~~Educational Changes~~ *		Representational Environment	2
Content Accessing Appss	27			Administration Environment	13
Total	71		145		74

*No data related to this area of private theories was analyzed

These results expose problematic nature of adoption of new technology by teachers. Previous study by Churchill (2005) inform that most desired outcomes in terms of embracing activity-base, student-centered pedagogy is achieved when teacher make their instructional planning decisions when driven by their private theories about 'Learning.' Driven by initial enthusiasm, we believed that iPad will have almost instant positive transformative effect on teachers, enabling them to more closely focus on uses of affordances to support their private theories about 'Learning,' and this will lead to more student-centered practices. However, on the contrary, the results show that this has not occurred, and the participating teachers were using iPads in a way that reflects traditional, teacher-centered approaches, where the technology was considered as a medium for transfer of knowledge, rather than as a set of tools that support learning through activities. The following are major observations:

- The most used category of Apps was Content Accessing Apps, while the most utilized affordance was Resources. This indicates inclination to adopt iPads as a medium for access to content materials such as web sites, Youtube videos, e-book, learning objects and readings.
- The most dominant theories are those about Design (planning of an instructional unit). Private Theories about Design most strongly related to Content Accessing Apps on one side, and Resources affordance on the other. Furthermore, Private Theories about Design strongly related to Productivity Apps on one side, and Administration affordance on the other. This shows that the participating teachers' instructional planning was strongly focusing on content, while there was a move to use certain productivity tools for administrative purpose during lesson planning.
- The second most dominant theories are about Technology. Private Theories about Technology most strongly related to Content Accessing Apps on one side, and Resources affordance on the other. Similarly to the previous observation, access to content resources played a central role. Focusing on technology has been documented in literature (see Churchill, 2005) to constrain teachers to not to give consideration to theories about learning.
- Private Theories about Students most strongly related to Content Accessing Apps and Resources affordance. Similarly, Private Theories about Learning most strongly related to Teaching and Content Accessing Apps on one side, and Resources affordance on the other. Content appears to dominate in both cases. This is problematic as it strongly indicates traditional, teacher-centered understanding of technology and education as a process of transmitting information.
- Private Theories about Teacher most strongly related to Teaching and Productivity Accessing Apps on one side, and Administration affordance on the other. This is a positive development and indicates that the participating teachers saw a lot of benefits of using iPad affordances to assist them in administrative tasks.

Strong focus on Content Accessing Apps and Resources affordances indicates that the participating teachers placed priority on an iPad to serve as a tool for access and delivery of information. What might be necessary is to engage teachers in exploring other possibilities of technologies, primarily those in which technology is used beyond delivery of resources, and serve as a tool for activities, support and evaluation, and where more emphasis is placed on collaboration, connectivity, representational possibilities and analytical uses.

Further data collection and analysis is expected to provide more in-depth understanding of connections between the affordances and private theories, and reveal areas of private theories that dominate the adoption of this technology over prolonged period of time. The researcher will attempt to understand any changes in private theories through uses of iPads and patterns of teacher change through such

experience, and contribute to articulation of a model for effective support for teachers and the application of TouchPad technology in higher education (with focus on more contemporary, student-centered teaching and learning). Study results will contribute to the articulation of specific recommendations to support teachers to transform their theories for effective utilization of affordances of iPad technology, and inform institutional planning to provide teachers with iPads or similar devices.

References

ASTRI. (2010). *Support for e-learning catches media's attention.* Retrieved from http://www.astri.org/main/?contentnamespace=news_room:event:content:20090401rrx.

Attewell, J. (2005). *Mobile technologies for learning.* London, UK: Learning and Skills Development Agency.

Banister, B. (2010). Integrating the iPod Touch in K–12 Education: Visions and Vices. *Computers in the Schools, 27*(2), 121-131.

Bansavich, J. C. (2011). *iPad study at USF.* Retrieved from http://ipad.wiki.usfca.edu/file/view/iPad+Study+at+USF+Report.pdf.

Barnes, S. (2000). What does electronic conferencing afford distance education? *Distance Education, 21*(2), 236-247.

Beebe, A. (2011). *iPads in the college composition classroom: A pilot program at the University of Texas at Tyler.* Retrieved from http://conferences.cluteonline.com/index.php/IAC/2011NO/paper/view/177.

Borko, H. & Shavelson, R. J. (1990). Teacher decision making. In B.F. Joney & L. Idol (Eds.), *Dimensions of thinking and cognitive instructions.* (pp. 311-346). Hillside, New Jersey: Lawrence Erlbaum Associates.

Brand, J. & Kinash, S. (2010). *Pad-agogy: A quasi-experimental and ethnographic pilot test of the iPad in a blended mobile learning environment.* Retrieved from http://www.ascilite.org.au/conferences/sydney10/procs/Brand-concise.pdf

Catholic Education-Dioces of Paramatta. (2010). *iPad in schools: Use testing.* Retrieved from http://learningwithipads.blogspot.com/2011_04_01_archive.html.

Chu, H.-C., Hwang, G.-J., Tsai, C.-C., & Tseng, C.-R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education, 55*(4), 1618-1627.

Churchill, D. (2005). Teachers' private theories and their design of technology-based learning. *British Journal of Educational Technology, 37*(4), 559-576.

Churchill, D., & Churchill, N. (2008). Educational affordances of PDAs: a study of a teacher's exploration of this technology. *Computers & Education, 50*(4), 1439-1450.

Churchill, D., & Hedberg, G. (2008). Learning object design considerations for small-screen handheld devices. *Computers & Education, 50*(3), 881-893.

Churchill, D., Kennedy, D. M., Flint, D. & Cotton, N. (2010). Using handhelds to support students' outdoor educational activities. *International Journal of Continuing Engineering Education and Life-Long Learning, 20*(1), 54-72.

Clark, M. C., & Peterson, L. P. (1984). *Teacher thought processes.* East Lansing, Michigan: The Institute for Research on Teaching.

Clyde, L. A. (2004). M-learning. *Teacher Librarian*, *32*(1), 45-46.

Creswell, W. J. (1998). *Qualitative inquiry and research design: choosing among five traditions.* Thousand Oaks, CA: Sage Publications.

Dwyer, D. C., Ringstaff, C, & Sandholtz, J. H. (1985-1998). *Apple Classroom of Tomorrow.* Cupertino, CA: Apple Computer Inc. Retrieved August 30, 2001 from http://www.apple.com/education/k12/leadership/acot/library.html.

Education Bureau. (2010). *Working Group on Textbooks and E-learning Resources: Main Report.* Government of Hong Kong Special Administrative Region. Retrieved from http://www.edb.gov.hk/FileManager/EN/Content_689/wg%20final%20report.pdf.

Flyvbjerg, B. (2006). Five Misunderstandings about case-study research, *Qualitative Inquiry, 12*(2), 219-245.

Griffits, M., & Tann, S. (1992). Using reflective practice to link personal and public theories. *Journal of Education for Teachers, 18*(1), 69-84.

Howard, B. C., McGee, S., Schwartz, N., & Pursel, S. (2000). The experience of constructivism: transforming teacher epistemology. *Journal of Research on Computing in Education 32*(4), 455-465.

Hsieh, S.-W., Jang, Y.-R., Hwang, G.-J., & Chen, N.-S. (2011). Effects of teaching and learning styles on students' reflection levels for ubiquitous learning. *Computers & Education, 57*(1), 1194-1201.

Janesick, V. J. (2000). The choreography of qualitative research design. In N.K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (2nd Ed.) (pp. 379- 399). Thousand Oaks, CA: Sage Publications.

Jennings, G., Anderson, T., Dorset, M., & Mitchell, J. (2011). *Report on the step forward iPad pilot project.* Retrieved August 22, 2011 from http://bit.ly/lddBoy

Jones, M., Buchanan, G., & Thimbleby, H. (2003). Improving web search on small screen devices. *Interacting with Computers, 15*(2003), 479-495.

Kazi, S. A. (2005). *Vocatest: an intelligent tutoring system for vocabulary using mlearning approach.* Paper presented at the Redesigning Pedagogy: Research, Policy, Practice Conference, 30 May - 1 June 2005, Singapore.

Kendall, K. E. (2010). Continually emerging technologies: will the iPad really change the way we live and work? *Decision Line, 21*(4), 11-13.

Klopfer, E., & Squire, K. (2005). *Environmental detectives: the development of an augmented reality platform for environmental simulations.* Retrieved from http://website.education.wisc.edu/kdsquire/manuscripts/ETRD-handheld-Draft.doc.

Liaw, S. S., Hatala, M., & Huang, H. M. (2010). Investigating acceptance toward mobile learning to assist individual knowledge management: based on activity theory approach. *Computers & Education, 54*(2), 446-454.

Lincoln, S. Y., & Guba, G. E. (1985). *Naturalistic inquiry.* Beverley Hills, CA.: Sage Publications.

Lloyd, J. M. (1999). *Knowledge and beliefs, roles, and guiding principles of two exemplary high school science teachers and a model for teacher reflection.* Unpublished doctoral dissertation, Virginia Commonwealth University, Richmond, Virginia.

Lovat, T. J., & Smith, L. D. (1990). *Curriculum: action on reflection.* Wentworth Falls, NSW: Social Science Press.

Luchini, K., Quintana, C., & Soloway, E. (2004). Design guidelines for learner-centered handheld tools. *CHI, 6*(1), 135-141.

Merriam, B. S. (1988). *Case study research in education.* San Francisco: CA: Jossey–Bass.

Moallem, M. (1998). An expert teacher's thinking and teaching and instructional design principles: An ethnographic study. *ETR&D* 46(2), 37-64.

Murphy, G. D. (2011). Post-PC devices: A summary of early iPad technology adoption in tertiary environment. *e-Journal of Business Education & Scholarship of Teaching, 5* (1), 18-32.

Murphy, T. & Williams, C. (2011). The iPad as a class presentation platform. Retrieved from http://155.225.14.146/asee-se/proceedings/ASEE2011/Papers/FP2011mur183_199.PDF.

New Media Consortium. (2011). The NMC Horizon Report: 2011 K-12 Education.

Norman, D. A. (1988). *The psychology of everyday things*. New York: Basic Books.

Ostashewski, N. & Reid, D. (2010). *iPod, iPhone, and now iPad: The evolution of multimedia access in a mobile teaching context*. In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2010 (pp. 2862-2864). Chesapeake, VA: AACE.

Patten, B., Sánches, I.A., & Tangney, B. (2006). Designing collaborative, constructivist and contextual applications for handheld devices. *Computers & Education, 46*, 294-308.

Pierson, E. M. (1999). *Technology integration practice as a function of pedagogical expertise.* Unpublished doctoral dissertation, Arizona State University, Arizona.

Ratto, M., Shapiro, R. B., Truong, T. M., & Griswold, W. G. (2003). *The active class project: experiments in encouraging classroom participation.* Retrieved from http://www-cse.ucsd.edu/~wgg/Abstracts/activeclass-cscl03.pdf.

Ray, B. (2002). PDAs in the classroom: integration strategies for K-12 educators. *International Journal of Educational Technology, 3*(1). Retrieved from http://www.ao.uiuc.edu/ijet/v3n1/ray/index.html.

Roschelle, J., & Pea, R. (2002). A walk on the WILD side: How wireless handhelds may change CSCL. *International Journal of Cognition and Technology, 1*(1), 145-168.

Savolainen, J. (1994). The rationality of drawing big conclusions based on small samples. *Social Forces, 72,* 1217-1224.

Schömmer, M. (1990). Effects of beliefs about the nature of knowledge and comprehension. *Journal of Educational Psychology, 8*2, 498-504.

Senge, M. P. (1990). *The fifth discipline: the art and practices of the learning organization*. London, UK: Century Business.

Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers & Education, 34*, 177-193.

Sharples, M., Corlett, D., & Westmancott, O. (2002). The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing, 6*, 220-234.

Small, M. (2009). How many cases do I need? On science and the logic of case selection in field-based research. *Ethnography, 10*(1), 5-38.

So, K. K. T. (2004). Applying wireless technology in field trips: A Hong Kong experience. *Australian Educational Computing, 19*(2). Retrieved from http://www.cite.hku.hk/people/tkkso/Publications/2004/Applying%20Wireless%

Song, Y., & Fox, R. (2008). Affordances of PDAs: undergraduate student perceptions. *The Journal of the Research Center for Educational Technology, 4*(1), 19-38.

Stake, R. (2003). Case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Strategies of qualitative inquiry* (2nd Ed.) (pp. 134 - 164). Thousand Oaks, CA: Sage.

Telecomasia. (2010). *iPad sales hit 2m in under two months.* Retrieved from http://www.telecomasia.net/content/ipad-sales-hit-2m-under-two-months.

Walters, E. A. (2011). *Will the iPad revolutionize education?* Retrieved from http://www.iste.org/Libraries/Leading_and_Learning_Docs/May-2011-Point-Counterpoint.sflb.ashx.

Heral Sun. (2011). *Tablet computer ownership is highest in Hong Kong.* Retrieved from http://www.heraldsun.com.au/technology/tablets/tablet-computer-ownership-is-highest-in-hong-kong/story-fn5qlb5w-1226102678709

Williams, M. (2000). Interpretivism and generalization. *Sociology, 34*(2), 209-224.

Wilson, M. S., Shulman, S. L., & Richert, E. A. (1987). '150 different ways' of knowing: representations of knowledge in teaching. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp. 104-124). London, UK: Cassell Educational Ltd.

Windschitl M., & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture. *American Educational Research Journal 39,* 1, 165-205.

Yin, R. K. (1989). *Case study research: design and methods.* Newbury Park, CA: Sage Publications.

Yinger, J. R. (1978). *A study of teacher planning: description and model of preactive decision making*. East Lansing, Michigan: The Institute for Research on Teaching.

Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handheld computers. *Computers & Education, 42*, 289-314.