EDUCATIONAL TECHNOLOGY

Kinshuk
Faculty of Science and Technology, Athabasca University, Canada

Nian-Shing Chen
Department of Information Management, National Sun Yat-sen University, Taiwan

Chin-Chung Tsai
National Taiwan University of Science and Technology, Taiwan

Gwo-Jen Hwang
National Taiwan University of Science and Technology, Taiwan

Qing Tan
Faculty of Science and Technology, Athabasca University, Canada

Keywords: Educational Technology, Game-based learning, Innovative design, Mobile learning, Science learning, Technology enhanced language learning, Technology facilitated assessment, Ubiquitous learning

Contents

Summary

Computers have penetrated the educational arena for many decades, impacting both the pedagogical approaches to instruction and inclusion of multiple modalities of content. With advent of availability of worldwide network infrastructure has widened the access to education for those who are not able to pursue the physical classroom based education for some reason. Technology has also penetrated in the classroom, enabling more realistic and contextual instruction that was not possible before. This chapter looks at various perspectives of educational technology, and the multiple directions in which the use of technology in education is impacting the learning process. A number of research areas are examined, ranging from the use of educational technology in science learning, the mobile and ubiquitous technologies to widen the access to education from anytime and anywhere and to make instruction more context sensitive by integrating physical objects from learners surrounding into the learning process, incorporating fun and games in learning process to make learning more joyful and effective, use of technology in language learning, innovative design of learning systems, to the use of technology to improve assessment process. With the help of comprehensive analysis of literature and examples, the trends and emerging directions in educational technology are discussed.

1. Introduction

The term "educational technology" has its origin dating back many decades, as early as the 1960s when Lawrence Lipsitz first started Educational Technology magazine. The use of the term educational technology has been rather varied, and researchers and practitioners have typically attributed the term to indicate use of various sorts of technologies to facilitate educational processes. It is worth noting that the term 'educational technology' also emphasizes on developing a technology of education and not only just using the existing product of the technology for education. With the explosive growth of computers in academia in later half of last century and for individual use in early eighties, and emergence of Internet in mainstream education in nineties, educational technology has become somewhat synonymous to computer based learning, technology enhanced learning, information and communication technologies (ICT) in education and online education.

The Association for Educational Communications and Technology (AECT) defined the term Educational Technology as "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources." (AECT, 2008). Some other terms have also emerged to indicate similar meaning, such as learning technology and instructional technology. In practical terms, educational technology encompasses both hardware and software. The technology part is also rather widely scoped to include any technologies, systems and applications that would contribute to different aspects of learning and instruction process.

The research areas in educational technology are very broad as they involve technological dimension, educational dimension, and cognitive & social dimensions (Cox, 2012). Within the umbrella of such wide encompassing meaning attributed to the

term educational technology, this chapter first introduces six major research areas in educational technology, namely technology enhanced science learning, ubiquitous and mobile technologies enhanced learning, joyful, fun and game-based learning, technology enhanced language learning, innovative design of learning systems, and technology facilitated testing and assessment. This is followed by the review of research trends in educational technology, ubiquitous and mobile technologies enhanced learning, and joyful, fun and game-based learning. Finally, some example studies are provided in the areas of technology enhanced language learning, innovative design of learning systems, and technology facilitated testing and assessment for better appreciation of educational technology advancements.

2. Major Research Areas in Educational Technology

2.1. Technology Enhanced Science Learning

The usage of technology for enhancing science education has become gradually widespread earlier than the 21st century (Linn, Clark, & Slotta, 2003). Due to the dynamic, spatial and complex features of many scientific concepts (such as mechanics, atomic structures, and evolution), technology, if used properly, is quite useful in facilitating science learning. For example, the utilizations of online resources (and searching), simulation/animation, virtual reality, discussion forums, and online game-based learning have been implemented in science education settings of K-12 schools (Lee et al., 2011). Recently, augmented reality is also applied to science education to foster students' inquiry, argumentation or spatial ability in high schools and colleges (Martín-Gutiérrez et al., 2010; Squire & Klopfer, 2007). Technology also has great potential to help science learning in authentic contexts, such as mobile/ubiquitous learning and technology-enhanced laboratory (Chu, Hwang, Tsai, & Tseng, 2010; Hwang, Yang, Tsai & Yang, 2009). In science education, multiple representations ability is the ability to depict scientific information using different representations such as graphs, diagrams, verbal descriptions, and equations. Scientists can understand complex phenomena/problem by applying multiple representations ability. It is expected that if students can learn the ability to extract and construct such representations with appropriate support of educational technologies, it would help them in deep conceptual understanding and complex problem-solving.

Lee et al. (2011) conducted a meta-analysis about the effects of technology enhanced science learning and the research methodologies used in related studies. They found that there is little research addressing the impact of technology enhanced science learning on more advanced aspects of learning such as promoting students' meta-cognition and epistemological development (e.g., Tsai, 2004). On the other hand, several researchers reported the potential of using computer and communication technologies in conducting science activities to enhance various competences or skills of students. For example, Hwang, Yang, Tsai and Yang (2009) showed the effectiveness of using computer systems as a tutor for guiding students to learn the procedure of complex science experiments; Kuo, Hwang & Lee (2012) demonstrated a series of web-based science learning activities to foster students' problem-solving competence; Hung et al. (2012) further presented a technology-enhanced learning environment for improving students' science inquiry ability. These findings imply the importance and challenges of

investigating the effects of using computer and web technologies on students' science learning performance as well as proposing effective technology-enhanced learning strategies and tools for science instruction.

2.2. Ubiquitous and Mobile Technologies Enhanced Learning

In recent years, the progress and popularity of mobile and wireless communication technologies have evolved the research issues of e-learning to mobile learning (m-learning) and ubiquitous learning (u-learning) (Hwang, Tsai, & Yang, 2008). A broad-sense definition of ubiquitous learning is “anywhere and anytime learning”; that is, any learning environment that allows students to access learning content in any location at any time can be called a u-learning environment, no matter whether wireless communications or mobile devices are employed or not. From this viewpoint, the mobile learning environment which allows students to access learning content using mobile devices with wireless communications is a special case of the broad-sense definition of u-learning.

During 2000-2010, many researchers have attempted to combine sensing technologies with mobile technologies to build context-aware ubiquitous learning environments, and have applied these technologies to teach different subjects, such as natural science (Chiou, Tseng, Hwang, , & Heller, 2010; Chu, Hwang, Tsai, & Tseng, 2010; Peng, Chuang, Hwang, Chu, Wu, & Huang, 2009), mathematics (Nussbaum et al., 2009), languages (Chen & Chung, 2008) and social science (Hwang & Chang, 2011; Shih, Chuang, & Hwang, 2010). Some researchers further established digital libraries for supporting context-aware ubiquitous learning activities (Chu, Hwang, & Tseng, 2010). In this learning environment, the system can detect real-world situations via sensing technologies, and guide students to learn through mobile devices in actual contexts (Uden, 2007; Hwang, Tsai, & Yang, 2008); the sensing equipment includes Bluetooth technology (González-Castaño, García-Reinoso, Gil-Castiñeira, Costa-Montenegro, & Pousada-Carballo, 2005) Radio Frequency Identification (RFID) (Hwang, Kuo, Yin, & Chuang, 2010) and Global Positioning Systems (GPS) (Huang, Lin, & Cheng, 2010). The major benefit of context-aware ubiquitous learning is to provide personalized scaffolding and support for students to observe and experience real-world situations so as to construct personal knowledge (Hwang, Yang, Tsai & Yang, 2009). The interaction with real contexts and learning systems fosters student’ independent thinking abilities and enhances their learning motivation to further promote learning achievement (Chu, Hwang, & Tsai, 2010).

Most of the research concerning context-aware ubiquitous learning has focused on outdoor ecological learning (Hwang, Tsai, & Yang, 2008; Hwang, Yang, Tsai, & Yang, 2009; Ng & Nicholas, 2009; Hwang, Kuo, Yin, & Chuang, 2010; Chu, Hwang, & Tsai, 2010). Recently, such a learning approach has also been applied to skills training. For example, Hwang, Yang, Tsai and Yang (2009) developed a context-aware ubiquitous learning environment for guiding inexperienced researchers to practice single-crystal X-ray diffraction operations with step-by-step guidance and feedback; the experimental results showed that the context-aware ubiquitous learning mechanism is beneficial for cultivating students’ problem-solving abilities and operational skills. Moreover, Wu,

Hwang, Su and Huang (2012) developed a context-aware mobile learning system for nursing training courses.

Promising research issues concerning system development, tutoring and assessment strategies, and learning management using mobile, wireless and sensing technologies have been identified as follows (Hwang, Tsai, & Yang, 2008):

(1) New pedagogical theories for mobile and ubiquitous learning environments: New modes of learning will involve new pedagogies. As mobile and ubiquitous learning is still in its developmental stage, educational researchers may propose some innovative thoughts about its pedagogy. Perhaps some modifications of existing theories are still feasible for implementing u-learning. For example, some cognitive or learning theories (such as the ideas of situated cognition and scaffoldings) may be revised and re-examined to interpret student learning in mobile and ubiquitous learning).
(2) Tutoring strategies for mobile and ubiquitous learning: As mobile and ubiquitous learning may induce new ways of learning, and the tutoring strategies may be revised accordingly. More research should be conducted to explore the teaching effectiveness of different tutoring strategies for various ways of implementing the learning approaches.
(3) Assessment strategies for mobile and ubiquitous learning: The assessment is critical and it is part of the instructional process. Mobile and ubiquitous learning environments will require more alternative ways of assessment. The assessment strategies for situated learning, adaptive learning and cooperative learning involving mobile and ubiquitous technologies need further research.
(4) Innovative and practical use of ubiquitous technologies for education, learning and training: Researchers are encouraged to implement more innovative applications of mobile and ubiquitous learning, and explore their potential to complement other forms of instruction. The actual effects of utilizing ubiquitous technologies need more large-scale research.
(5) Psychological analysis for mobile and ubiquitous learning and training: A better understanding of the psychological factors related to u-learning can help educators or system designers to develop more appropriate learning environments. As mobile and ubiquitous learning environments have the capacity to record a variety of each individual learner's personal information, related behaviors, and environmental parameters (in the form of a personal electronic portfolio), researchers can use these data to analyze in depth student learning processes and related factors which may facilitate learning.

2.3. Joyful, Fun and Game-based Learning

In recent years, digital games have become promising tools for providing highly motivating learning situations to the learners. Equipping with the elements of challenge, fantasy, goals, rules, feedback, curiosity and control, digital games can provide rich learning experiences and therefore can play an important role in the development of learners' skills, motivation and attitudes (Inal & Cagiltay, 2007; Asgari & Kaufman, 2004; Garris, Ahlers, & Driskell, 2002; Malone, 1981; Gros, 2007). Game-based learning has potential to enable learners to construct knowledge from trial and error within the immersive, engaging and experiential game playing process (Adcock, 2008;

Van Eck, 2007). Previous studies have illustrated positive aspects of digital games as well as negative impacts on learning (Inal & Cagiltay, 2007; Kiili, 2005).

From the knowledge acquisition perspective, digital games play a role of cognitive tools to (a) provide multiple representations; (b) activate prior knowledge (Squire, 2003); (c) connect game-playing experience and real-life learning experience (Pivec & Kearney, 2007); and, (d) provide trial-and-error opportunities for problem-solving and higher order cognitive thinking (Adcock, 2008). From the affective perspective, digital games play a role in motivating learners by adding challenge, feedback, curiosity and fantasy features within the learning process (Garris, Ahlers, & Driskell, 2002). On the other hand, some negative effects may occur, such as (a) learners may gain less from learning when game features are added and learners' attention is distracted; and (b) digital games may not appeal to every student. These negative aspects imply that game features and specific domain knowledge should be taken into careful consideration when designing game-based learning. Furthermore, despite the potential advantages mentioned, very few studies have been conducted to actually provide empirical evidence for supporting the effectiveness of game-based learning. As mentioned above, digital game-based learning has become a potential tool to enable learners to actively engage in learning activities, construct knowledge by playing, maintain high learning motivation and apply acquired knowledge to real-life problem solving. However, what an effective game play process consists of, what critical phases need to be involved, and what types of game play are pedagogically meaningful, still need to be further investigated.

Many researchers believe that digital game-based learning has great potential in serving as an epistemological tool in providing opportunities for learners to construct knowledge and skills. Through a pedagogically designed game play, content, skills and attitudes can be integrated into the game-based learning context for engaging learners in higher order cognitive activities that promote attention, selection, activation and retention. Thus, learning can be enhanced by game play. However, two critical issues emerge from the foregoing assertions. Firstly, learners' personal epistemology can be successfully developed only when game play is integrated with meaningful learning. Secondly, learners' knowledge transformation must be supported by game play in order to evolve epistemological growth in the learners. Empirical studies are needed for finding evidences in supporting the following assertions (Hwang & Wu 2012):

1. Learners' epistemological growth relies on the smooth and successful knowledge transformation within game play processes.
2. Learners' knowledge transformation is related to their prior knowledge and game preferences.
3. Learners with more advanced epistemological background prefer to learn from a more complex gaming context.
4. Game play serves as a scaffold to help the disadvantaged learners to achieve learning goals.

Promising research issues in joyful, fun and game-based learning are as follows:

1. A better/deeper understanding about the nature of learning within game play.
2. The role of gaming context such as mini games, complex games, mobile games and alternative reality games.

3. Developing explanatory models for knowledge transformation through game play within various contexts.

2.4. Technology Enhanced Language Learning

During 1990-2010, research in technology enhanced language learning has witnessed tremendous developments both in theory and practice. However, what is still needed, as White (2006: 249) identifies, "is the development of research tools, methods and approaches appropriate to the new paradigms for distance language learning". Learning a second language at a distance brings great challenge to learners. Physical separation of teacher and learners and learners among themselves makes language learning extremely difficult. However, recent advances in synchronous technologies have created a great potential to address various difficulties facing distance language learners (Chen & Wang, 2008; Levy, Chen & Ko, 2010).

Some studies have pointed out that teacher education in technology enhanced language learning should not be only about learning, about teaching, or even teaching about teaching. It should also be about fostering the trainee's personal development to become a confident and competent online language teacher by paying careful attention to students' emotions, feelings and reactions (Wang, Chen, & Levy, 2010). In recent years, collaborative language learning mediated through technologies has also received increasing attention from researchers in technology enhanced language learning (Lund, 2008).

Promising research issues in technology enhanced language learning are as follows:

1. What an effective teacher training program should incorporate to respond to the challenges of training and teaching in an online teaching and learning setting.
2. How to respond to the needs of the trainee teachers, and how to guide their learning process appropriately in technology enhanced language learning environments.
3. How to apply advanced learning technologies, like augmented reality, natural user-interface computing and learning analytics, in transforming language learning in the 21st century.

-

-

-

Bibliography

Adcock, A. (2008). Making Digital Game-based Learning Working: An Instructional Designer's Perspective. *Library Media Connection. 26* (5), 56-57. [This paper describes approaches for effective digital game based learning]

AECT (2008). Definition. In A. Januszewski and M. Molenda (Eds.), *Educational Technology: A definition with commentary*, New York: Lawrence Erlbaum. [This chapter describes the definition of educational technology as per the Association for Educational Communications and Technology]

Asgari, M., & Kaufman, D. (2004). Relationships among Computer Games, Fantasy, and Learning. *Paper presented at the 2nd Annual Conference on Imagination and Education*, July 14-17, 2004, Vancouver, Canada. [This paper explores the relationships among computer games, fantasy, and learning]

Chang, W., & Tan, Q. (2010). Augmented reality system design and scenario study for location-based adaptive mobile learning. *Proceeding of the 13th IEEE International Conference on Computational Science and Engineering*, Washington, DC, USA: IEEE Computer Society, 20-27. [This paper presents a design of Multi-Object Oriented Augmented Reality (MOOAR) system for location-based adaptive mobile learning environment]

Chao, K. J., Hung, I. C., & Chen, N. S. (2012). On the design of online synchronous assessments in a synchronous cyber classroom. *Journal of Computer Assisted Learning*. doi: 10.1111/j.1365-2729.2011.00463.x [This paper describes the design and evaluation of online synchronous assessment in a formal credit course]

Chen, N. S., Kinshuk, Wei, C. W., & Liu, C. C. (2011). Effects of matching teaching strategy to thinking style on learner's quality of reflection in an online learning environment. *Computers & Education, 56* (1), 53-64. [This paper discusses whether learners' reflection levels can be improved if teaching strategies are adapted to fit with learners' thinking styles in an online learning environment]

Chen, N. S., Ko, H. C., Kinshuk, & Lin, T. (2005). A model for synchronous learning using the Internet. *Innovations in Education and Teaching International, 42* (2), 181-194. [This paper describes an online synchronous learning model that aims to provide guidelines for teachers and students to conduct synchronous instruction]

Chen, N. S., & Ko, L. (2010). An Online Synchronous Test for Professional Interpreters. *Educational Technology & Society, 13* (2), 153–165. [This paper describes an experiment for conducting an interpreting test for multiple candidates online, using web-based synchronous cyber classrooms]

Chen, N. S., Teng, C. E., Lee, C. H., & Kinshuk. (2011). Augmenting paper-based reading activity with direct access to digital materials and scaffolded questioning. *Computers & Education, 57*(2), 1705-1715. [This paper discusses the use of QR codes in association with mobile technology to deliver supplementary materials and questions to support students' reading]

Chen, N. S., & Wang, Y. (2008). Testing principles of language learning in a cyber face-to-face environment. *Educational Technology & Society, 11* (3), 97-113. [This paper discusses the application of the established principles of instructed language learning in a cyber fact-to-face environment supported by an advanced Synchronous Learning Management System]

Chen, C. M., & Chung C. J. (2008). Personalized mobile English vocabulary learning system based on item response theory and learning memory cycle. *Computers & Education, 51* (2), 624-645. [This paper describes a personalized mobile English vocabulary learning system based on Item Response Theory and learning memory cycle]

Chiou, C. K., Tseng, Judy. C. R., Hwang, G. J., & Heller, S. (2010). An adaptive navigation support system for conducting context-aware ubiquitous learning in museums. *Computers & Education, 55* (2), 834-845. [This paper describes the navigation support problem for context-aware ubiquitous learning and proposes two navigation support algorithms based on learning efficacy and navigation efficiency]

Chu, H. C., Hwang, G. J., & Tsai, C. C. (2010). A knowledge engineering approach to developing mindtools for context-aware ubiquitous learning. *Computers & Education, 54* (1), 289-297. [This paper describes a knowledge engineering approach to develop Mindtools for mobile and ubiquitous learning scenarios]

Chu, H. C., Hwang, G. J., & Tseng, J. C. R. (2010). An innovative approach for developing and employing electronic libraries to support context-aware ubiquitous learning. *The Electronic Library, 28* (6), 873-890. [This paper proposes an approach to assist teachers in using electronic libraries to develop learning activities for context-aware ubiquitous learning, in which the learning system can detect students' behaviors and guide them to learn in the real world with personalized support from the digital world]

Chu, H. C., Hwang, G. J., Tsai, C. C., & Tseng, J. C. R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science course. *Computers & Education, 55* (4), 1618-1627. [This paper presents a mobile learning system that employs Radio Frequency Identification (RFID) technology to detect and examine real-world learning behaviors of students]

Ellis, R. (2005). Principles of instructed language learning. *System, 33* (2), 209-224. [This paper draws together findings from a range of second language acquisition studies in order to formulate a set of general principles for language pedagogy]

Garris, R., Ahlers, R., & Driskell, J.E. (2002). Games, Motivation, and Learning: A Research and Practice model. *Simulation & Gaming. 33* (4), 441-467. [This paper presents an input-process-output model of instructional games and learning that elaborates (a) the key features of games that are of interest from an instructional perspective; (b) the game cycle of user judgments, behavior, and feedback that is a hallmark of engagement in game play; and (c) the types of learning outcomes that can be achieved]

González-Castaño, F. J., García-Reinoso, J., Gil-Castiñeira, F., Costa-Montenegro, E., & Pousada-Carballo, J. M. (2005). Bluetooth-assisted context-awareness in educational data networks. *Computers & Education, 45* (1), 105-121. [This paper proposes an auxiliary location network to support user-independent context-awareness in educational data networks]

Cox, M. J. (2012). Formal to informal learning with IT: research challenges and issues for e-learning. *Journal of Computer Assisted Learning*. doi: 10.1111/j.1365-2729.2012.00483.x [This paper reviews the wide range of technological and educational research changes that have taken place over the last 40 years.]

Gros, B. (2007). Digital Games in Education: The Design of Game-based Learning Environment. *Journal of Research on Technology in Education. 40* (1), 23-38. [This paper discusses the design of digital games for education]

Hampel, R. (2006). Rethinking task design for the digital age: A framework for language teaching and learning in a synchronous online environment. *ReCALL, 18* (1), 105-121. [This paper discusses a framework for the development of tasks in a synchronous online environment used for language learning and teaching]

Hastie, M., Chen, N.S., & Kuo, Y.H. (2007). Instructional design for best practice in the synchronous cyber classroom. *Educational Technology & Society, 10* (4), 281-294. [This paper investigates the correlation between the quality of instructional design and learning outcomes for early childhood students in the online synchronous cyber classroom]

Hastie, M., Hung, I. C., Chen, N. S., & Kinshuk. (2010). A blended synchronous learning model for educational international collaboration. *Innovations in Education and Teaching International, 47* (1), 9-24. [This paper proposes a blended synchronous learning model for better supporting educational international collaboration through maximizing interconnectivity and social interactions]

Hsu, Y. C., Ho, S. N., Tsai, C. C., Hwang, G. J., Chu, H. C., Wang, C.Y., & Chen, N. S. (in press). Research Trends in Technology-based Learning from 2000 to 2009: a content analysis of publications in selected journals. *Educational Technology & Society*. [This paper provides a content analysis of studies in technology-based learning during 2000 and 2009]

Huang, Y. M., Huang, T. C., Wang, K. T., & Hwang, W. Y. (2009). A Markov-based recommendation model for exploring the transfer of learning on the web. E*ducational Technology & Society, 12* (2), 144-162. [This paper proposes use of the learning sequence recommendation system to help learners achieve effective Web-based learning transfer using recommendations based on group-learning paths]

Huang, Y. M., Lin, Y. T., & Cheng, S. C. (2010). Effectiveness of a Mobile Plant Learning System in a science curriculum in Taiwanese elementary education. *Computers & Education, 54* (1), 47-58. [This paper describes a Mobile Plant Learning System that provides instructors with the ways and means to facilitate student learning in an elementary school level botany course]

Huang, Y. M., Liu, C. H., Lee, C. Y., & Huang, Y. M. (in press). Designing a personalized guide recommendation system to mitigate information overload in museum learning. *Educational Technology & Society*. [This paper proposes a personalized guide recommendation system to mitigate the problem of information overload]

Huang, Y. M., & Wu, T. T. (2011). A systematic approach for learner group composition utilizing u-learning portfolio. *Educational Technology & Society, 14* (3), 102-117. [This paper proposes an effective and systematic learner grouping scheme containing transformation processes from u-portfolios to a proposed Portfolio Grid, creating a learner similarity matrix, and group composition]

Hung, P. H., Hwang, G. J., Su, I. S., & Lin, I. H. (2012). A concept-map integrated dynamic assessment system for improving ecology observation competences in mobile learning activities. *Turkish Online Journal of Educational Technology, 11* (1), 10-19. [This paper describes a concept map integrated mobile learning design for ecology observation]

Hwang , G. J., Kuo, F. R., Yin, P. Y., & Chuang, K. H. (2010). A Heuristic Algorithm for planning personalized learning paths for context-aware ubiquitous learning. *Computers & Education, 54* (2), 404-415. [This paper formulates an optimization problem that models the objectives and criteria for determining personalized context-aware ubiquitous learning paths to maximize the learning efficacy for individual students, by taking into account the meaningfulness of the learning paths and the number of simultaneous visitors to each learning object]

Hwang, G. J., & Chang, H. F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education, 56* (1), 1023-1031. [This paper proposes a formative assessment-based approach for improving the learning achievements of students in a mobile learning environment]

Hwang, G. J., Tsai, C. C., & Yang, S. J. H. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning. *Educational Technology & Society, 11* (2), 81-91. [This paper presents the basic criteria, strategies, and research issues of context-aware ubiquitous learning, and identifies the necessary check items as well for the development of such learning environment]

Hwang, G. J., & Tsai, C. C. (2011). Research trends in mobile and ubiquitous learning: A review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology, 42* (4), E65-E70. [This is a colloquium article describing research trends in mobile and ubiquitous learning during 2000-2010]

Hwang, G. J & Wu, P. H. (2012). Advancements and trends in digital game-based learning research: a review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology, 43* (1), E6-E10. [This is a colloquium article describing research trends in digital game-based learning during 2000-2010]

Hwang, G. J., Yang, T. C., Tsai, C. C., & Yang, S. J. H. (2009). A context-aware ubiquitous learning environment for conducting complex science experiments. *Computers & Education, 53* (2), 402-413. [This paper describes a context-aware u-learning environment for guiding inexperienced researchers to practice single-crystal X-ray diffraction operations]

Inal, Y., & Cagiltay, K. (2007). Flow Experiences of Children in an Interactive Social Game Environment. *British Journal of Educational Technology. 38* (3), 454-464. [This paper examines children's flow experiences in an interactive social game environment]

Kiili, K. (2005). Content Creation Challenges and Flow Experience in Educational Games: The IT-Emperor Case. *Internet and Higher Education, 8*, 183-98. [This paper examines the experiences of university students playing IT-Emperor, an educational game designed to facilitate flow experience]

Kuo, F. R., Hwang, G. J., & Lee, C. C. (2012). A hybrid approach to promoting students' web-based problem solving competence and learning attitude. *Computers & Education, 58* (1), 351-364. [This paper describes a hybrid approach to integrate the cognitive apprenticeship model with the collaborative learning strategy]

Lee, S. W.-Y., Tsai, C.-C., Wu, Y-T., Tsai, M.-J., Liu, T.C., Hwang, F-K., Lai, C.H., Liang, J.-C., Wu, H-C., & Chang, C.-Y. (2011). Internet-based science learning: a review of journal publications. *International Journal of Science Education, 33,* 1893-1925. [This paper reviews research on Internet-based science learning in two categories: the role of demographics and learners' characteristics and the learning outcomes]

Levy, M., Wang, Y., & Chen, N. S. (2009). Developing the skills and techniques for online language teaching: A focus on the process. *Innovation in Language Learning and Teaching, 3* (1), 16-33. [This

paper describes the experience of two online tutors as they learn to teach the language to learners at a distance]

Liang, T. H., Huang, Y. M., & Tsai, C. C. (in press). An investigation of teaching and learning interaction factors for the use of the interactive whiteboard technology. *Educational Technology & Society*. [This article defines four interactive whiteboards supported teaching and learning interaction factors: interactive whiteboards supported teaching, interactive whiteboards supported learning, teacher supported learning, and student interactive learning]

Lin, Y. T., Huang, Y. M., & Cheng, S. C. (2010). An automatic group composition system for composing collaborative learning groups using enhanced particle swarm optimization. *Computers & Education, 55* (4), 1483-1493. [This paper describes formulation of a group composition problem to model the formation of collaborative learning groups]

Lin, Y. C., Lin, Y. T., & Huang, Y. M. (2011). Development of a diagnostic system using a testing-based approach for strengthening student prior knowledge. *Computers & Education, 57* (2), 1557-1570. [This paper proposes a testing-based diagnosis system to assist instructors and students in diagnosing and strengthening prior knowledge before new instruction is undertaken]

Linn, M. C., Clark, D., & Slotta, J. D. (2003). WISE design for knowledge integration. *Science Education, 87* (4), 517–538. [This paper describes the Web-based Inquiry Science Environment (WISE) that offers designers a technology-enhanced, research-based, flexibly adaptive learning environment]

Loughran, J. (2006). *Developing a Pedagogy of Teacher Education: Understanding teaching and learning about teaching*, London: Routledge. [This book explores the complex nature of teaching and learning about teaching and illustrates how important teacher educators' professional knowledge is and how that knowledge must impact teacher education practices]

Lund, A. (2008). Wikis: a collective approach to language production. *ReCALL, 20* (1), 35-54. [This paper looks at the potential of wikis for representing a particular type of collaborative learning environment where collaboration can result in aggregated, collective products]

Malone, T.W. (1981). Toward a Theory of Intrinsically Motivating Instruction. *Cognitive Science: A Multidisciplinary Journal. 5* (4), 333-369. [This paper reviews a number of previous theories of intrinsic motivation, followed by several studies of highly motivating computer games]

Martín-Gutiérrez, J., Luís Saorín, J., Contero, M., Alcañiz, M., Pérez-López, D. C., & Ortega, M. (2010). Design and validation of an augmented book for spatial abilities development in engineering students. *Computers and Graphics, 34* (1), 77-91. [This paper presents an application of augmented reality for improving spatial abilities of engineering students]

Ng, W., & Nicholas, H. (2009). Introducing pocket PCs in schools: Attitudes and beliefs in the first year. *Computers & Education, 52* (2), 470-480. [This paper explores the realities of introducing and integrating handheld computers into schools]

Nussbaum, M., Alvarez, C., McFarlane, A., Gomez, F., Claro, S., & Radovic, D. (2009). Technology as small group face-to-face Collaborative Scaffolding. *Computers & Education, 52* (1), 147-153. [This paper reports on the design of a digital system that aims to support the practice of face-to-face collaboration on open-ended tasks]

Peng, H., Chuang, P. Y., Hwang, G. J., Chu, H. C., Wu, T. T., & Huang, S. X. (2009). Ubiquitous performance-support system as Mindtool: A case study of instructional decision making and learning assistant. *Educational Technology & Society, 12* (1), 107-120. [This paper describes a ubiquitous performance-support system that can facilitate the seamless use of powerful new technologies in the school setting]

Pivec, M. & Kearney, P. (2007). Games for Learning and Learning from Games. *Informatica, 31*, 419-423. [This paper describes a model of game-based learning and suggests how this can be applied to both the playing of computer games and learning within the classroom environment]

Prensky, M. (2001). *Digital Game-based Learning*, New York: McGraw Hill. [This book advocates learning from digital game]

Shih, J. L., Chuang, C. W., & Hwang, G. J. (2010). An inquiry-based mobile learning approach to enhancing social science learning effectiveness. *Educational Technology & Society, 13* (4), 50-62. [This

paper presents a mobile exploration activity that guides elementary students to learn during a social science activity with digital support from mobile devices and wireless communications]

Squire, K. (2003). Video Games in Education. *International Journal of Intelligent Games & Simulation, 2* (1), 49-62. [This paper examines the history of games in educational research, and argues that the cognitive potential of games have been largely ignored by educators]

Squire, K., & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *Journal of the Learning Sciences, 16* (3), 371-413. [This paper discusses the pedagogical potential of augmented reality simulations in environmental engineering education by immersing students in the roles of scientists conducting investigations]

Tan, Q., Zhang, X., Kinshuk, & McGreal, R. (2011). The 5R Adaptation Framework for Location-Based Mobile Learning Systems. *Proceedings of the 10th World Conference on Mobile and Context Learning*, Beijing, China: Beijing Normal University, 87-94. [This paper describes a framework for location-based mobile learning systems by considering the factors of learner, time, location, device and content]

Tsai, C.-C. (2004). Beyond cognitive and metacognitive tools: the use of the Internet as an "epistemological" tool for instruction. *British Journal of Educational Technology, 35*, 525-536. [This paper looks at the role of Internet-based instruction not only as a cognitive tool or a metacognitive tool but also as an epistemological tool]

Uden, L. (2007). Activity theory for designing mobile learning. *International Journal of Mobile Learning and Organisation, 1* (1), 81-102. [This paper presents the use of activity theory as a framework for describing the components of an activity system for the design of a context-aware mobile learning application]

Van Eck, R. (2007). Six Ideas in Search of a Discipline. In: Shelton, B.E. & Wiley, D.A. (Eds.), *The Design and Use of Simulation Computer Games in Education* (pp. 31-56), Rotterdam: Sense. [This chapter looks at various aspects of digital game-based learning]

Wang, Y., Chen, N. S., & Levy, M. (2010). The design and implementation of a holistic training model for language teacher education in a cyber face-to-face learning environment. *Computers and Education, 55* (2), 777-788. [This paper reports a qualitative investigation examining the design and implementation of a holistic teacher training model in a cyber face-to-face language learning context]

Wang, Y., Chen, N. S., & Levy, M. (2010). Teacher training in a synchronous cyber face-to-face classroom: Characterizing and supporting the online teachers' learning process. *Computer Assisted Language Learning, 23* (4), 277-293. [This paper discusses the learning process undertaken by language teachers in a cyber face-to-face teacher training program]

White, C. (2006). Distance learning of foreign languages. *Language Teaching, 39*, 247-264. [This paper provides a critical overview of the field of distance language learning, challenging the way in which the field is often narrowly conceptualized as the development of technology-mediated language learning opportunities]

Wu, P. H., Hwang, G. J., Su, L. H., & Huang, Y. M. (2012). A context-aware mobile learning system for supporting cognitive apprenticeships in nursing skills training. *Educational Technology & Society, 15* (1), 223-236. [This paper describes a context-aware mobile learning system for nursing training courses]

Biographical sketches

Kinshuk is NSERC/iCORE/Xerox/Markin Industrial Research Chair for Adaptivity and Personalization in Informatics, Associate Dean of Faculty of Science and Technology, and Full Professor in the School of Computing and Information Systems at Athabasca University, Canada. His work has been dedicated to advancing research on the innovative paradigms, architectures and implementations of online and distance learning systems for individualized and adaptive learning in increasingly global environments. Areas of his research interests include learning technologies, mobile, ubiquitous and location aware learning systems, cognitive profiling and interactive technologies. With more than 300 research publications in refereed journals, international refereed conferences and book chapters, he is frequently invited as keynote or principal speaker in international conferences (19 in past five years) and visiting professor around the world (14 in the past five years in China, Hong Kong, Finland, Italy, Japan, and

Taiwan). He also has a successful record of procuring external funding over 11 million Canadian dollars as principal and co-principal investigator. He is Founding Chair of IEEE Technical Committee on Learning Technologies, and Founding Editor of the Educational Technology & Society Journal (SSCI indexed with Impact Factor of 1.066 according to Thomson Scientific 2010 Journal Citations Report).

Nian-Shing Chen is Chair Professor at the Department of Information Management in the National Sun Yat-sen University, Taiwan. He has published over 350 papers in the international referred journals, conferences and book chapters. One of his papers published in Innovations in Education and Teaching International was awarded as the top cited article in 2010. He is the author of three books with one textbook entitled "e-Learning Theory & Practice". Prof. Chen received the distinguished research awards from the National Science Council, Taiwan in 2008 and 2011-2013. His current research interests include assessing e-Learning course performance; online synchronous teaching & learning; mobile & ubiquitous learning; natural user interface & game-based learning. Prof. Chen is serving as an editorial board member for many international journals and guest editors for more than 10 special issues of international journals. He has also organized and chaired numerous international conferences and workshops in the area of advanced learning technologies. Professor Chen is a senior member of IEEE, ACM and the Chair of the IEEE Technical Committee on Learning Technology (http://lttf.ieee.org/). He is Co-Editors-In-Chief of the SSCI-indexed Journal of Educational Technology & Society.

Chin-Chung Tsai is Chair Professor at National Taiwan University of Science and Technology, Taipei, Taiwan. His research interests deal largely with science education and human perceptions and behaviors toward Internet-based learning environments. He is currently the Co-Editor of *Computers & Education* (published by Elsevier). In recent five years, he has published more than sixty papers in English-based international journals. Address for correspondence: Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, #43, Sec. 4, Keelung Rd., Taipei, 106, Taiwan. E-mail: cctsai@mail.ntust.edu.tw.

Gwo-Jen Hwang is Chair Professor at the National Taiwan University of Science and Technology. He received his Ph.D. degree in Computer Science and Information Engineering from the National Chiao Tung University in Taiwan in 1991. Dr Hwang serves as an editorial board member and a reviewer for more than 30 academic journals. His research interests include mobile and ubiquitous learning, computer-assisted testing, web-based learning, and artificial intelligence in education. Dr. Hwang has published nearly 400 academic papers, including 150 papers in such professional journals as British Journal of Educational Technology, Computers & Education, Educational Technology & Society, Innovations in Education and Teaching International, Interactive Learning Environment, and Computer-Assisted Learning among others. Owing to the good reputation in academic research and innovative inventions in e-learning, he received the annual most Outstanding Researcher Award from the National Science Council in the years of 2007 and 2010. Moreover, in 2007, Dr. Hwang was elected as the Chair of the Special Interest Group of Mobile and Ubiquitous Learning in the Information Technology Education Division of the National Science Council in Taiwan. He has been serving the position since then.

Qing Tan is Assistant Professor at Athabasca University. His background is in aviation navigation, control engineering, computer science, and computer information system. Dr. Tan grew up in Chengdu, China. His undergraduate study was major in Gyroscope and Inertial navigation at Northwest Polytechnic University in Xi'an, China. Before he left China for his PhD studies at Norwegian Institute of Technology in Trondheim, Norway, he had worked on development of navigation system in Chinese Aviation industry for a few years. His PhD research was on Robotics, anthropomorphic robot teleoperartion. Dr. Tan conducted his post doctoral research at Japan Atom Energy Research Institute, Tokai, Japan. Before joining Athabasca University in 2007, Dr. Tan worked in location sensors related industries for ten years. Dr. Tan's research interests include Location-Based Technologies, Mobile Computing and Technologies, Mobile Learning, Adaptive Mobile Learning and Commerce, Wireless Sensor Networks, Computer Network and Cyber Security, Enterprise Modeling and Information Management System, and Robot Telepresence. Dr. Tan has been invited as program committee member and reviewer of various international conferences. He has also served as guest editor of journals and has been invited to give research talks in various universities. He has published widely in various international conferences and journals on location-aware technologies for mobile learning since his return to academic career.