

Guest Editorial: Special Issue on Seamless, Ubiquitous, and Contextual Learning

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ADVANCES in mobile and sensor technologies, cloud computing, and related Internet technologies have been phenomenal in recent years. Worldwide, the number of people with access to mobile technologies is also increasing very rapidly. There are currently more than 1.75 billion smartphone users in the world [1]. The number of mobile apps for supporting learning and education has grown exponentially. Due to their relatively affordable cost and ubiquity, mobile technologies enable educators to reach out to populations of people that do not have universal access to education.

These developments are altering the landscape of technological infrastructure for work, play, and learning. The potential for and the space of possibilities for enhancing or disrupting learning ecologies has never been greater than at any other point in human history. It is now opportune to reflect on what research has informed us on where we are now in this journey of designing and implementing designs of seamless, ubiquitous, and contextual learning, and developing and refining the underlying theories and supporting software applications and technologies.

Seamless, ubiquitous, and contextual learning are notions of learning which are motivated or enabled by the mobility, ubiquity, and contextual awareness of digital and networked technologies. In seamless learning, learning happens continuously and bridges contexts such as formal and informal learning via different technologies [2]. In ubiquitous learning, learners draw from the pervasive and embedded technologies around us. In contextual learning, awareness of the context can be detected and supported by location-based and other sensor-based technologies. Seamless, ubiquitous, and contextual learning are fully resonant with the lowering of barriers between three types of mobile learning: in the classroom, outside the classroom, and embedded as part of everyday life [3].

This special issue focuses on demonstrations and discussions of new designs and developments in the field of seamless, ubiquitous, and contextual learning. Twenty nine submissions were received. Of these, 27 were in scope and went through several rounds of peer review. Finally, 11 papers were accepted. In the papers, while the discussions of issues about seamless, ubiquitous, and contextual learning

overlap almost inevitably to some extent, we can identify a primary focus for each paper in one of these three strands. Thus, we will use this perspective to organize and cluster the papers in this issue.

Four papers in the seamless learning strand address issues concerning design of seamless learning in art education, infrastructure to provide mobile seamless learning support, a research framework for designing seamless language learning, and an evaluation of students' progressions with seamless learning. Yael Kali, Tsvi Kuflik, Ornit Sagy, Orit Mogilevsky and Emma Maayan-Fanar report a novel model that applies the notion of seamless learning to artwork appreciation in their paper "Harnessing Technology for Promoting Undergraduate Art Education: A Novel Model that Streamlines Learning between Classroom, Museum, and Home". A learning trajectory was designed in which the technology (website, collaborative docs and mobile apps) supports streamlining of learning across multiple settings (class, museum and home) and conducting collaborative inquiry *in situ* (e.g., museum). The study contributes to the understanding of the dynamics of seamless learning across settings, and the changing roles of the cognitive apprenticeship processes (from modelling and scaffolding to learners' independent learning) in supporting context switching.

In their paper on "A Tailorable Infrastructure to Enhance Mobile Seamless Learning", Delfina Malandrino, Ilaria Manno, Giuseppina Palmieri, Vittorio Scarano, Luca Tateo, Daniele Casola, Ivan Ferrante, and Francesco Foresta describe the requirements for designing a platform-independent infrastructure to provide mobile seamless learning support. They present two tools to exemplify the approach: the aCME system developed to allow different groups of people to use their mobile devices in order to get involved in learning activities and improve on inquiry and critical thinking skills; and the Text Quiz Tool developed over the aCME system which allows for responding to quiz-based questionnaires during learning activities.

In the paper "Employing the TPACK Framework for Researcher-Teacher Co-Design of a Mobile-Assisted Seamless Language Learning Environment" by Lung-Hsiang Wong, Ching Sing Chai, Xujuan Zhang, and Ronnel B. King, the Technological Pedagogical Content Knowledge (TPACK) and the design-based research frameworks were synthesized to guide a long-term researcher-teacher collaboration in designing a learning environment to support young students in ongoing seamless language learning. The study contributes to current development of technology-enhanced learning by demonstrating the application of the TPACK framework in broadening the design considerations

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to go beyond what is technologically possible by including what is pedagogically desirable for specific content learning.

In their contribution “Exploring Students’ Progression in an Inquiry Science Curriculum Enabled by Mobile Learning”, Chee-Kit Looi, Daner Sun, and Wenting Xie report on a sustained and scaled-up seamless learning project in a primary school that aims to develop and implement an innovative curriculum supported by mobile technologies. Through narrating a cross-year comparison of students’ academic achievements, mobile learning artifacts and their activity performance, they provide an evaluation of the outcomes and processes of mobile learning when such a curriculum is deployed at a scaled-up level.

There are three papers in the ubiquitous learning strand addressing issues of providing user support, different stages of use of ubiquitous computing, and teacher orchestration. In the paper “Towards User Support in Ubiquitous Learning Systems” by Ekaterina Gilman, Iván Sánchez Milara, Marta Cortés, and Jukka Riekk, a ubiquitous learning environment is characterized as a physical environment enriched with networked computational technologies, sensors and actuators that capture the situation and the needs of the different actors participating in the learning process. The authors provide a survey of recent research into ubiquitous learning especially in relation to issues of context and adaptivity, and identify that current research on such issues tends to focus more on learners rather than assistance for the other roles of instructors, developers and researchers. They propose a meta-level framework to guide the provision of support for these differing user roles in ubiquitous learning environments.

In the paper “Four Stages of Research on the Educational Use of Ubiquitous Computing”, Jari Laru, Piia Näykki, and Sanna Järvelä performed an extensive literature review and classified the research on the educational use of mobile technology into four stages: (i) a period of mobility and personal digital assistants; (ii) the era of wireless Internet learning devices; (iii) the introduction of social mobile media; and (iv) a ubiquitous future. Three case studies were then presented to demonstrate the diversity of contexts, methods, and technologies used. The four stages of educational use and the case studies together emphasize that pedagogically-grounded instructional design is needed to put emergent technologies into effective use for promoting self-regulated and collaborative learning skills, and for preparing people for the 21st century learning society.

The paper “Supporting Teacher Orchestration in Ubiquitous Learning Environments: A Study in Primary Education” by Juan A. Muñoz-Cristóbal, Iván M. Jorrín-Abellán, Juan I. Asensio-Pérez, Alejandra Martínez-Monés, Luis P. Prieto, and Yannis Dimitriadis, analyses the complex process of teacher orchestration in Ubiquitous Learning Environments and presents an evaluation of a proposed orchestration support framework called GLUEPS-AR to help a teacher in the coordination of learning situations across spaces. Their evaluation of the system when used by a pre-service teacher shows that he was assisted in several aspects of orchestration such as implementation of pedagogical ideas, adaptation in run-time, and sharing of orchestration load with students. This work makes contributions to the application of mobile devices or augmented reality systems to instructional practices.

Four papers in the contextual and adaptive learning strand discuss issues of tapping on the affordances of real-world contexts for designing mobile learning, supporting reflective learning with contextual data or with mobile notifications, and providing content adaptation features in MOOCs.

The paper “Rethinking the Impact of Activity Design on a Mobile Learning Trail: The Missing Dimension of the Physical Affordances” by Esther Tan & Hyo-jeong So highlights the need to consider the interaction of task designs with the affordances of the physical and social settings, and how this influences participants’ interpretations and enactments of learning activities. The work reported that even well-structured tasks in real-world physical environments may stimulate rich dialogues for learning, highlighting the affordances of real-world contexts for supporting contextual mobile learning experiences.

The paper “Context Becomes Content: Sensor Data for Computer-Supported Reflective Learning” by Lars Müller, Monica Divitini, Simone Mora, Verónica Rivera-Pelayo, and Wilhelm Stork, presents an approach to support reflective learning at work by capturing sensor data to provide contextual information that becomes content to support reflective learning. The proposed approach is based on the integration of persuasive technology which is designed to change person attitudes, lifelogging tools to track personal data generated by everyday activities, and visualization of the context data. The approach has been applied and evaluated in two workplace environments, namely, dementia care and crisis preparedness. The results showed that the subjects were able to learn by reflecting on their work experiences based on their recorded context. The authors also outline lessons learned for the design of sensor-based capturing methods for reflective learning.

The paper “Stop and Think: Exploring Mobile Notifications to Foster Reflective Practice on Meta-Learning” by Bernardo Tabuenca, Marco Kalz, Stefaan Ternier, and Marcus Specht reports an attempt to fill the research gap on investigating the effectiveness of mobile notifications to foster reflection on meta-learning. Drawing from the findings of two studies with secondary school students and adults as the subjects respectively, the authors envision a higher knowledge gain and motivation for the group assigned with the least complex interactions with mobile devices during the reflection exercise.

An adaptive educational system known as mobile integrated and individualized course (MIIC) is put forward in the paper “Individualization for Education at Scale: MIIC Design and Preliminary Evaluation” by Christopher G. Brinton, Ruediger Rill, Sangtae Ha, Mung Chiang, Robert Smith, and William Ju. It integrates video, text, assessment, and social learning into a mobile learning app, and collects behavioural measurements about each user as they interact with it. These measurements are used to update the student’s user model for doing the content adaptation. The system demonstrates a potential way to enhance massive open online courses (MOOCs) by incorporating content adaptation features based on individual students’ clickstream-level behavioural measurements.

Altogether this collection of papers provides one view on the current state of the art in the synergistic areas of

seamless, ubiquitous and contextual learning. They demonstrate methodological and technological advances continually made in ubiquitous and contextual computing, in adaptations for personalized learning, and in infrastructures for seamless learning. Concomitantly, they also tell us that thoughtful attention and considerations need to be put onto issues of design approaches, teacher orchestration, task designs, and evaluation of effectiveness. We hope that these papers representing a holistic continuum of research from technological to pedagogical and learning aspects, can stimulate more productive research into seamless, ubiquitous and contextual learning in the near future.

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