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Technology for Learning across Physical and Virtual Spaces

J.UCS Special Issue

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Learning is a process that happens at moments and in spaces that go beyond those typically defined by formal educational institutions. In fact, it is widely recognized that learners' physical and social interactions with the "real world", outside the traditional classroom, cannot be neglected when promoting the acquisition of certain skills [Bruce 08]. For example, and within the context of formal education, a visit to a museum could be used for complementing in-classroom learning with situated activities in the "real world".

Additionally, certain current types of widely adopted learning technology such as Virtual Learning Environments (VLEs), or 3D Virtual Worlds (3DVWs), to name a few, have promoted new types of "virtual spaces" for learning (in contrast to the "physical space" of the traditional classroom). These "virtual spaces" provide significant affordances in terms of, e.g., remote interaction and digital content access and distribution, and may also complement and enhance traditional in-classroom learning.

How to effectively support the linking, the mutual influence, and the transitions among learning activities happening, even simultaneously, in different spaces (e.g. virtual vs. physical, classroom vs. "real world") has been for a long time a significant topic of research within the field of technology-enhanced learning [Sharples and Roschelle 10]. RFID, geo-positioning, QR codes, Augmented Reality (AR), and Immersive Virtual Worlds are examples of researched technologies that make "across spaces learning" feasible [Dunleavy et al. 08]; [Klopfer et al. 11]; [Pérez-Sanagustín et al. 11]. Additionally, the current landscape of portable computing devices (smart phones, tablets, …), as well as the pervasive Internet connectivity, have definitively paved the way for the widespread availability of those across spaces enabling technologies in authentic learning settings.

For example, and using state-of-the-art mobile devices, it could be easy and affordable for students, depending on their current location during a visit to a museum, to access documents previously generated during a preparatory VLE-based activity and augment their current environment. Or, it might be feasible for a teacher to scaffold an in-classroom discussion using geo-located pictures taken by the students during a previous fieldtrip to a botanic garden. Or, students and instructors may completely immerse together in 3D Virtual Worlds, wherever they physically might be.

Nevertheless, the mere availability of the aforementioned enabling technologies for across spaces learning may not be sufficient for their adoption in real practice. Additional challenges seem to arise for the different stakeholders involved in educational contexts: teachers, students, instructional designers, institutions, and even policy makers. Examples of those challenges include: how are educators going to cope with the additional burden associated to the management of these new technologies?; how can existing pedagogical strategies (game-based learning, collaborative learning, …) be appropriated within across spaces learning?; how the "new" affordances of learning activities happening in other spaces (e.g. situated learning) might be incorporated in those existing pedagogical strategies?; what are the challenges that across spaces learning pose to the evaluation of pedagogical innovation and to the assessment of students acquired skills?; how to frame learning activities happening in physical spaces outside the classroom within the contextual restrictions coming from educational institutions and policy regulations? Many of these challenges would probably require additional technological support, new pedagogical conceptual frameworks, as well as a potential renewal of the constraints of formal educational contexts.

The main aim of this special issue is to present an updated view of the undergoing research efforts, within the technology-enhanced learning community, to tackle the aforementioned challenges for the adoption of across spaces learning. The process towards the elaboration of this special issue started in September 2011 with the celebration of a workshop, in the context of the EC-TEL 2011 Conference in Palermo (Italy), titled: "*Learning activities across physical and virtual spaces (AcrossSpaces2011)*". Selected contributions to that workshop were invited to be extended and submitted to this special issue, although other contributions not presented at the workshop were also welcome. 12 submissions were received, all of them peer-reviewed by at least three internationally recognized referees. Only 5 were selected for publication, covering a representative set of topics:

- In their paper "Design-Oriented Pedagogy for Technology-Enhanced Learning to Cross Over the Borders between Formal and Informal Environments", Vartiainen, Liljeström, and Enkenberg propose a novel instructional model that fosters a "design-oriented pedagogy". The model is framed within the principles of participatory learning, co-development of "learning objects" and the use of technology. The model is motivated by the need of engaging students in design-oriented learning activities beyond the borders of traditional classrooms, making use of technology for linking different "spaces". The authors explain how the model was incrementally evaluated (and subsequently improved and refined) throughout the setting up of three authentic experiments. Additionally, the

authors describe a fourth experiment in which they try to gain insight about the perception of the model by practitioners from different cultural contexts.

- In their paper "A Review of Mobile Location-based Games for Learning across Physical and Virtual Spaces", Avouris and Yiannoutsou provide an analytical framework for classifying and comparing existing mobile location-based games for learning. This type of games represents a significant example of across spaces learning in which a well-known pedagogical strategy (game-based learning) is applied to activities in the physical space that, simultaneously, are supported by actions and events happening in a virtual space. The paper identifies enabling across spaces technologies employed by the different surveyed proposals. Additionally, the paper provides interesting reflections about the learning affordances (both expected and emergent) of location-based games, thus leading to further research questions.
- In their paper "ARLearn: Augmented Reality Meets Augmented Virtuality", Ternier, Klemke, Kalz, van Ulzen, and Specht elaborate on the advantages of applying game-based learning to situations happening in "mixed reality" (physical and virtual). The authors advocate the linking of mobile-based augmented reality and desktop-based augmented virtuality technologies for achieving an effective across spaces learning in immersive games. After identifying some shortcomings in current existing proposals, the authors propose their own technological solution called ARLearn. ARLearn is an open architecture that enables educators to design serious games that can be enacted by means of a Google Android client for mobile phones (activities in the "real world") and a Google StreetView mashup (activities in the "virtual space"). Both technological and educational issues of ARLearn were evaluated by means of three authentic learning situations.
- In their paper "SOS: Orchestrating Collaborative Activities across Digital and Physical Spaces Using Wearable Signaling Devices", Hernández-Leo, Nives, Arroyo, Rosales, Melero, and Blat propose the use of wearable signalling devices so as to facilitate the coordination of participants in non-trivial collaborative learning activities happening in the (technologically augmented) physical space. The information provided by those signalling devices (the designs of which are also described in the paper) covers issues such as group formation, distribution of resources and work areas, role assignment and change of activities. More importantly, the signalling devices are controlled by events occurring in the virtual space, thus providing an interesting approach for reducing the coordination burden associated to the application of collaborative learning pedagogical strategies across virtual and physical spaces. The paper also describes how the authors evaluated the SOS system in two authentic learning situations in which the well-known jigsaw technique was used as the pedagogical strategy.
- In their paper "Architecture for Collaborative Learning Activities in Hybrid Learning Environments", Ibáñez, Maroto, García Rueda, Leony, and Delgado Kloos present a proof-of-concept for another type of hybrid learning environment: the combination of the physical space and a 3D virtual world (3DVW). The authors propose a system that supports synchronous collaborative

learning situations by establishing a one-to-one correspondence among objects (physical and virtual) of both spaces by exchanging and sharing geolocation information. Interestingly, participants in the collaborative situation might interface with a desktop-based 3DVW or actually go to the physical space with a mobile phone. Consequently, participants of the 3DVW are represented by avatars that, at the same time, are shown to participants in the physical space in the form of geolocated augmented reality objects (displayed by the mobile phone). And, the other way around: participants in the physical space have their corresponding avatars in the 3DVW that are located at the "mirrored" coordinates of the virtual world. All participants can exchange multimedia information regardless of the space they belong to. The paper describes how the authors carried out a qualitative usability study of the system in the context of an authentic experiment aimed at the collaborative learning of a foreign language.

We hope that you, the reader, find these contributions useful and inspiring.

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