Experiments with collaborative blended-reality laboratory technology for distance learners

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Introduction

Traditionally, laboratory work for distance learners has been limited to video recordings, simulations using software interfaces and other solutions that restrict the possibility of interaction with real equipment and collaboration with other learners. In previous work [1], [2] we proposed an innovative conceptual model and architecture to interconnect multiple mixed-reality learning environments based on a distributed computing architecture, allowing bidirectional communication between environments, smart objects and users; managing multiple dual-reality states and creating blended-reality spaces. Blended-reality can be defined as a space "*where the physical and the virtual are intimately combined (blended not merely mixed)*" [3]. The goal of the proposed architecture is to enhance laboratory activities for distance learners based on a constructionist perspective [4].

Blended-Reality Lab

Our blended-reality lab (BReal lab) is formed by 3 components: a) the ***physical world***, where the user and the xReality objects are situated. **xReality objects** [1] are smart networked objects coupled to a 3D virtual representation of them; creating a dual reality state that is updated and maintained in real time; b) the ***virtual world***, where the real-world data will be reflected using the virtual object; and c) the ***interreality portal***, a human-computer interface (HCI) which captures the data obtained in real-time by the *xReality object*, processes this data so it can be mirrored by its virtual object and thereby links both worlds.

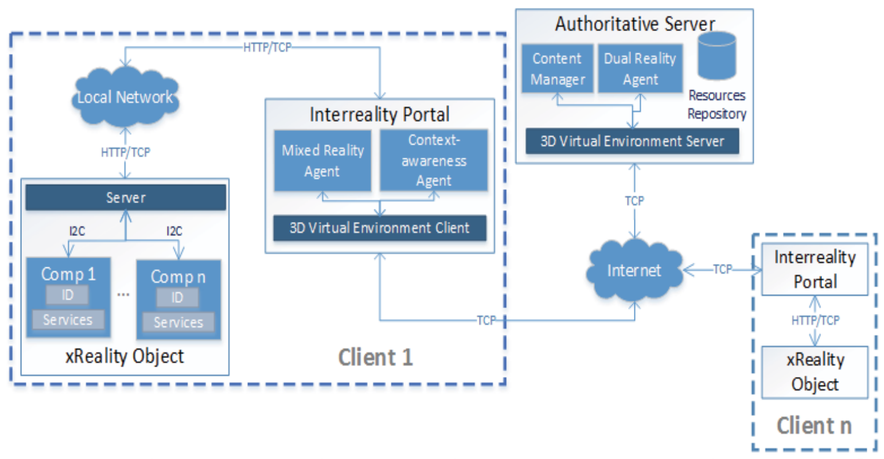


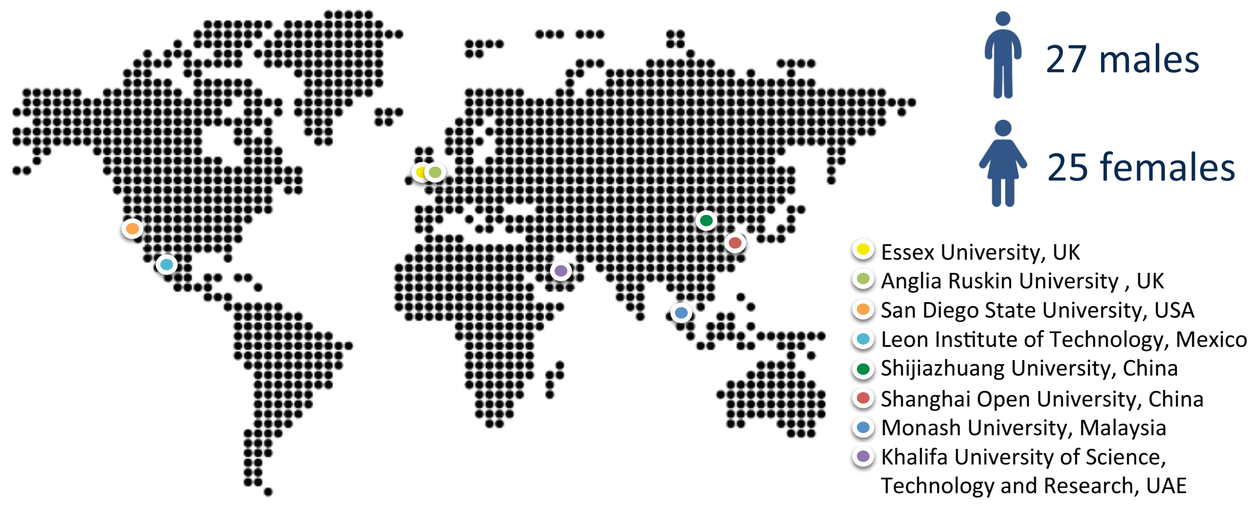
Figure 1. Blended-Reality Distributed System architecture [1]

Fig. 1 describes the architecture used for the Blended-Reality Distributed System. To implement the real/physical side of a xReality object (fig. 3) we utilise two components: 1) a collection of pluggable hardware boards for rapid prototyping, which can be interconnected in diverse combinations to create a variety of quick Internet-of-Things (IoT) prototypes (Fortito's BuzzBoard Educational Toolkit) and 2) a Raspberry Pi, a low cost small computer used in electronic hobbyist projects and education. The virtual representation (fig. 4) was developed using Unity3D, a cross-platform game engine used for videogames and 3D content. To mirror and synchronize virtual representations we used SmartFoxServer X2 (SFS2X), a middleware to create large scale multiplayer games and virtual communities.

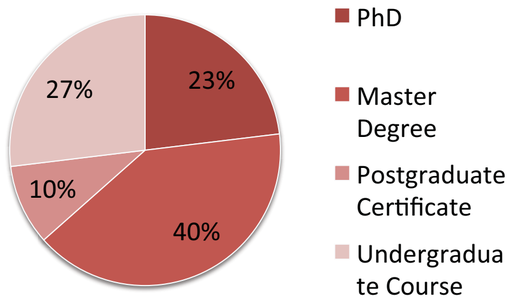
[1] A. Peña-Rios, V. Callaghan, M. Gardner, and M. J. Alhaddad, "Interactions within Distributed Mixed Reality Collaborative Environments" *Proc. 10th International Conference on Intelligent Environments*, Shanghai, 2014.
[2] A. Peña-Rios, V. Callaghan, M. Gardner, and M. J. Alhaddad, "Remote mixed reality collaborative laboratory activities: Learning activities within the InterReality portal" *Proc. IEEE/WIC/ACM Int. Conf. Web Intell. Intell. Agent Technol. Work. WI-IAT 2012*, Macau, 2012.
[3] K. Hoshi and J. a Waterworth, "Tangible Presence in Blended Reality Space" *Interfaces (Providence).* pp. 1–10, 2009.
[4] S. Papert, I. Harel, and B. S. Papert, "Situating Constructionism" *Constructionism*, vol. 36, pp. 1–11, 1991.

Experiments

User evaluation took place with 52 students between March to May 2015.



Level of Studies



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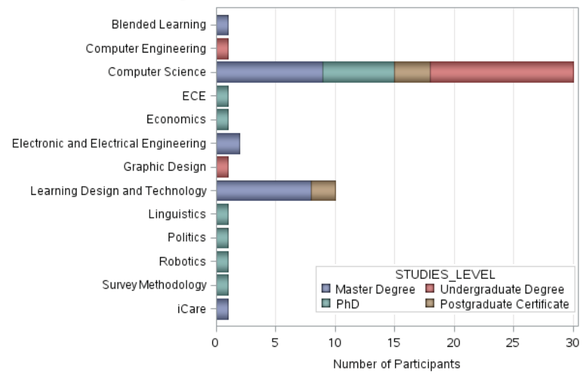

The laboratory activity undertaken by students was to create (as a team), a set of IF-THEN-ELSE behavioural rules to control a shared xReality object using the 3D virtual interface.

Figure 2. Students doing the collaborative lab activity

Figure 3. xReality object [1][2]

Figure 4. 3D Virtual Interface

Preliminary Results

- **80.77%** answered they were very likely to use the technology if it was available to them in their schools and universities.
- **88.46%** of participants found it easy to use the proof-of-concept implementation.
- **76.92%** of participants answered that the blended-reality principles were not difficult to them to understand.

User's reasons given for not using the technology were related to interface design issues, worries about Internet reliability, and team communication issues. Overall, users' comments were positive, explaining that they enjoyed the experience. These preliminary results show a positive user's acceptance towards the use of blended-reality and xReality objects in collaborative laboratory scenarios, opening up new opportunities for collaboration and development, which aims to provide real benefit for distance learners.

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