Presented at iLRN'15, Prague, Czech Republic, 15-17 July, 2015

Towards Measuring Learning Effectiveness considering Presence, Engagement and Immersion in a Mixed and Augmented Reality Learning Environment

Ahmed ALZAHRANI[a,1], Michael GARDNER[a], Vic CALLAGHAN[a], and Malek ALRASHIDI[a]

[a] *School of Computer Science and Electronic Engineering, University of Essex, UK*

Abstract. The current era of advanced display technologies, such as a head mounted displays, smart glasses and handheld devices, have supported the usage of mixed-reality and augmented reality concepts in smart educational classrooms. These advanced technologies have enabled enhanced collaboration and an interactive communication between distance learners and local learners. Being present' is a key factor in both worlds (real and virtual) as it plays an important role in increasing the students' collaborative engagement during the learning activity. However, few studies have considered how much using such immersive interfaces with various learning scenarios may ultimately affect learning outcomes, and whether students feel fully engaged or not in such environments. This work-in-progress paper will demonstrate a MiRTLE+ prototype of how remote students can collaborate within mixed-reality environments by using an augmented reality approach. Secondly, it will explore the learning effectiveness based on the following factors: students' presence, engagement, and immersion in smart environments. With regard to the learning task, we will consider a card game task to measure the learners' progress as they progress from novice to expert player. To evaluate these factors, we utilise several existing frameworks which have been applied to our mixed-reality worlds that help us to examine the learning outcomes from using these environments.

Keywords. Presence, engagement, immersion, augmented reality, mixed reality, learning effectiveness, smart classrooms, group learning, turn-taking technique.

1. Introduction

Advances in 3D virtual environments and the use of other equipment such as head mounted displays, goggles and new smartphones can provide new opportunities for teaching and learning. These new environments can potentially lessen the sense of isolation of distant learners [1] and allow students to communicate in a more natural way with a greater sense of "being there".

Some recent studies [2][3] have used mixed-reality concepts to achieve interactive communication amongst remote and local people in 3D virtual-reality environments (VE). For example, Gardner and O'Driscoll [4] and Schmidt et al. [5] found that representing remote students as avatars on a screen in a real smart classroom could enhance the remote students' sense of engagement and increase their feeling of 'being there' (through virtual connections to their real teacher and fellow students). On the

[1] Corresponding Author: Ahmed Alzahrani, School of Computer Science & Electronic Engineering, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ, UK; E-mail: araalz@essex.ac.uk

other side, concerning platforms and immersive interfaces in teaching environments, newly announced technology innovations, such as Microsoft's Hololens [6] provide the prospect that, within the next few years, there will be affordable platforms available for education what will make the realisation of the hologram-style vision described later in this paper a realistic prospect.

However, users of virtual environments have usually very limited interactions with their real teaching environments and people within it. Our research is firstly focusing on developing the MiRTLE system in order to increase the interactivity between remote virtual and 'real' students in the teaching environment using augmented reality technologies. So far, however, there has been little done to increase the interactivity of remote virtual students in physical smart spaces based on the dynamics of interconnecting physical objects and people with their virtual counterparts using augmented reality technologies and various immersive interfaces. In this respect, we are also investigating the learning effectiveness considering the students sense of presence, engagement and immersion factors in such learning environments.

In the remainder of this paper, we discuss this further, in four parts. The first part describes the background and related work. In the second part, various learning scenarios and the system architecture of our research experiment are presented. The third part will demonstrate the experimental approach which includes our MiRTLE+ prototype, test bed and research challenges. Finally, conclusions arising from this approach and future work are discussed.

2. Background and Related Work

2.1. Mixed Reality

Previous work has demonstrated how a mixed reality approach can be used as an advanced tele-presence method, which connects a virtual environment with a physical environment [7]. With regard to the Reality-Virtuality Continuum as shown in Figure 1, mixed-reality has been divided into two components: Augmented Reality and Augmented Virtuality, where the world is mostly real, or virtual (computer-generated), respectively, with the two extremes at either end of the Mixed Reality continuum correspondingly being reality and virtuality (i.e. where the world is 100 per cent real or computer-generated). As a result, [8] observed that "*the most straightforward way to view a mixed reality environment, therefore, is one in which real world and virtual world objects are presented together within a single display, that is, anywhere between the extreme of the Virtuality Continuum*" [8]. The Mixed Reality Teaching and Learning Environment (MiRTLE), from the University of Essex [9], and the Holodeck system from the University of Hawaii [5] are examples of mixed-reality learning environments.

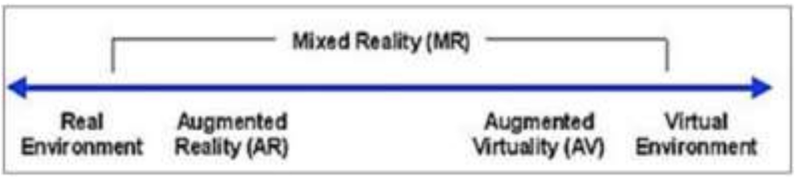

Figure 1. Milgram's Reality-Virtuality Continuum [8].

2.1.1. MiRTLE

MiRTLE has been deployed in the iClassroom, which is a high-tech teaching environment at the University of Essex. It consists of speakers, microphones, and a voice-bridge (in the system) to enable voice communications between remote and local students. Furthermore, the iClassroom also includes an Internet camera and a large display screen, which are both MiRTLE components. Thus, physical students can be viewed in the virtual world screen through the use of the camera, which is mounted on the iClassroom's back wall. The virtual students are displayed in the real environment through the screen positioned at the rear of the iClassroom. This screen allows the teacher and real students in the iClassroom to see virtual students in the lecture as shown in Figure 2.

Figure 2. Lecturer's View of Remote Students (left) and Remote Students' View of the Lecture (right)[4].

Moreover, the remote student's avatar can be viewed on the screen based on the user's preferences [7][9]. Therefore, the virtual student's presence in the real world is screen-based, which can be seen as a limitation in terms of having more interactive communication with real students in the physical classroom.

2.2. Augmented Reality

The Augmented Reality (AR) term was defined by Caudell and Mizell [10]. AR is used in the real-world (physical) environment where elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. It relates to the more general concept called mediated reality in which a view of reality is modified by a computer [11]. AR systems generally consists of three key points [12][13]:

- Binding real and virtual objects in a real environment.
- Registering real and virtual objects with each other.
- Making the use of 3D and 2D objects in a real environment.

Recently, engineers at Microsoft have developed a fully immersive augmented reality headset called the Hololens [6]. It is a computer headset that enables the projection of hologram-style images within the real world, which is different to technologies such as the Oculus Rift that present a fully immersive virtual environment around the user [14]. In our study we plan to investigate the use of these technologies from a pedagogical perspective. We also plan to determine the learning affordances of such augmented and mixed reality devices.

For educational purposes, the use of AR promises new opportunities for fostering a greater sense of engagement and motivation amongst students. For instance, an AR based game called "Learning Words", which uses a head mounted display (HMD) device, was developed and tested among 32 pupils. The results indicates that more than 80 % of the audience preferred AR systems over conventional systems for learning [15].

Our study plans to more deeply investigate the impact of using different user interfaces in a mixed and augmented reality space particularly for increasing the sense of presence and engagement of the users. Moreover, it will examine other factors that may affect the users sense of presence and engagement in these spaces, such as the choice of learning tasks being carried out in collaborative learning groups.

Several factors can contribute to measuring the sense of presence in a VE based on the users sense of ‘immersion’ and ‘involvement’ in the task.. These factors include control, sensory, realism, and distraction factors as shown on Table 1. These factors can be used to help form the content of subjective questionnaires for measuring the users sense of presence. Some studies [16][17][18] have applied these factors to measure presence and other emotional and subjective feelings. Also, these studies have already shown their validity for generating questionnaires for measuring these factors in 3D mixed and virtual environments. In our study we plan to consider some of these factors to help us generate questionnaires in order to measure the users sense of presence and immersion in a range of collaborative learning tasks.

Table 1. Factors hypothesised to contribute to a sense of presence [17]

Control Factors	Sensory Factors	Distraction Factors	Realism Factors
Degree of control	Sensory modality	Isolation	Scene realism
Immediacy of control	Environmental richness	Selective attention	Information consistent with objective world
Anticipation of events	Multimodal presentation	Interface awareness	Meaningfulness of experience
Mode of control	Consistency of multimodal information		Separation anxiety/disorientation
Physical environment modifiability	Degree of movement perception		

3. MiRTLE+

Our ongoing research project is based on the original MiRTLE concept [1]. However, we plan to extend this approach to investigate more interactive and engaging techniques for merging local and remote learners within a real classroom setting. By using augmented and mixed reality concepts within MiRTLE, we plan to bring remote students (by using their virtual representation), more closely together with their local (physically present) students. We hope that this approach will enrich the learning activities within the mixed-reality learning environment and will particularly improve the collaboration and sharing between local and remote learners. We refer to this new system as MiRTLE+.

3.1. Learning Scenario

Alrashidi et al. [19] proposed a 4D learning activity framework that structures learning activities from simple single learner discrete tasks to more complex group learning sequenced tasks. We are using this framework to define the scope of learning tasks being considered for MiRTLE+. Thus, in our learning activity scenario, we focus on group learning with multiple sequenced task. Typically in our scenario this involves four students, two local and two distant, who work together to achieve the learning tasks being undertaken.

We propose a simple learning activity task where a group of students are asked to play a card game, which will have a number of rules and instructions. Usually, people prefer to learn these types of games by being able to practice with experts whilst playing a real game. Thus, we will be using a ‘learning by doing’ approach. We plan to apply this approach to our learning activity by splitting the group into two expert and two novice students. This will hopefully help the novice learners who do not have any previous background or knowledge of playing the card game to practice and play with their expert peers.

Moreover, as the group working together, turn-taking coding approach will be considered as a key factor in our study to allow equal rights between members, since there is no teacher to decide who plays next and when. Thus, the software will enforce the turn-taking and controlled play, and however the expert from each team may also take over the turn once the novices need.

By mixing the group, the novice learners will start learning the game concepts by questioning experts, and discussing the rules before playing the game for real. We plan to examine the effect of mixing the novice and expert pairs across the different real and virtual spaces to explore how the virtual and real world dynamics affect the performance of the collaboration and the learning outcomes achieved.

3.2. System Architecture

The MiRTLE+ architecture extends the approach already developed by the original MiRTLE system to more closely involve remote students in live classroom teaching sessions. It particularly aims to develop this work by more closely involving remote (virtual) learners in the real classroom by using new approaches based on augmented reality and the use of head-mounted immersive displays. The main focus for integrating the real and virtual students is the development of a virtual classroom that synchronises the activity that is taking place in the real and virtual settings. Figure 3 shows the main view layers and components in both the virtual and real classroom. All of these components are mirrored in both classrooms, as discussed in the following sub-sections.

1) *User interfaces layer:* this uses several augmented and mixed reality displays such as traditional PC screens, handheld displays, AR glasses and MR glasses. The learner can use these displays as a means to communicate between the different learning environments. We anticipate that this will support the following learning affordances:
    1. Visualising remote learners in a real environment – enhanced collaboration.
    2. Supporting richer problem solving learning activities.
    3. Supporting seamless voice communication between the participants.
    4. Providing real-time feedback on the learning activity.
    5. Allow for greater interaction with the objects being used.
2) *Real environment layer:* this is where the local learners attend. For this we are using the iClassroom at the university of Essex [20]. This iClassroom consists of smart objects such as a meeting table, tablets, smart windows, light sensors, air-conditioning and chairs. These smart objects have virtual representations in the virtual world. In addition, each local learner will have a virtual representation in the virtual world. The remote students will also be displayed within the real environment as an avatar using augmented reality. Thus, this layer utilise a marker-based augmented reality approach to combine both local and remote students within a real classroom.
3) *3D Virtual environment layer:* Is where the remote learners meet the local learners in a virtual classroom. Both local and distant learners are presented each as an avatar within the 3D virtual environment. This virtual classroom is identical to the iClassroom in terms of the objects within it and its shape. This layer provides the view for the distant learner as a means to collaborate with their peers in the real environment.

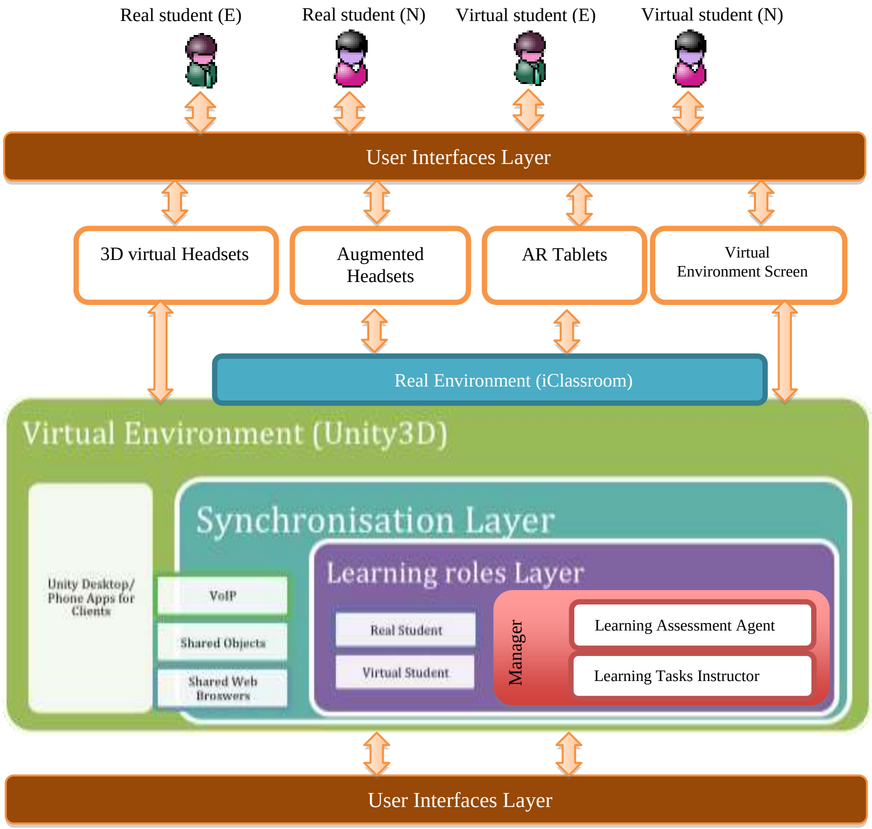

Figure 3. System architecture.

4) *Synchronisation layer:* Manages the interactions and communications between both worlds in real time. Any changes that occur in the real or virtual world should be notified and updated to both worlds. The main components, which the system keeps track of, are as follows:

   a. *Voice component:* Is responsible for delivering multi-party voice communication over the network. It allows distant learners to use voice communication to discuss and interact with their local learners

   b. *Shared objects component:* Contains all the materials required for the learning activity: such as screens, chairs and tables. For example, the remote (virtual) student, whose avatar will be 'sitting down' on a remote virtual chair, can be viewed as an augmented avatar in the same chair in the real environment. At the same time, the real student can choose to sit down on the available (not already occupied by a virtual student) chair in the real environment.

   c. *Shared web browsers component:* This is responsible for providing the shared content and learning instructions for real and virtual students and allows the students to collaborate together on the learning activities in both the real and virtual iClassroom environments.

5) *Learning Design layer:* Defines the role of the learners (local and distant), and the specification of the learning activity, and the assessment and feedback strategies that will be used.
    a. *Real students component:* Allows the usage of augmented reality tools and physical smart boards, objects (chairs, table and tags) and a physical screen for displaying shared content in the real world.
    b. *Virtual students component:* Allows the usage of all 3D virtual objects (i.e. web browsers textures, chairs, table and voice) in the virtual world.
    c. *Learning content:* Provides students with the instructions and learning content to begin and achieve the learning tasks. It's main objective is also to support and guide the students as they work through the tasks.
    d. *Learning assessment component:* Is responsible for monitoring the students performance and providing feedback.
6) *Repository layer:* Is responsible for communicating with the server and clients in order to store and retrieve the users' roles and profiles, environment settings, and learning content and feedback.

4. Experimental Approach

Based on the learning activity scenario proposed (see section 3.1), we have divided our group into four possible scenarios. This division is based on two factors; the students' location (real or virtual world) and their level of expertise (expert (E) or novice (N)). This will be used to determine whether their location (in the real or virtual space) has an affect on the learning outcomes and their overall performance. The following figure 4 illustrates these scenarios.

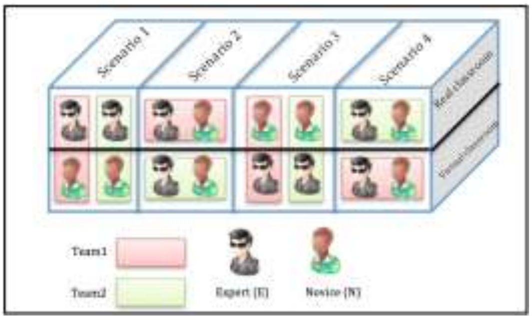

Figure 4. Structure of the learning scenarios.

The learning activity will have 4 players, with two teams of 2 players. In the first scenario, each team will have an E and N player. The E of each team will play from the real environment, and the N of each team will play from the virtual environment. In the second scenario, the distribution of players based on their levels is the same as in the scenario 1. However, the team 1, which consists of E and N player, who will play from the real environment and the team 2 will play from virtual environment. The third scenario is the opposite of the scenario 1 in terms of the students' locations, and therefore the E of each team will play from the virtual environment, and the N of each team will play from the real environment. The scenario 4 is also the opposite of scenario 2, and therefore the team 1 will play from the virtual environment and the team 2 will play from the real environment. However, the groups will go through two phases:

1. Phase 1 (using tablets for real learners and VW screens for the remote learners).
2. Phase 2 (using an AR headset for the real learners and an Oculus Rift headset for the remote learners).

4.1. Research Questions

We proposed the four scenarios and both phases to answer the following research questions:

1. Is there any difference in the students' sense of presence, engagement and immersion depending on which of the learning platforms they are using (i.e. real or virtual)?
2. Is there any difference in the students' learning effectiveness depending on which of the two platforms being used?
3. Are students more immersed and engaged in the phase 2 than phase 1?
4. Is there any difference in students' learning effectiveness relying on the phase 1 and phase 2?
5. Is there any difference in the students' sense of presence, engagement and immersion depending on the learning scenario/activity being used?
6. Is there any difference in the students' learning effectiveness depending on the learning scenario/activity being used?

4.2. Technical Implementation

Our initial implementation of the MiRTLE+ prototype is illustrated in Figure 5 and 6, for a local (female) student and a remote (male) student, respectively. The female student will have entered the real iClassroom and logged in to the virtual environment using a tablet interface. Then using the augmented reality interface she will have seen on the left chair that her virtual colleague was already sitting down (with a red t-shirt as shown in Figure 5). While she can see his avatar and communicate with him (via the tablet), the male student on the other side (virtually) can see her as an avatar and communicate with her using his microphone.

Figure 5. A screenshot during real user communication with the virtual user as an augmented reality avatar, using their iPad.

Figure 6. A screenshot during the virtual user communication with the real user (via her avatar), using his PC.

In our first phase prototype, we have developed two collaborative learning platforms. First, we have developed an Augmented Reality Collaborative Application (ARCA) to be used within the real iClassroom to allow local students to communicate with the remote students. This ARCA is based on our system architecture as shown in figure 4. This AR based platform was developed with the Unity3D game engine [21] by using the Metaio Augmented Reality Software Development Kit [22].

In the second phase platform, we have developed a 3D virtual environment where all the students are visualised. This environment is similar to the first platform (ARCA) in terms of shape and components. We have used the SketchUp [23] modeling software and Unity3D environment in order to build this VR-based platform. This platform consists of chairs, table, boards speakers, web browsers, lights and avatars. Furthermore, we have developed the voice communication interface by using the DFVoice package [24], and a shared web browser by using the uWebKit package [25]. Both packages are integrated within the Unity3D environment.

The aim is to synchronise all activity in both the real and virtual worlds. To do this we have used a SmartFoxServer [26] server. This also integrates with the real iClassroom web services in order to communicate with its intelligent components (i.e. lights, sensors, air-conditioning system and electronic window) and synchronise them with the virtual world.

4.3. The iClassroom Test Bed

We use the iClassroom for our learning activity as a test bed. Figure 7 shows two environments; the iClassroom on the left side, and the simulated 3D virtual environment on the right side. The real iClassroom as well as the simulated 3D space (virtual iClassroom) have the following components:

- A table.
- Four chairs.
- Markers on chairs.
- Two iPads in the real iClassroom.
- Smart boards.
- Two Web browsers in the virtual environment.
- A PC on the real table.

Figure 7. The real iClassroom (left) and the simulated virtual iClassroom (right).

The local students will enter the iClassroom and log into the virtual iClassroom using their tablet. At the same time, the remote students will log into the virtual environment using their personal computer (laptop or PC). Once both learners (local and distant) are logged in, then they can go to the discussion table. Here, the system will give the learners the choice of their preferred seat. The local learner can check the availability of the seat by pointing their tablet's camera at the marker that is placed on the chairs. If the local learners see an avatar overlay on top of the marker that will mean that this chair is already reserved (see figure 5), otherwise the learner can see a text overlay asking them to confirm their choice for sitting on the chair. The local learners interact, communicate and discuss with the virtual learners by pointing their device camera at the chairs to see their avatar as an overlay on the real world. This is the first phase of our experiment.

In addition, the second phase, which is still under development, will enable both local and remote students to use immersive headsets and they will follow the same scenario as in phase 1. This will allow us to explore whether the level of immersion (provided by the end user device) will have an effect on the performance of the session.

The real and virtual learners can look at the learning activity task by using a shared electronic board; this will include information on the learning instructions, objectives and assessment being used. Once the students are familiar with the learning activity and their roles, then they can start the learning activity. In each above-mentioned scenario, the novice of each team starts to discuss the rules of the card game with the expert using either the voice or chat interfaces. They also play and discuss their achievements using the smart board in the real iClassroom and virtual iClassroom. The real smart board is synchronously connected with the virtual one, so that both worlds share the same web-resource.

4.4. Evaluation Design

We will use 6 groups of students who play in both phases. Each group will have four students: two are experts in playing cards, and two are novices. The participants will complete a basic pre-test in order to allocate their roles in the game.

Our study will follow between-subjects design. Thus, the groups will be distributed based on our learning scenarios (see section 3.1), and our control groups are: all players in the real world and all players in the virtual world. Therefore, our independent variables are based on the students expertise (experts and novices), students locations (real and virtual environment) and students interfaces (phase 1 and phase 2).

To evaluate our experiment, participants in each group will also be given an electronic pre-survey questionnaire in order to test their knowledge in playing cards as well as the use of augmented and mixed reality technologies. Subjective post-survey questionnaires including presence, engagement, and immersion measurements will also be given to the participants after they finish the learning activities. An example question used for measuring the users sense of presence which is derived from the work of Witmer and Singer [17] that specifically focuses on the ‘involvement’ factor is presented in table 3.

Table 3. Questions in the ‘involvement’ category [17]

Please rate your experience for each question on scale of 1–5 where 1 = none, 2 = poor/mild, 3 = moderate, 4 = good, and 5 = excellent:	
1	How strong was your sense of being involved in the visual environment?
2	How strong was your sense of events occurring in the real world around you while involved in the environment?
3	How strong was your sense of being involved in the experimental task?
4	How strong did you feel comfortable inside the environment?
5	To what extent did you feel confused or disoriented at the beginning of break or the end of the experimental session?
Please rate your experience for each question on scale of 1–5 where 1 = very quickly, 2 = quite quickly, 3 = moderate, 4 = quite slowly, and 5 = very slowly:	
6	How quickly did you adjust to the AR environment experience?

Considering the turn-taking technique in our experiment, we also have other quantitative factors to be measured. Novices’ time taken to achieve their turn will be calculated and compared with the control group. Additionally, the number of queries and questions made by the novices, which indicate their progress in learning, will be taken in account and measured too.

In addition, the learning outcomes for the users, which is based on novices learning the rules for a new game, will be measured based on the participants (novices) learning achievements as well as the feedback of participants (experts). Their achievements will be recorded as marks during the learning process. These marks will be compared with the control groups marks later on to basically evaluate the performance of learning in our experiment.

5. Conclusion and Future Work

With the increasing development of display technologies such as smart glasses, handheld devices and AR tools, we have demonstrated in this work-in-progress paper a further elaboration and development of our MiRTLE+ system to enhance the collaboration between remote students in a mixed-reality smart classroom using AR technologies and various handheld and head-mounted devices. Our paper mainly focuses on exploring the learning effectiveness based on several factors; the students’ sense of presence, engagement, and immersion in a smart mixed-reality space (across different scenarios, immersive interfaces and learning tasks). Our initial proposed learning activity is based on a well know card game which will be used for the quantitative evaluation of the system with expert and novices learners. Furthermore, our proposed qualitative evaluation is based on several established frameworks for measuring the aforementioned factors in 3D virtual and mixed reality spaces. We are aiming to present the results from this research in future publications.

References

[1] D. Novak, M. Wang, and V. Callaghan, “Looking In, Looking Out: A Discussion of the Educational Affordances of Current Mobile Augmented Reality Technologies,” *Educ. Stages Interact. Learn. Kindergart. Workplace Train.*, pp. 92–106, 2012.

[2] C. J. Breiteneder, S. J. Gibbs, and C. Arapis, “TELEPORT—an augmented reality teleconferencing environment,” in *Virtual Environments and Scientific Visualization’96*, Springer, 1996, pp. 41–49.

[3] H. Groenda, F. Nowak, P. Rößler, and U. D. Hanebeck, “Telepresence techniques for controlling avatar motion in first person games,” in *Intelligent Technologies for Interactive Entertainment*, Springer, 2005, pp. 44–53.
[4] M. Gardner and M.-L. O’Driscoll, “MiRTLE (Mixed-Reality Teaching and Learning Environment): from prototype to production and implementation,” in *Workshop background and aim*, 2011, p. 25.
[5] M. Schmidt, J. Kevan, P. McKimmy, and S. Fabel, “The best way to predict the future is to create it: Introducing the Holodeck mixed-reality teaching and learning environment,” 2013.
[6] J. Hempel, “Satya Nadella’s Got a Plan to Make You Care About Microsoft. The First Step? Holograms,” *WIRED*, 21-Jan-2015. [Online]. Available: http://www.wired.com/2015/01/microsoft-nadella/. [Accessed: 01-Jan-2015].
[7] A. Pena-Rios, V. Callaghan, M. Gardner, and M. J. Alhaddad, “Towards the Next Generation of Learning Environments: An InterReality Learning Portal and Model,” in *2012 8th International Conference on Intelligent Environments (IE)*, 2012, pp. 267–274.
[8] P. Milgram and F. Kishino, “A taxonomy of mixed reality visual displays,” *IEICE Trans. Inf. Syst.*, vol. 77, no. 12, pp. 1321–1329, 1994.
[9] B. Horan, M. Gardner, and J. Scott, “MiRTLE: a mixed reality teaching & learning environment,” 2009.
[10] T. P. Caudell and D. W. Mizell, “Augmented reality: An application of heads-up display technology to manual manufacturing processes,” in *System Sciences, 1992. Proceedings of the Twenty-Fifth Hawaii International Conference on*, 1992, vol. 2, pp. 659–669.
[11] J. Steuer, “Defining virtual reality: Dimensions determining telepresence,” *J. Commun.*, vol. 42, no. 4, pp. 73–93, 1992.
[12] R. T. Azuma, “A survey of augmented reality,” *Presence*, vol. 6, no. 4, pp. 355–385, 1997.
[13] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, and B. MacIntyre, “Recent advances in augmented reality,” *Comput. Graph. Appl. IEEE*, vol. 21, no. 6, pp. 34–47, 2001.
[14] S. Parkin, “Oculus Rift,” *Technol. Rev.*, vol. 117, no. 3, pp. 50–52, 2014.
[15] M. C. Juan, E. Llop, F. Abad, and J. Lluch, “Learning Words Using Augmented Reality.,” in *ICALT*, 2010, pp. 422–426.
[16] M. Slater and S. Wilbur, “A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments,” *Presence Teleoperators Virtual Environ.*, vol. 6, no. 6, pp. 603–616, 1997.
[17] B. G. Witmer and M. J. Singer, “Measuring presence in virtual environments: A presence questionnaire,” *Presence Teleoperators Virtual Environ.*, vol. 7, no. 3, pp. 225–240, 1998.
[18] M. Slater and M. Usoh, “Presence in immersive virtual environments,” in *Virtual Reality Annual International Symposium, 1993., 1993 IEEE*, 1993, pp. 90–96.
[19] M. Alrashidi, V. Callaghan, M. Gardner, and J. Elliott, “ViewPoint: An Augmented Reality Tool For Viewing and Understanding Deep Technology,” vol. Volume 17: Workshop Proceedings of the 9th International Conference on Intelligent Environments, 2013, pp. 252 – 261.
[20] J. Dooley, V. Callaghan, H. Hagras, M. Gardner, M. Ghanbari, and D. Al-Ghazzawi, “The Intelligent Classroom: Beyond Four Walls,” in *iClassroom Workshop, Intelligent Environments conference*, 2011.
[21] “Unity - Game Engine.” [Online]. Available: http://unity3d.com/. [Accessed: 28-Feb-2015].
[22] “metaio | home | Augmented Reality Products & Solutions.” [Online]. Available: http://www.metaio.com/. [Accessed: 28-Feb-2015].
[23] “3D for Everyone | SketchUp.” [Online]. Available: http://www.sketchup.com/. [Accessed: 15-Mar-2015].
[24] “DFVoice | VoIP Solution for Unity3D.” [Online]. Available: http://daikonforge.com/dfvoice/. [Accessed: 28-Feb-2015].
[25] “HTML5 WebView for Unity Pro | uWebKit.” [Online]. Available: http://uwebkit.com/. [Accessed: 28-Feb-2015].
[26] “SmartFoxServer: massive multiplayer game server for Flash, Unity, HTML5, iOS and Android games, MMO, virtual worlds and communities.” [Online]. Available: http://www.smartfoxserver.com/. [Accessed: 28-Feb-2015].