An Innovative Educational Format Based on a Mixed Reality Environment: A Case Study and Benefit Evaluation

Alessandro Fiore(✉), Luca Mainetti, and Roberto Vergallo

Department of Innovation Engineering, University of Salento,
Via Monteroni, 73100 Lecce, Italy
{alessandro.fiore, luca.mainetti,
roberto.vergallo}@unisalento.it

Abstract. We are in the midst of an information revolution, in which emerging technologies are creating new products and services that are redefining many aspects of our lives. The introduction of Information and Communication Technologies (ICT) in the educational context has allowed leading researchers and practitioners to find new ways of performing learning processes. It is evident that students are naturally attracted by activities that incorporate technology. In this work we propose an innovative competition-based educational format, known as "TIWE Linguistico," that exploits a Mixed Reality (MR) environment in order to encourage the learning of English as a foreign language. The "TIWE Linguistico" has been used experimentally in an Italian high school and the benefits obtained have been validated by exploiting the FEE (Features Extractions) method.

Keywords: Mixed reality · Collaborative Virtual Environment · M-learning · Features Extraction · QR-Codes

1 Introduction

Over the past decade, we have witnessed the invasion of a number of innovative ICT applications into many different spheres of our lives. Disruptive technologies such as smartphones, tablets, social networks and game stations have dramatically changed the way we interact with each other and with the environment. Many people no longer go out for a walk without their smartphone, and social networks have become the main site for sharing real time media and thoughts.

Young people today grow up surrounded by digital media and hardware and thus are dubbed 'digital natives.' Handheld video game players, music players and smart devices are at kids' fingertips. Unsurprisingly, parents worry about the content being delivered and the amount of time spent on digital devices, and thus often see such tools as an encroachment on the education of their children.

Having innovative content and relevant services for children is even more important at school. It has been shown that adopting ICT-based pedagogical approaches to delivering educational content and co-ordinating learning activities can lead to significant benefits [1] such as best subject comprehension, acquirement of new skills,

G. Vincenti et al. (Eds.): eLEOT 2014, LNICST 138, pp. 93–100, 2014.
DOI: 10.1007/978-3-319-13293-8_12

inclusion benefits and best class cohesion. Also, both central and local governments have realized that the virtual augmentation of classrooms is worth investing in, so considerable economic efforts have been made so that schools can catch up with and exploit students' computer skills more effectively.

Nevertheless, traditional teachers and principals often dislike technologies they cannot control, therefore many schools remain behind the curve in this ICT revolution. Another problem with this ICT revolution at school is that educational experts are often left alone to configure their innovative educational formats, resulting in the adoption of poor or inappropriate technology or in technical problems during the delivery of the educational experience delivery.

In this paper we evaluate the experiences we had designing, experimenting and evaluating with innovative educational formats based on Mixed Reality (MR). The aim of this educational format, known as "TIWE Linguistico," is to encourage students to learn English as a foreign language by exploiting two technologies that pupils love: Android smartphones and 3D virtual worlds. The MR game consists of a crime novel based on an adventure of Sherlock Holmes by Sir Arthur Conan Doyle ("The Hound of the Baskervilles"). The content (texts and questions) and the learning objectives were prepared and arranged accordingly by the teachers. Two interviews with the teachers – before and after the delivery – were carried out, and the most relevant features of the experience were extracted according to the FEature Extraction (FEE) method, in order to assess the teachers' expectations and the results obtained.

The rest of the paper is organized as follows: In Sect. 2 we report on the main related works in the field of MR formats at school. Section 3 presents the TIWE Linguistico educational format. Section 4 reports on the test bed made in an Italian school and the experimental results. Finally, in Sect. 5 we summarize the lessons learned as well as future research.

2 Related Work

Several research works have explored the benefits and issues that emerge when teachers use multi-user 3D Virtual Learning Environments (VLE) in order to augment their educational activities [2, 3]. Moreover, a remarkable number of experiments have been carried out in order to introduce these technologies in an educational context.

For example, in [4] a Virtual Interactive Storytelling is created. This makes real-time story generation possible, as well as user intervention in a storyline. User involvement can take different forms: a user can participate in the story, play the role of an actor, or intervene in the course of action from a spectator's perspective.

In [5], an experiment that ends up in a survey about a global distance-learning course attended by 68 students is performed. The survey was conducted to identify factors that may have an influence on the effectiveness of VLEs. The results included a set of features such as students' characteristics, their attitudes towards VLE, technology reliability, media richness and virtual team support related to the effectiveness of virtual learning.

An important element of the work which is related to the use of MR environments in the education scenario is MiRTLE (Mixed Reality Teaching & Learning Environment)

[6] which allows teachers and pupils to take part in real-time mixed and online classes, interacting with avatar representations of the other participants. In MiRTLE, the teachers in the physical classroom can deliver traditional lectures, but in addition they have a presentation station, consisting of a large display mounted in the classroom, showing the remote students' avatars. MiRTLE uses the full potential offered by the Shanghai e-Learning Platform [7].

Other works bringing to the attention the more frequent use of auto-identification technologies exist in the learning context. In [8], mobile phones are used as QR-code readers to conduct surveys during classes, in order to provide feedback to the teacher in the middle of a long class (i.e. of 90 min).

3 The "TIWE Linguistico"

The related works examined show that different pieces of technology can be used together in order to improve the outcomes of learning processes. However, existing MR environments for education are not free to download and not easy to set up [9]. MiRTLE appears to be the best MR environment for the educational context, but MiRTLE learning experiences have not been rigorously classified or shared. Therefore we felt it necessary to build up our own MR-based format, experiment with it in an Italian school and identify its main experiential features by exploiting a rigorous methodology.

Before introducing the "TIWE Linguistico," it is necessary to define what we mean by an "educational format". From our point of view, an educational format is a didactic project characterized by certain levels of abstraction and decontextualization (compared to its applicability/experimentation). Thanks to such features, such a format is potentially transferable to any educational level and has three dimensions:

1. The pedagogical and didactic dimension, referring to the educational models that can be implemented by the format itself.
2. The tools dimension, referring to the "technologies" that can support both the learning processes and the evaluation of the educational format.
3. The organizational dimension, which interacts with the educational models and the tools that are adopted.

The "TIWE Linguistico" is a competition-based educational format whose purpose is to encourage the learning of English as a foreign language. The format is based on the novel "The Hound of the Baskervilles" by Sir Arthur Conan Doyle and implements a treasure hunt carried out in a MR environment where two teams compete in order to solve a crime. Each team is composed of two groups:

- 3D Group: the players in the virtual world, who guess the crime's perpetrator and the weapon used by interacting with some 3D objects in four different virtual environments (game levels);
- Sherlock Group: the players in the real world, who have to answer a set of questions using a smartphone for reading objects labeled with QR-Codes in 4 real classrooms (QR-Rooms).

To access the next levels of the game, each member of the 3D Group has to wait for the corresponding Sherlock Group to communicate relevant clues to them. A particular clue can be obtained by answering a specific question correctly in the real world. Pupils in the Sherlock Group can show and answer the question by reading the associated QR-Code tag, using a smartphone with the "TIWEApp" installed. If the given answer is correct, the 3D players can receive help to find some secret 3D objects (the clue). By clicking on such objects, the 3D Group can show and answer a new question, which allows them to gain access to new crime information and then go on to the next level of the game. The number of game levels (environments) is four, i.e. there are four real classrooms and four game levels. The winner is the team whose 3D Group guesses the right culprit and weapon the fastest. In Fig. 1 the interaction between the virtual world and real world is shown.

The "TIWE Linguistico" involves three main technologies:

- **WebTalk04** (WT04) [8] is a Collaborative Virtual Environment (CVE) which is able to deliver three-dimensional multimedia learning experiences in real-time. WT04 provides a runtime 3D rendering engine which is fully configurable through XML in order to easily modify virtual world settings as well as collaborative interaction rules, thus allowing geometries, forms of behavior and content to be controlled independently. In the "TIWE Linguistico," the WT04 platform is used for proposing educational activities through navigation in the virtual world and interaction with blackboards that show contents or propose more complex questions. The WT04 client (see Fig. 2) runs on a regular web browser. This feature makes it easier to deliver 3D experiences at school – for example in the computer room – avoiding difficult and time-consuming setup procedures like installation and updating. WT04 uses a central server to retain a shared state among objects and for propagating a user's state changes (such as chat, movements or interactions).
- **TiweApp** (see Fig. 2) is a mobile learning system (m-learning), which allows the delivery of multiple choice quizzes by reading objects labeled with QR-Code tags. Thanks to the simplified interface, students are not distracted by the difficulties of interacting with the device. TiweApp contents can be configured by editing an XML file. It also provides a scoring mechanism. The latest version is available for Android [10]. All the contents required for the interaction are stored on a memory card, hence it is not necessary to connect the device to the network. A log file

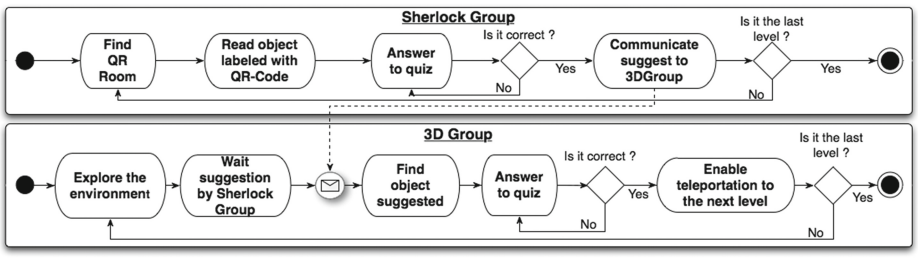


Fig. 1. The interaction between Sherlock Group and 3D Group. To access the next environment, 3D Group must wait the correspondent Sherlock Group to communicate them the clue to find.

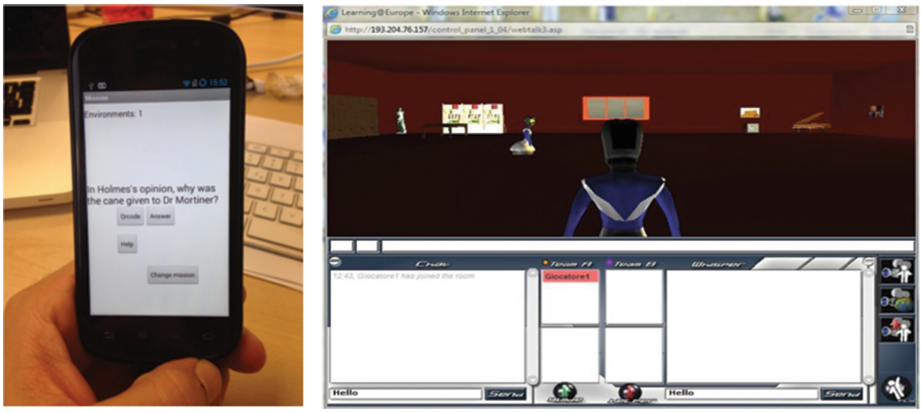
containing data on correct/wrong answers, attempts, and time spent is generated so it can be used later in a debriefing phase.
- **Moodle** is a free, open-source PHP web application for producing modular Internet-based courses that support a modern social constructionist pedagogy. Students can find out about documents, tutorials and multimedia materials, which allow them to have out rich educational experiences.

4 Test Bed and Experimental Results

The "TIWE Linguistico" has been used experimentally at the "Luigi Scarambone", an Italian vocational high school located in Lecce, during the 2012–2013 school year. This involved two English teachers and 24 pupils selected from the most talented of the school's third and fourth classes. In this case, the experience was tailored to strengthening the English level for the best performing pupils rather than a recovery tool for the less well performing ones. The learning experience lasted 10 days and was structured as follows:

- **Preliminary Phase.** In this phase we held two meetings with the students and teachers, in order to increase their familiarity with WT04 and the TiweApp. During the last meeting, the story of "The Hound of the Baskerville" was presented to the pupils by playing a video that included clips from one of the movies of the story. In addition, we created and assigned the Moodle login credentials for each student so that they could refer to the documentation available at any time. During the same phase, the two English teachers worked on the contents of the format in order to adapt them to the level of knowledge of the students.
- **Experience delivery.** During the experience day, the pupils were split into two teams of twelve students. Each team was then divided into a Sherlock Group (6 students) and a 3D Group (6 students). The school provided 4 classrooms to be used as QR-Rooms, and one computer laboratory for hosting both the 3D Groups. Each Sherlock Group was equipped with one smartphone on which was installed the TiweApp, and one netbook for communicating with the 3D Group by using WT04 chat.

The experience lasted 2 h, in which the pupils co-operated to solve a crime before the opposing team did so. In order to obtain a qualitative analysis of our experiment, we adopted the FEature Extraction (FEE) method [11]. This consists of carrying out two interviews with the teachers (before and after the experience), and then "extracting" the relevant features. The FEE method aims to highlight the benefits achieved by the educational format. The expectations interview has been taken before the "Tiwe Linguistico" was implemented and reflects what the teachers expected from the format. The results interview was carried out after the implementation of the learning experience and reflects the actual outcomes. We transcribed the interviews with the teachers, then extracted the relevant features in order to create a synthesis of all the interesting aspects of the educational experience. We filled out four different FEE forms: an expectation FEE, a result FEE, a comparison FEE and an experience FEE form. Figure 3 shows an extract from the transcription of the results of the interviews.



(a) (b)

Fig. 2. The main technologies used in the "Tiwe Linguistico": Webtalk04 on the left and TIWEApp on the right. Firstly, in (a) the Sherlock student has shot a QR code placed in a real classroom and a question shows up. Giving the right answer makes it possible for him to access the next real classroom. The real student also gives the clue to the 3D students via the WT04 chat (in this case, he asks him to search for something like a 'cane' in the 3D world).

By conducting FEE method analysis we deduced that the MR experience had helped achieve a number of significant benefits. From the point of view of integration, the students had improved their ability to work in teams thanks to the purely co-operative characteristics of the learning format. Furthermore, they had explored several semantic-linguistic aspects, which allowed them to understand the text more easily and answer the questions more quickly. The students used technologies autonomously without any external support, proving that the innovative tools involved were easy to

I: What kind of benefits do you think your students have achieved during the experience?

T: *A little bit of everything, because the students have had the possibility of using technologies that they know very well, so they have started to improve their English […] Students have deepened several concepts and worked in group with a certain autonomy without the help of the teacher, whose contribution was limited to finding relevant content before the experience of implementation.*

I: In your opinion, what were the crucial features of your experience that made these achievements possible?

T: *It was crucial to have the same level of language and technological skills.*

I: Did you notice unexpected benefits?

T: *Sure! The team that was apparently weaker (because of the patchy composition of race and social condition) did exploit a cooperation method that was effective for winning the game.*

Fig. 3. Transcription of the interview

use and encouraged learning. The teachers highlighted how the school had become a place where the ludic experiences make studying more interesting than traditional frontal lectures. The one major problem was related to the school's network infrastructure, whose network speed did not match up to the requirements of the tools.

5 Conclusions and Future Work

In this paper we have presented an innovative educational format based on Mixed Reality (MR) environments. The format uses two technologies beloved by pupils – Android smartphones and 3D virtual worlds – in order to encourage the learning of English as a foreign language while fostering a sense of community among the players. The format is structured as a competition between two teams. Such teams can be two schools or two classrooms in the same school. The object of the game is to detect the culprit and the weapon in a crime novel, based on the stories of Sherlock Holmes.

In order to prove the validity and effectiveness of the system, we experimented with the "TIWE Linguistico" in the Luigi Scarambone high school, with the collaboration of two English teachers. The contents delivered (texts and questions) and the learning objectives have been prepared and arranged accordingly by the teachers during the preparational phase. Two interviews with the teachers – before and after the experience delivery – were carried out in order to assess the teachers' expectations and the results obtained. This kind of evaluation was structured according to the FEature Extraction (FEE) schema.

The educational format we delivered at the Luigi Scarambone high school has proved that this kind of technology can be used at school without any particular effort by the pupils, and that the use of such innovative tools can significantly encourage pupils during the learning process.

This experience confirmed that an educational renewal in the school is still required and cannot be postponed any longer. A strict collaboration between those who develop the technology and those who create the learning objects will be absolutely necessary to get the best from an innovative educational format. Unfortunately, many schools still struggle to catch up and exploit the pupils' computer skills. Also, a set of problems was identified during the process of experience delivery. Firstly, the IT assets of the school were not always reliable. For example, the WiFi network signal strength was not always sufficient. Secondly, a number of learning professionals did not appear to approve the changes, probably because they require a considerable effort on their part.

In the future we plan to move into two important research areas. From the technical perspective, we are intending to enrich the "TIWE Linguistico" with more and more engaging technologies such as Near Field Communication (NFC), indoors localization, and interaction with social networks (Facebook, Twitter, and Google+). From an educational perspective, we hope that teachers will get even closer to the technology, in order to try to minimize the mental block that too many teachers still have about it.

Acknowledgment. The work is partially funded by the Italian Ministry of Education, University and Research (MIUR) under the PON04a2_B EDOC@WORK3.0 (EDucation On Cloud) national research project.

References

1. Youssef, A.B., Dahmani, M.: The impact of ICT on student performance in higher education: direct effects, indirect effects and organizational change. Revista de Universidad y Sociedad del Conocimiento **5**(1), 35–44 (2008)
2. Warburton, S.: Second life in higher education: assessing the potential for and the barriers to deploying virtual worlds in learning and teaching. Br. J. Educ. Tech. **40**(3), 414–426 (2009)
3. Cavazza, M., Charles, F., Mead, S.J.: Developing re-usable interactive storytelling technologies. In: Jacquart, R. (ed.) Building the Information Society. IFIP, vol. 156, pp. 39–44. Springer, Heidelberg (2004)
4. Tang, N., Yan, S.: Study of the effectiveness of virtual learning. Psychol. Sci. **27**(2), 462–465 (2004)
5. Callaghan, V., Gardner, M., Horan, B., Scott, J., Shen, L., Wang, M.: A mixed reality teaching and learning environment. In: Fong, J., Kwan, R., Wang, F.L. (eds.) ICHL 2008. LNCS, vol. 5169, pp. 54–65. Springer, Heidelberg (2008)
6. Shen, L., Wang, M., Shen, R.: Affective e-learning: using emotional data to improve learning in pervasive learning environment. Educ. Tech. Soc. **12**(2), 176–189 (2009)
7. Susono, H., Shimomura, T.: Using mobile phones and QR codes for formative class assessment. Curr. Dev. Tech. Assist. Educ. **2**, 1006–1010 (2006)
8. Barchetti, U., Bucciero, A., Mainetti, L.: Collaborative learning through flexible web CVE: the experience of webtalk. In: Vincenti, G., Braman, J. (eds.) Teaching Through Multi-User Virtual Environments: Applying Dynamic Elements to the Modern Classroom, pp. 471–490. IGI Global Publications, Hershey (2011)
9. Vergallo, R.: Classroom 3.0: the real world meets virtuality through ambient sensing in education. In: Proceedings of the 12th IEEE International Conference on Advanced Learning Technologies (ICALT) 2012, Rome, Italy, pp. 722–723, 3–6 July 2012. doi:10.1109/ICALT.2012.76
10. Google Android. www.android.com
11. Paolini, P., Di Blas, N., Guerra, L, Falcinelli, F., Mainetti, L., Costabile, M.F., et al.: Assessing and sharing (technology-based) educational experiences. In: Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications (EdMedia 2011), pp. 3150–3157. AACE Press (2011). ISBN 1-880094-35-X