A Content Creation Tool for AR/VR Applications in Education: The ScoolAR Framework

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Abstract. Nowadays, in education environments, new societal challenges and opportunities induce teachers to use new methods to improve the quality of learning. For this purpose, technology has proved to be a helpful aid in education, since it allows to ease the teaching methods, increasing the performances by introducing affordable and reliable means to convey digital contents. Studies revealed that Augmented Reality (AR) and Virtual Reality (VR) have a great potential to help two kinds of users: on one side the students, improving their knowledge and skills; on the other teachers, widening their teaching methods. In fact, the relation between AR/VR and education makes the teaching and learning experience more efficient and stimulating. Notwithstanding, a platform specifically designed does not exist for an agile creation of AR/VR contents, even for not skilled programmers. There is thus the necessity of developing new tools to enable users to become, easily, producers of such experiences. The aim of this paper is to introduce a novel framework, named ScoolAR, specifically designed to allow teachers to create tailor-made didactic proposals involving the students in the training action, thus bringing more involvement and contents awareness, managed in the realization of AR and VR applications and declined within the disciplinary topics.

Keywords: Augmented Reality · Virtual Reality · Education · Learning · Framework

1 Introduction

Nowadays, there are many fields of application and development of Augmented Reality (AR) and Virtual Reality (VR) [6,9]. The school, albeit in more discreet

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ways and with slower times than in other sectors, is opening up to these new technologies [7]. Such technologies find fertile ground in their use because of their appeal to a young audience, such as students, who are already familiar with devices that offer applications for AR and VR [14,16], especially in the video game sector. This familiarity constitutes one of the elements of strength that allows an easier introduction of the new digital methodologies in the didactic field [1]. All young people know the features of a smartphone, they know how to download apps, how to search and manage content in internet. However, the so-called digital natives [19] need to be educated in the use of AR and VR technologies to prevent them from being identified only as a game tool for its own sake. Besides, it is essential the contribution of the teacher who, mediating the contents and methods of approach and use of the devices, makes these tools effective and functional to the learning path, through a correct valorisation and a real strengthening of the intrinsic and extrinsic characteristics which has been mentioned. The figure of the teacher then determines the level of training and the correct and complete transmission of knowledge through the use of different teaching/learning methods. Another element to take into consideration concerns not only the levels of learning and the active involvement of students, but also the correct use of the contents they transmit through disciplinary knowledge [18]. In fact, immersive technology risks overloading students with information and decreasing the ability to correctly process data [12]. The intervention of the teacher who plans and organizes the didactic action is fundamental, carrying out the necessary maieutic function in the learning process. Lessons supported by AR and VR applications shall be, therefore, planned and structured in order to not lead to stereotypes, since they could be misleading for the students, who are used to different learning dynamics that are created within the classes.

Given the above, the aim of this paper is to introduce a novel framework, named ScoolAR, specifically designed to enable teachers and students in creating tailor-made contents and didactic proposals. The present research work follows a previous study [10] in which the benefits of using AR and VR applications has been proved, highlighting the necessity to facilitate the development of multimedia experience even by non-expert programmers. After demonstrating the potential of such technologies with a real user test, emerged the need to provide students and teachers with an editor platform for autonomously developing AR and VR applications. Interested readers can find the full research results in [17]. It is well known, in fact, that a bottleneck which prevents the diffusion of such technologies for learning purposes is the lack of easy editing applications. For this purpose, ScoolAR has been developed to overcome such limitation, enabling an autonomous content creation process and thus bringing more involvement and awareness in the realization of AR and VR applications. The synergy between traditional didactic actions and technological innovation allows to obtain better results both in terms of knowledge and skills, especially in the experiences in which the disciplines interface in a transversal way. Supported by the results achieved so far and from the data collected in terms of improved knowledge and students' satisfaction (in synergy with a traditional activity of knowledge transmission), the validity of ScoolAR framework is shown, together with its main concept and design.

2 Related Works

Applications based on AR and VR can help students to improve their knowledge and skills. In fact, the link between AR/VR and education makes the teaching experience more efficient and engaging [9]. Using these technologies, students not only learn better, but learning processes to reach a more accurate knowledge [4]. In this regard, the work conducted by Gargalakos and others [11] has shown that the technology has significantly improved learning outcomes by increasing the ability to attract students and their willingness to communicate and share their experiences, their provision in the use of new technologies and acquisition of knowledge, while having fun and experiencing new realities. However, according to [2] there are challenges and disadvantages in using AR/VR as an educational tool in most classes of the world. In 2009, Dunleavy, Dede and Mitchell designed Alien Contact!, a mobile augmented reality (MAR) game that focuses on teaching mathematics, language arts and scientific literacy to middle and high school students. Students can interview virtual characters, collect digital objects and solve scientific, mathematical and linguistic problems to answer the question and find out why the aliens have landed on earth. The results obtained from the study documented the high involvement of students in the various case studies [8]. In 2009, Ardito and others [3] presented a MAR game called Explore! with the aim of supporting the exploration of middle school students towards archaeological sites in Italy. From the study of the results, it was shown that the students had fun playing with Explore! but for learning, there were no significant differences. The authors in [13] proposed an educational application called EnredaMadrid to make it easier for students to learn history using mobile devices based on geolocation and AR technology. The evaluation was carried out through a questionnaire and the results showed that AR certainly contributes to making learning better and more enjoyable. The virtual application, Google Expeditions[1] allows to take part of several virtual visits to the most evocative locations around the world but also in the depths of the oceans and in the space. It is a product purposely designed for classroom work. A VR tour, produced with a mobile phone and a Google Cardboard headset, requires 360° viewing so that the participant overall observes the scene they are viewing. The Vatican app[2] is an application that provides tours and information about the Vatican in Rome. Students can enter each room with High Definition pictures. This application is only available for 360 views and not Google Cardboard. Cave Automatic Virtual Environments (CAVE) [4] is a tool supporting immersive VR approach where the user is in a room where all the walls and the floor are projection screens and the user can wear 3D glasses where he can move around freely in the projected world. CAVE environments are still rather expensive and is particularly used in cultural heritage education [15].

1 https://edu.google.com/products/vr-ar/expeditions/?modal_active=none.
2 http://w2.vatican.va/.

3 Materials and Methods

Prior to describe the ScoolAR framework, for the sake of completeness, a brief overview of the users' test is given. As well, to facilitate the reader in understanding the potentials of the developed framework, a brief description of the applications used for this tests is reported.

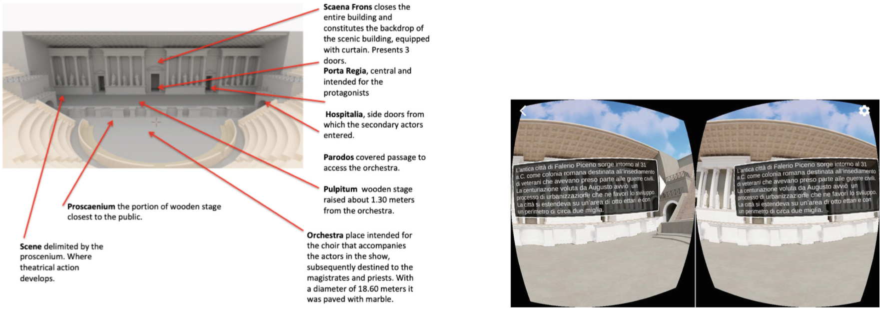
The AR and VR apps contained within the SmartMarca[3] project have been the support for the didactic action undertaken within the school programs developed during the year, in order to test the contribution of digital technology in the learning process of the students. The AR apps concern the guided reading of two paintings preserved in exhibition structures in the territory of Fermo, in the Marche region. The first concerns the painting "Adorazione dei pastori" of P.P. Rubens preserved in the Palazzo dei Priori in Fermo, the second concerns the painting "Paesaggio" by O. Licini kept inside the artist's house-museum in Monte Vidon Corrado (Fig. 1).

Fig. 1. AR applications: left "Adorazione dei Pastori" by P.P. Rubens, right "Paesaggio" by O. Licini

The VR app allows a 360° view of the reconstruction of the Roman Theater of Falerone. All the apps allow the reading of the works through tags that, illustrating the fundamental elements, propose a more accurate view of the details and

[3] http://www.marcafermana.it/it/SmartMarca/.

the entire work. The SmartMarca project is mainly aimed at a public of tourists, but in the drafting of the texts of the app, edited by the teacher (Fig. 2), it was also thought to a didactic use that allows to start a first proposal of knowledge of the artist, the work or the monument in its essential elements.



(a) Contents (b) VR App

Fig. 2. Teaching content developed by the teacher inserted in the tags of the SmartMarca application and related to the theater of Falerone.

In general, art and architecture lend themselves to an empathetic cognitive approach because they are based mainly on the image, shapes and colors, thus favoring a direct knowledge through the view that results according to Classen "... the most important of the senses and the sense more closely linked to reason" [5].

The protagonists of the methodological analysis are the students of the Course of Surveyors (now C.A.T. Construction Environment Territory) of the ITET Carducci Galilei of Fermo. The students were invited to read the works in different ways: with or without the teacher's explanation, with or without the use of the app. The combination of the different readings was then completed with an online verification, prepared by the teacher, on Socrative[4] an application that allows to carry out checks and collect results, data and statistics related to the learning of the students. The analysis of the collected data has led to the following conclusions:

– The combination of the frontal lesson with the use of the app is the best learning method in terms of motivation and knowledge of the contents.
– During the teaching/learning action the apps proved to be a useful compendium of theoretical and practical knowledge.
– The use of the devices involves a greater level of attention and involvement of the students in the proposed activities.

A further verification phase was carried out to compare the two AR and VR technologies and verify their best correspondence both in terms of teaching and

[4] https://socrative.com.

use. For this purpose, the SmartMarca application was used for VR with the 360° view of the Piazza del Popolo di Fermo (Fig. 3), for AR with the "Adorazione dei pastori" of P.P. Rubens.

Fig. 3. Students test the use of Virtual Reality applied to the 360° view of the "Piazza del Popolo" in Fermo, collected with 360° camera.

In this case, the data (Fig. 4) were collected through a questionnaire formulated through the Google Docs application, to which the students had access in real time, at the end of the test and through a QR code.

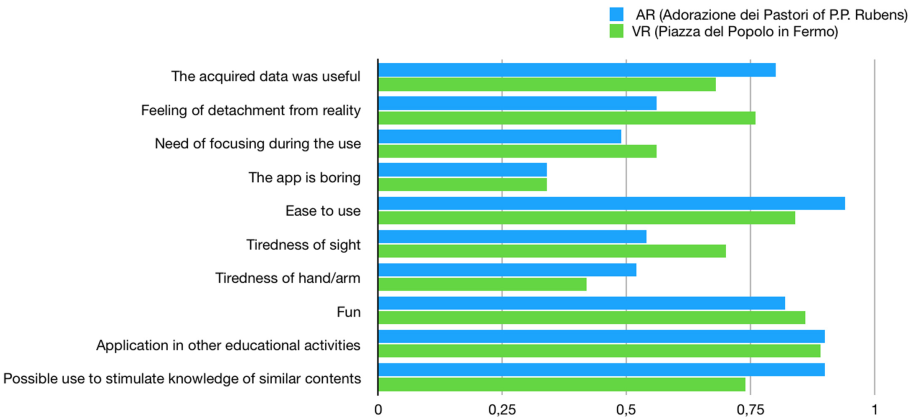


Fig. 4. Comparative histogram of the answers to the questions in the online questionnaire about the comparison between AR and VR.

The following conclusions have been deduced:

– Virtual Reality is the medium most known and used by young people, thanks to its diffusion in the video game sector and despite creating greater detachment from reality and straining the eyes with the use of the viewer.
– Augmented Reality, a lesser known tool, encourages greater contact with the surrounding reality and stimulates better involvement in the comprehension of the proposed text.

The results gathered from the research carried out so far validate the potential of the AR and VR applications in the didactic field, as a support tool and compendium of the training action. For the teacher, the development of the content of the app, its use within the training course offered to the students and the following verification has constituted an interesting methodological study. In fact, in tracing the founding points of the subject matter, to carry out the insertion in the various tags, the teacher has identified the so-called minimum disciplinary objectives necessary for the students to develop the skills and knowledge that can be spent in a transversal way. Characteristics to be developed emerge such as those concerning the long-term verification of the knowledge acquired by students, the possibility of creating similar methodological situations declined on the different topics and on the different disciplines, the involvement of students in the realization of the training path to create a participatory teaching. To this end, the development of the ScoolAR project is an excellent training ground for continuing to study new scenarios for the shared use of the resources offered by AR and VR.

4 Description of ScoolAR Framework

As stated, based on the tests conducted on AR and VR experiences, the necessity of developing new tools has increased to enable users to become producers of contents of AR/VR experiences, because a platform specifically designed does not exist yet for an agile creation, even for not skilled programmers.

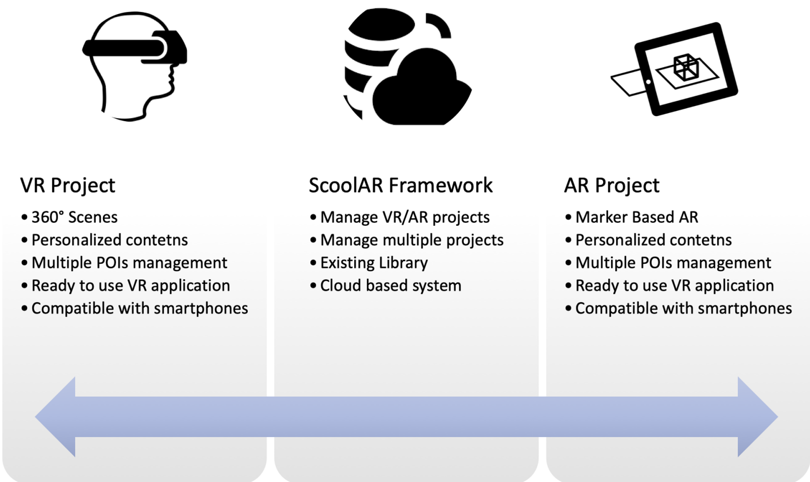


Fig. 5. General overview of ScoolAR; the schema demonstrates the modularity of the framework which enables a multi-scale and multi-app development.

The aim of this section is to describe the educational ScoolAR application, a platform for the creation of educational contents (a brief overview of the developed framework is reported in Fig. 5).

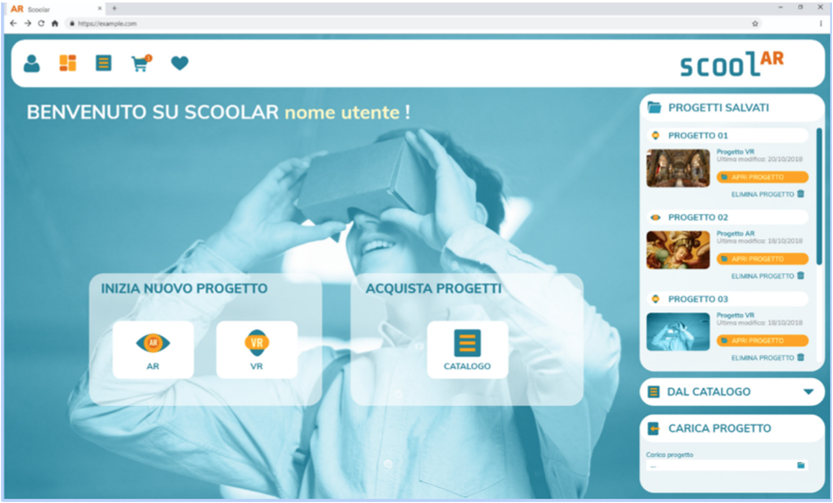


Fig. 6. Screenshot of the ScoolAR homepage.

The intent is to propose a cooperative platform between teachers and students, which allows the use of innovative technologies (AR and VR) to stimulate student learning. After the log-in, the user will be able to access a series of sections that will give the opportunity to continue the projects started, create new projects or consult the catalog of available content. The main objectives of the educational platform are:

- Provide a user-friendly platform for creating educational content.
- Use of innovative technologies to stimulate learning.
- Create a cooperative platform between teachers and students.
- Drivers for the digitization of the territory.
- Platform for selling partners' digital content.

Figure 6 shows the home screenshot of ScoolAR, the project upon which our research group has concentrated the efforts.

The contents of the *HOMEPAGE* can be briefly described as follows:

- *New project:* Opens a new work area for AR or VR projects.
- *Buy contents:* Access the "Catalog" section containing shared or purchasable content.
- *Saved projects:* list of projects saved by the user.
- *From the catalog:* User projects from the catalog.

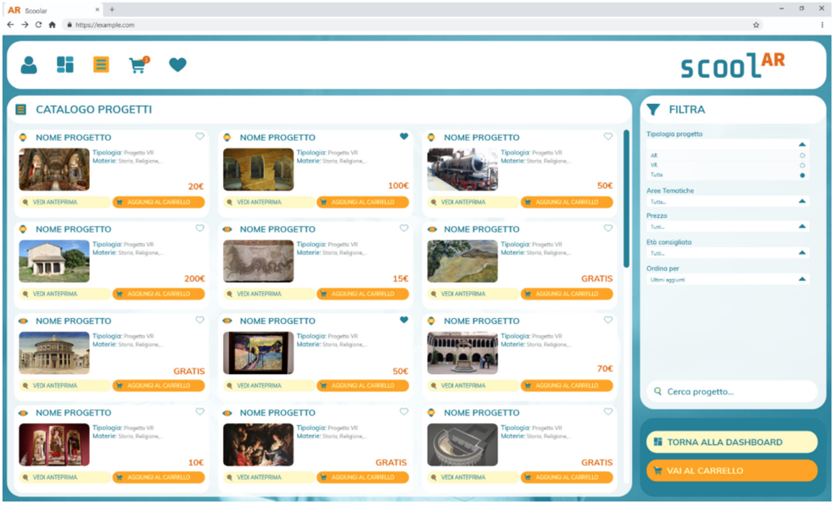


Fig. 7. Screenshot of the catalog.

– *Charge project:* Upload projects previously exported and modified by third parties.

In the *CATALOG*, the contents shared by other users and purchasable projects will be available.

– *Navigation bar:* The icons redirect the user to the user page, dashboard, catalog (Fig. 7), shopping cart and favorites.
– *Project catalog:* Windows show a preview of the contents with basic information and action buttons.
– *Filters:* To facilitate searching for projects of interest, completing the research area by name.

Clicking on the "Preview content" action button, the page related to the selected project is opened. This will allow users to find more information and to view the contents.

The contents of the *PROJECT PREVIEW* section, of which an example is showed in Fig. 8, are:

– *Content preview:* includes a series of useful information (Content Type, Subjects, Topics, Recommended Age, Available Languages, Related Projects, Last Update, Author); in addition to a brief description and images of the content.
– *Similar content:* automatically recommended based on the characteristics of the content displayed.
– *Action keys:* can be placed in the shopping cart or added to favorites.

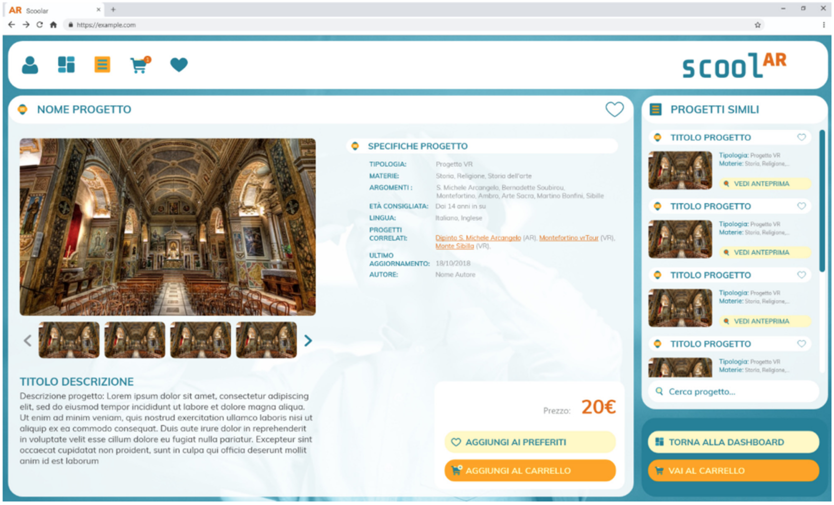


Fig. 8. Screenshot of the "Project preview".

4.1 AR Project

When opening a new AR project, the user will be asked to upload a target image, i.e. the image object of the project that the application will have to recognize. Feedback will be immediately provided on the resolution of the uploaded image but above all on its recognizability. Once the image is approved, it will be possible to add tags. All elements on the work area will be editable via Drag-and-drop. Selecting *Add Tag* in the right section will open a panel with the tool for selecting the Tag area. Once the instrument has been selected, the image will appear in semi-transparency, thus helping the selection. Once the area is selected, the *tag navigation bar* will appear at the bottom, which will contain all the selected areas, giving the user the possibility to easily navigate between them. In case of selection not sufficiently recognizable by the application, a negative feedback will be provided which will force the user to reselect the tag area.

Adding information content to the right panel, a containment window will appear automatically. All contents, including the window, will be editable via Drag-And-Drop. A dialog box will help the user addressing it to an *Instructions* page. Once the project is completed, the user can save it on his dashboard and/or export it for the application. An example of a completed project is showed in Fig. 9.

4.2 VR Project

When creating a new VR project, the user will be asked to upload a 360° image, in order to start working. Feedback on the resolution of the uploaded image will be immediately provided. Once the image has been approved, it will be possible

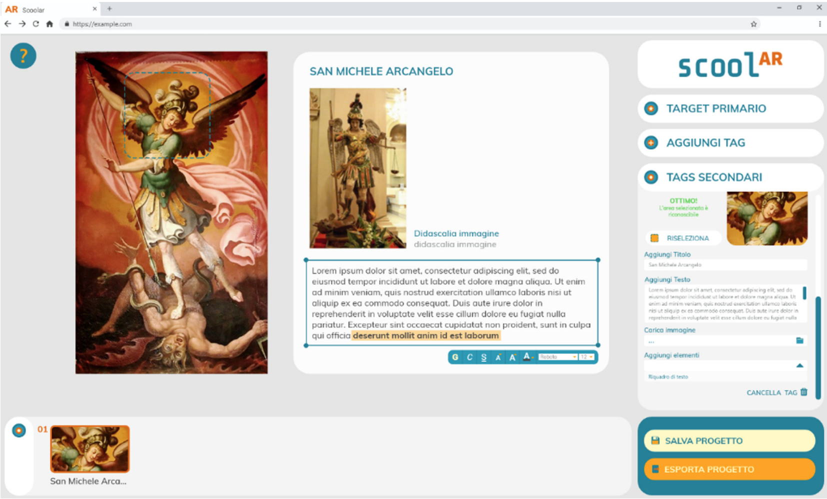


Fig. 9. Screenshot of a new completed AR project.

to add elements, Waypoints and Hotspots. Waypoints allow to navigate from one image to another; Hotspots to insert windows with informational contents. By adding a Waipoint, the associated icon will appear on the work area that will allow the passage from one 360° image to another. On the right panel will be present all the Waypoints created. In the active Waypoint section, it will be possible to select the image to be associated, via drop-down menu if previously loaded, or load another. All the 360° images loaded will be visible at the bottom on the 360° *image bar*.

Adding a Hotspot, the associated icon will appear on the work area that will allow consultation of the contents inserted. Once added, as for AR projects, a series of elements will appear to be added to the contents window of the hotspot. By filling in any section, a containing window can be created which can be modified using Drag-and-Drop. Once the work is finished, the project can be saved on the user dashboard and/or exported. An example of a completed project is showed in Fig. 10.

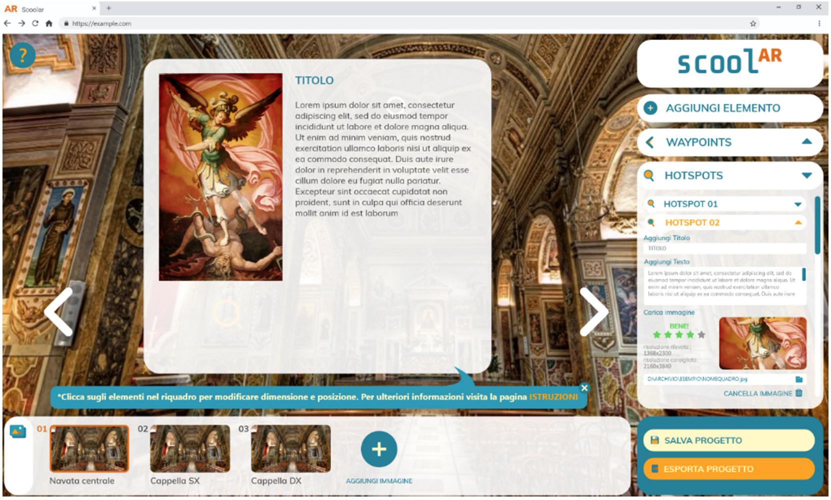


Fig. 10. Screenshot of a new completed VR project.

5 Discussion and Conclusion

For evaluating the framework performances, preliminary tests have been conducted with teachers of the same higher school. In particular, we proposed a comparison between existing development platforms (namely Unity3D for VR and Unity Vuforia Plug-in for AR). From the very beginning of the test, it emerged a clear difficulty on developing AR/VR contents autonomously by the teachers, which obviously didn't have programming skills. Using ScoolAR instead, teachers were able to create AR/VR projects by their own. Unity3D is actually the only platform which permits the development of AR/VR experiences within the same environment[5]. Albeit it is a powerful tool, its interface is very complex; for instance, developing VR experiences requires programming skills for allowing the end-user to interact with 360° scenes. As well, the development of AR experiences is entrusted on the use of Vuforia (a plug-in based on marker-based AR) which presents a more easy-to-use development pipeline but it is not designed for non-experts. In the following, a comparison between the two frameworks (Unity and ScoolAR) is reported Table 1, highlighting the benefits of our approach.

To summarise, the proposed ScoolAR framework enables users to become producers of contents of AR/VR experiences; it tackles the challenging issue of facilitating the use of new media in the education environment. In fact, up to now, there no exists a platform specifically designed for an agile creation of AR/VR applications. We can affirm that the proposed framework revealed to be a promising solution. The intent is to propose a cooperative platform between teachers and students, which allows the use of innovative technologies (AR and VR) to stimulate student learning. Students use a platform that makes them

[5] https://www.oreilly.com/ideas/.

Table 1. Comparative analysis between Unity 3D and our framework

Feature	Unity3D	ScoolAR
Time spent for developing AR app	5 h	1 h
Time spent for developing VR app	N/A	1 h
Manage multiple projects	No	Yes
Easy to use interface	No	Yes
Programming skills required	Yes	No
3D Environment	Yes	No

more autonomous and aware of the contents, managed in the realization of AR and VR projects within the disciplinary topics. The main novelties introduced by our framework are the creation of an all in one solution for the creation of AR/VR applications, the autonomous content creation thanks to the easy and friendly interface (aimed for not expert programmers) and the deploying of ready to use AR/VR applications suitable for different devices.

As a final remark, it is fair to say that, in its current version, this framework is not multi-language (only Italian language is supported). Moreover, it is designed to become a commercial tool, in which costs are related to the purchase of existing projects and on annual fees, depending to the hosting platform, hence to the dimension of the content that the user should manage. Though this framework has been developed for the education domain, it can be foreseen, in the future, that other domains like tourism or gaming can benefit from it.

Even the benefits of AR/VR in the educational context deserve few comments. The introduction of new AR and VR technologies can help teachers in their task of learning new topics, increasing the ability to attract and involve more and more students. Tests were conducted on two classes of adolescents for which the different teaching approaches served as a method of evaluating the effectiveness of the use of these technologies for the educational process. However, despite technology is capable of transmitting "disposable" information, it does not stimulate the students' self-elaboration, which still remains entrusted to the role of teacher. The only way to facilitate the introduction of new media in the education domain is to enable non-expert users to create by multimedia contents autonomously, and ScoolAR paves the way in this direction. In our future work, we are planning to evaluate, with specific learning paths, the benefits for learning at different levels. Moreover, it will be interesting to expand the platform to other fields beyond Cultural Heritage, as there are several disciplines that could be taught with the support of AR/VR applications.

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