Measuring and Assessing Augmented Reality Potential for Educational Purposes: SmartMarca Project

Emanuele Frontoni[1(✉)], Marina Paolanti[1], Mariapaola Puggioni[2], Roberto Pierdicca[2], and Michele Sasso[3]

[1] Department of Information Engineering, Universitá Politecnica delle Marche, Via Brecce Bianche 12, 60131 Ancona, Italy
e.frontoni@staff.univpm.it
[2] Dipartimento di Ingegneria Civile, Edile e dell'Architettura, Universitá Politecnica delle Marche, 60100 Ancona, Italy
r.pierdicca@staff.univpm.it
[3] UBISIVE s.r.l., Via Dell'Universitá 13, 63900 Fermo, FM, Italy
info@ubisive.it

Abstract. Augmented and Virtual reality proved to be valuable solutions to convey contents in a more appealing and interactive way. Their use is nearly embracing several domains like medicine, geospatial applications, industry, tourism and so on. But among the others, the one that might benefit the most by their use is the Cultural Heritage. In fact, given the improvement of mobile and smart devices in terms of both usability and computational power, contents can be easily conveyed with a realism level never reached in the past. However, despite the tremendous number of researches related with the presentation of new fascinating applications of ancient goods and artifacts augmentation, few papers are focusing on the real effect that these tools have on learning. In fact, whether a disposable use of such tools seems to have a great benefit in terms of visual impact for the users, the same cannot be said about the long-term effect they have on the users, especially for education purposes. Within the framework of SmartMarca project, that will be briefly explained in these pages, this paper focuses on assessing the potential of AR applications specifically designed for Cultural Heritage. More specifically, tests have been conducted on an Augmented Reality experience upon different paintings. For evaluating the benefits of such technology in terms of learning, we have performed our experiment on classrooms of teenagers. By testing different learning approaches, we were able to evaluate and assess the effectiveness of using these technologies for the education process. The paper will even argue on the necessity of developing new tools to enable users to become producers of contents of AR/VR experiences, since up to now there no exists a platform specifically designed for an agile creation, even for not skilled programmers.

L. T. De Paolis and P. Bourdot (Eds.): AVR 2019, LNCS 11614, pp. 319–334, 2019.
https://doi.org/10.1007/978-3-030-25999-0_28

1 Introduction

Augmented Reality is now expanding in many sectors and fields, not only those specifically dedicated to digital technology, but equally in those of everyday life. Even in educational environments, the use of new technologies that develop Augmented Reality proposals is spreading [1–3]. Great development has taken place in the Primary School thanks to the didactic paths that are closer to the learning transmitted through the game, which is the preferential model of development of Augmented Reality applications. Reconstructing a 3D image by framing a page of a book or increasing the didactic content of a text thanks to the use of a device makes it possible to involve students' attention. Some disciplines lend themselves particularly to the use of these new didactic forms, such as the sciences [4]. The scientific disciplines generally have a greater field of application in this new learning methodology so that these increased spaces, presenting themselves through mobile devices widely used by the younger generations, create greater familiarity and therefore relaxation during the learning process [5]. The often difficult and complex aspect of scientific disciplines, such as mathematics, take on the form of play or a enjoyable quiz. The topics covered in a lecture are transformed into survey data in which they often involve themselves in competitive ways. A survey is then carried out through interactive processes that involve students and stimulate their learning. New terms are coined as "learning by searching" [6], "Inquiry based science education" [7] which translates the different processes that are implemented through the construction of a knowledge that is based on researches, surveys and modeling construction. The possibility of being completely immersed in the artifact, in the case of monuments, or deepening its contents and meanings, in the case of paintings or sculptures, without losing contact with the real environment that surrounds them, is essential to enjoy immersive, experiential and interactive of the work of art itself [8,9]. This perspective presents innumerable advantages in terms of dissemination of cultural heritage by creating direct interactions between the reality of the artwork and its knowledge mediated by the digital tool. The technology facilitates in this sense the empathetic approach with the good that, favored by the enhanced use of the sense of sight, produces a greater response of attention from the student. The process of learning, however, requires other factors that produce in the student, beyond the immediate and emotional response to the proposal of content, even a permanence in time of them. This condition favors a correct re-elaboration and use of information in different situations and contexts. The so-called skills must, in other words, produce a capacity for understanding and reworking the acquired data to produce cross and multidisciplinary skills. It is therefore essential to use the technologies without impoverishing the student's ability to create his own patrimony of skills that is created in a personal way, refining the cognitive techniques through the study and personal re-elaboration. In the didactic activity, normally modulated on the class and on the single students, the use of the technologies could lead to a method of work that is not flexible and can be modeled on the variable context of the students. The learning experience is modified by technological means [10] so it is important to study the effects of

such technologies on learning itself, in particular on the student's ability to reuse in different fields, as learned during the lesson. The goal of creating a cognitive tool, which should be Augmented Reality, which facilitates participative and metacognitive learning processes through an active observation as suggested by Dunleavy and Dede [11], must be supported by a thorough development of the terms of verification of the valence long-term teaching of the contents transmitted. It is Dede himself who claims that technology has advantages that affect the way the content is designed. The variables that are used depending on the type of technology could lead to results that should be interpreted as a guide. A certain result is the motivational one of the student who, through technological skills, manages to build paths that are more familiar and participated to him. A real judgment on learning requires a more careful path to the relapse over time of the educational activities carried out with Augmented Reality.

Given the above, the purpose of this work is to verify the real potential of the digital tool within a didactic environment that includes all the processes related to teaching and learning, possibly with long-term effects on the student's cultural and personal training. This process should also be supported by an ability to re-elaborate what has been learned, its decoding and subsequent implementation in other professional and cultural fields. The work carried out with this research therefore aims to offer a contribution to the studies on the use of Augmented Reality environments and applications in the educational field, verifying how the contents and methods of these new paths can promote real learning and how through an effective didactic action we can direct the student to an effective cognitive process and to re-elaborate knowledge, which will last over time. Tests have been performed within the framework of SmartMarca project, that will be briefly explained in Sect. 3. During the project duration, several outputs have been produced in terms of multimedia experience; in fact the platform underling the project was specifically designed to manage AR/VR contents related to the Cultural Heritage displaced among the south part of Marche Region, in Italy. The advantage of such approach is that, with a cloud based architecture, contents distributed in a quite wide territory can be exploited by different users in every location they are, with the benefits of spreading the knowledge thanks to the use of new technologies. Among these users, students and teenagers are well oriented toward the use of new media. The outputs of the project have been thus exploited and tested among this kind of users, with specific focus in assessing AR potential for learning in the field of Cultural Heritage.

2 Related Work

In the literature there are few data and in-depth research that allow to support the actual educational value of Augmented Reality that does not go beyond motivational development, the creation of a relaxed learning atmosphere, a collaborative participation and a communication facilitation. It is necessary to measure the effect of educational content. There are still a few jobs that are based on the theory of learning and its validation. The main reason lies in a generalized

lack of significant research projects oriented for a real involvement of a wide public. Tourism oriented services might act as a flywheel toward this direction. In the literature however some projects moves towards this direction. It has been proved in fact, that the use of ICT tools and specifically AR can contribute in the process of helping visitors to enhance their knowledge [12]. Beside improving the quality of experience for the visitors [13], AR can be adopted in tourism related project.

From the e-learning standing point, Mobile Augmented Reality (MAR) has proved to be a winning solution [15]. In Garau and Ilardi [14] for instance, a specific application was designed allowing people to download contents related to the Cultural Heritage (CH) area they were discovering. Given the huge disposal of CH related artifact produced in the latest years, contents such as paintings of buildings have been augmented, especially in archaeological site. A good example can be found [14]. And more, with the specific purpose of testing such contents for learning purposes, in [15] similar solutions have been tested. By the way, there is neither a clear direction among researchers in the way AR/VR can be evaluated for learning purposes, nor well structured methodologies to quantify their benefits.

In [16] the research objectives are highlighted: *As a first goal, this paper aims to measure the effect of AR educational content to show whether or not it is useful. Although there are many educational AR prototypes in the current literature, only a few are developed by interdisciplinary groups and base their work on learning theory. Even if the current state-of-the-art execution of AR educational content is effective, it can only be replicated to other contexts if a guideline exists for applying AR for education. As a second goal, we provide a guideline for effective AR content by first summarizing the state-of-the-art implementation and evaluation of AR prototypes.*

The use of Augmented Reality as a learning technology had already been included in the Horizon Report 2011, highlighting the great advantages offered by learning in the use of digital data superimposed on the real world [17]. In Horizon Report Preview 2019 Higher Education Edition developed by Educase published in February 2019 aims to develop within a year or less mobile learning that is based mainly on learning no longer focused on the App but on synchronized access from different devices everywhere and at any time[1]. This is why the use of Augmented Reality makes learning more active and collaborative, although this is still an early experience. The educational experiences promoted in the educational field with possible applications of Augmented Reality are many and have different connotations between the different levels of education and the different disciplines [18]. Currently, both at an international level and in Italy there are several experiences in the educational field that in some way put attention to the possible applications of Augmented Reality in the teaching-learning processes but still do not have significant data about their concrete consequences. Certainly the thrusts determined by the technological evolution

[1] https://library.educause.edu/-/media/files/library/2019/2/2019horizonreportpreview.

and by the introduction of digital tools on the market that increasingly use this technology with particular reference to mobile devices, which are no longer simple cell phones, impose rapid response times and fine-tuning research programs that are able to give the appropriate indications to face the inevitable changes also in the educational field [17]. These important changes in the forms of teaching must therefore be monitored, studied and evaluated to understand the real learning levels of the students that go beyond the simple involvement or participation of the students. All studies agree that students show interest and consensus on the use of immersive and interactive technologies [19], but the results on the actual learning of content remain an open question. Some research even lead to a significant reduction in the ability to build learning outcomes due to the overload of information due to immersive technology that distracts the learner from a correct reprocessing of data [20].

3 Brief Description of SmartMarca Project

The SmartMarca project[2] aims to enhance the cultural and tourist heritage of the local area (specifically "Fermano"), introducing innovative and digital systems to support managers and users. These tools are currently still under used and need a cultural leap in the territories with respect to the Digitization of Cultural Heritage and Tourism in general. The project explores the relationships between the user, the space and technologies, looking with a new key to understanding this synergistic relationship of interaction that links the material space to the digital space. SmartMarca intends to enhance the cultural offerings of the territory, through the use of advanced technologies such as Augmented and Virtual Reality, beacons and geolocalization systems to provide users with contextual services when exploring the territory. The main innovation brought by the project is the management platform, which has been conceived to manage different contents and output from a single cloud based service. Then, the micro-services structure enable the managers of the platform to exploit different contents with different output. A general overview of the ICT architecture of the project can be found in Fig. 1. The common denominator of the project is the concept of Senseable Space used to define a new scenario in which the user is provided with contextual services, but at the same time is able to measure actions, analyze them and react accordingly, creating an exchange of seamless information [21]. Not being the main purpose of this paper, we will not describe in deep the SmartMarca project. However, to acquaint the reader about the complexity of the project, it is important to highlight that the platform is able to manage heterogeneous kind of multimedia (e.g. 360° images, video, virtual tours, AR/VR, 3D models) every of which can be used with different devices, on-site and on the web. An example of 3D models exploitation can be seen in Fig. 2. However, for the matter of this article, it is fair to say that, to test multimedia for learning purposes, only the AR application have been used. To achieve these goals, contents can be exploited by the users thanks to the use of a mobile

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

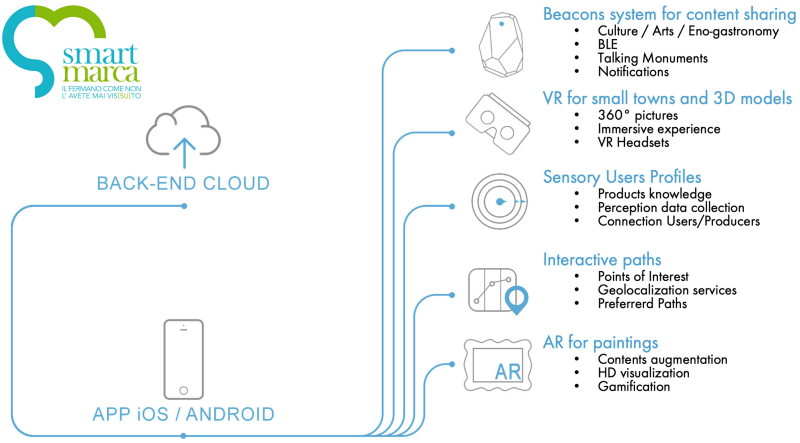
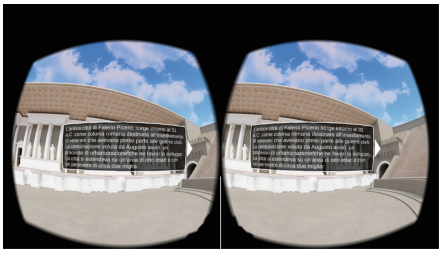
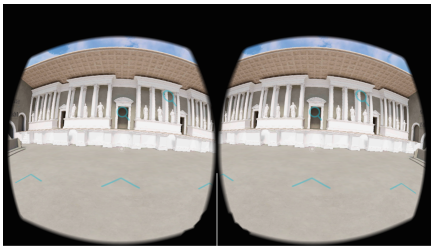


Fig. 1. General overview of the project architecture. The system allows to manage different multimedia contents in an all-in-one solution.



(a) App



(b) App

Fig. 2. Virtual Reality visualization of Falerone amphitheater 3D model. The picture represent the visualization when the users interact with VR headsets.

application, specifically designed for iOS[3] and Android[4]. Some screenshots of the developed service can be found in Fig. 3.

[3] https://itunes.apple.com/it/app/smartmarca/id1404807790.
[4] https://play.google.com/store/apps/details?id=it.ubisive.smartmarca&hl=it.

For the specific case of this paper, we will focus on the AR services specifically designed to augment two of the most important paintings of the "Fermano", to improve accessibility and learning of the painting itself. Through Augmented Reality it is possible to recognize a painting simply by framing it with the camera of your mobile phone to access increased contents, as for example (Fig. 4):

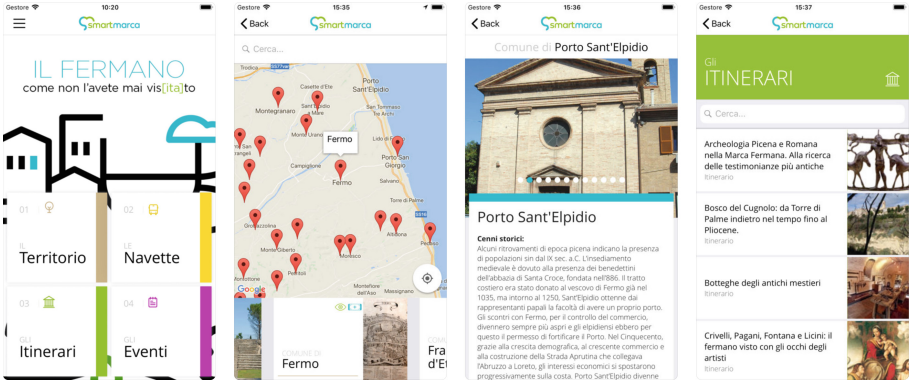


Fig. 3. Screen shots of the app running. From left to right, the home page, the geolocalized POIs, a detail of a POI, a possible itinerary.

- highlighting certain areas of the painting to provide accurate information on a specific feature;
- reproduction of video superimposed to the painting;
- display of images and texts in overlay.

.

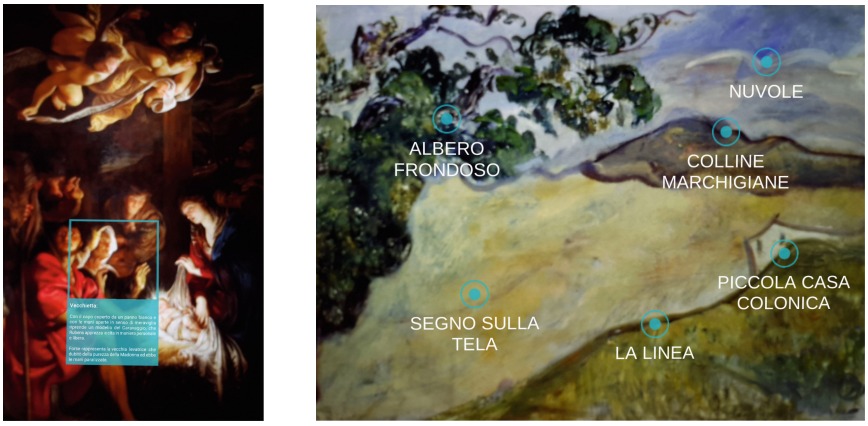
In addition to this feature we want to obtain an ultra-high definition image to allow, through the use of the application, the display of details of the paintings that would be impossible to see in the original.

4 Methodology

Within the SmartMarca project some experiences of Augmented Reality have been developed, related to the interpretation of artworks present in the territory of Fermo: the "Adorazione dei pastori" of P. P. Rubens preserved in Palazzo dei Priori in Fermo and "Paesaggio" of Osvaldo Licini, present in the artist's house (museum in Monte Vidon Corrado). The app allows the reading of the artwork through tags that, deepening the critical contents of the paintings, offer a more attentive view of the details and the entire work. The product is mainly aimed at tourists, but in the drafting of the texts it was also thought of a possible didactic use that allows to start a first proposal of knowledge of the artist and of the work in its essential contents. These tools have been used to undertake an educational validation path of AR.

Some screenshots of the application running can be found in Fig. 4(a) and (b).

The research activity has been structured in different stages and modalities, summarized in the following Table 1. This is just the first step of the research, whilst the second stage will be conduct as a future work with VR, as described in Sect. 6.



(a) Adorazione dei pastori, Rubens

(b) Paesaggio, Licini

Fig. 4. AR application in front of the paintings.

Table 1. First Step of the research path: description of the methodology used in the learning-teaching process, using AR application from SmartMarca project.

First step				
With device	Explanation of the artwork by the teacher	Check online with the *Socrative* support	Data collection and statistical definition	Analysis, data comparison and conclusions
	Without explanation of the artwork	Check online with the *Socrative* support		
Without device	Explanation of the artwork by the teacher	Check online with the *Socrative* support		

In the secondary school curriculum, the programs have provided a first approach to the history of art through interdisciplinary links that link various disciplines (Italian, History, Drawing). The students are then introduced to a comparative reading of History and History of Art which includes, although simplified, a synchronic and diachronic method of study. The use of pictorial works also favors the use of the image as a tool facilitating the vision of the object of study. The students, coming from the two-year period and the three-year period of a technical institute and a high school, were introduced to the reading of the

works - original or copied - through different methodologies, which provided a brief or thorough introduction by the guide and/or the teacher. At the end of the explanation the students were invited, through their smartphones, to access the dedicated app within the SmartMarca application. Framing the painting they had access to Augmented Reality content through overlay texts and the visualization of details, to which the markers were linked (see Fig. 5).

Fig. 5. Students using the application before the learning test.

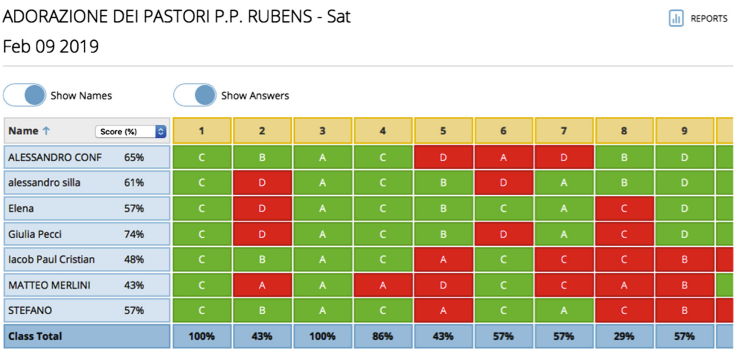
This information was subsequently verified through a series of multiple-choice questions included within *Socrative*[5] - an online application that allows verification and collection of results, data and statistics related to student learning. The questions were structured to verify the effective comprehension of the content of the texts included in the App, expanding the request to a reprocessing of the explanations. In addition to notional requests, which can be assimilated without understanding their meaning and without reworking their content, requests were made regarding critical interpretations of the symbolic meanings of the elements present in the paintings. The questions included in the *Socrative* program and explained with the help of images, were structured as in Tables 4 and 5, which can be found in the Appendix section of this manuscript.

Questions have been structured with keywords that matches with the overlay contents of the AR application. This was done to facilitate the link between the

[5] https://socrative.com.

image and its related comment. All questions are with multiple choice (four options with only one correct) in order to have homogeneous data to be later elaborated with statistical meaning. However, for some questions keywords have been removed to catch the effective learning effect on the student. Questions Q5, Q6, Q7, Q21 in Table 4 are related to the main theme of the hands of the subjects within the artwork scene. This theme was choose for its evocative value. Students have been asked to re-elaborate what was visualized in the app, to stress test their meta-cognitive learning. In the questionnaire related to Table 5 questions to check the ability to re-elaborate contents and concepts are Q8, Q9, Q10, Q11, since they attempt to deepen some details of the painting like tree and house, the main theme of the whole painting.

For the sake of completeness, we report in Figs. 6 and 7 the questionnaire results as it appear in the application used for this test, namely Socrative.

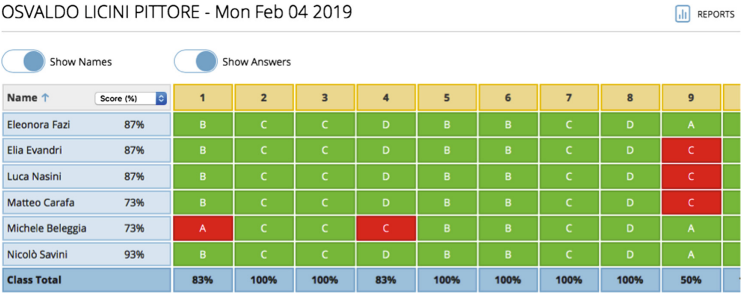

ADORAZIONE DEI PASTORI P.P. RUBENS - Sat Feb 09 2019

REPORTS

Show Names Show Answers

Name	Score (%)	1	2	3	4	5	6	7	8	9
ALESSANDRO CONF	65%	C	B	A	C	D	A	D	B	D
alessandro silla	61%	C	D	A	C	B	D	A	B	D
Elena	57%	C	D	A	C	B	C	A	C	D
Giulia Pecci	74%	C	D	A	C	B	D	A	C	D
Iacob Paul Cristian	48%	C	B	A	C	A	C	C	C	B
MATTEO MERLINI	43%	C	A	A	A	D	C	C	A	B
STEFANO	57%	C	B	A	C	A	C	A	C	B
Class Total		**100%**	**43%**	**100%**	**86%**	**43%**	**57%**	**57%**	**29%**	**57%**

Fig. 6. Questionnaire data report "Adorazione dei pastori" of Socrative program


OSVALDO LICINI PITTORE - Mon Feb 04 2019

REPORTS

Show Names Show Answers

Name	Score (%)	1	2	3	4	5	6	7	8	9
Eleonora Fazi	87%	B	C	C	D	B	B	C	D	A
Elia Evandri	87%	B	C	C	D	B	B	C	D	C
Luca Nasini	87%	B	C	C	D	B	B	C	D	C
Matteo Carafa	73%	B	C	C	D	B	B	C	D	C
Michele Beleggia	73%	A	C	C	C	B	B	C	D	A
Nicolò Savini	93%	B	C	C	D	B	B	C	D	A
Class Total		**83%**	**100%**	**100%**	**83%**	**100%**	**100%**	**100%**	**100%**	**50%**

Fig. 7. Questionnaire data report "Paesaggio" of Socrative program

5 Results and Discussion

In Fig. 8 the comparison between different testing method are reported. Percentages are related to the kind of learning process by the students, with or without

the support of AR. It is very interesting to note that Q8, Q9, Q10, Q11 have an higher percentage of positive answers in the combined modality lesson with AR (85,25%). The only use of the app is not sufficient to reach a higher degree of in depth knowledge, hence the student is not able to elaborate meta-cognitive processes (less that 50%). The classical lecture confirms an average of 65% of right answers. Thus, the use of AR increases the learning process, even if its use alone is not enough. The overall statistics collected during the tests can be found in Table 2 and Fig. 9.

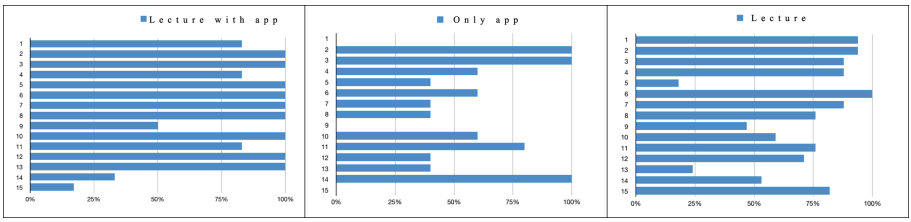


Fig. 8. Comparison of different learning methods. Left chart reports the number of right answers after the combination of classical lecture and AR. Central charts are the answers after the sole use of AR. Right chart the correct answer after the lecture without AR.

Table 2. Data final report. Comparison of all data collected with the different didactic approaches: classical lecture, only app and app plus lecture.

	Licini	Rubens	Average
Lectures	70.11%	46.25%	58.18%
App	50.82%	57.33%	54.07%
Lectures+App	83.33%	57.85%	70.59%

The results obtained in this first stage of the research path gave the following results:

1. The only frontal lesson is still a good means of transmitting contents and skills, valid for a satisfactory average learning response (58.18%).
2. The only use of the app is not a valid means of learning even if it is motivating and innovative (54.07%).
3. The synergy between the frontal lesson and the use of the app is the educational tool with the greatest results in terms of learning, with results much above average, an element that validates the value in terms of learning (70.59%).

The classical lecture still keep maintained its own value to share and spread the knowledge, since involves a bidirectional involvement between students and

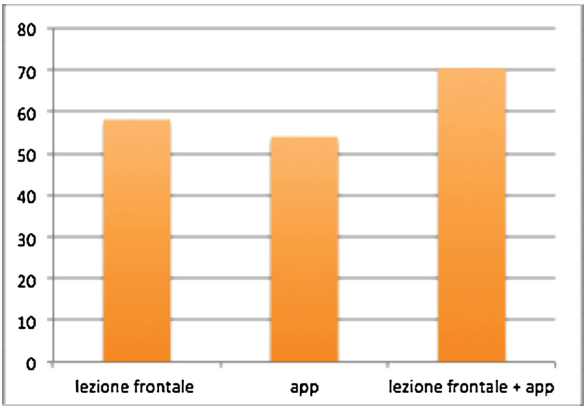


Fig. 9. Data final report

teacher. The dynamics of teaching-learning involves various factors: emotional, experiential, relational, didactic, communicative, psychological. For this reason it is not a simple passage of contents but a construction of links between the learner and the student. It is also true that learning also takes place through gestures and interaction with the environment and with the surrounding reality. In the particular case of art being able to visit a museum, to know an archaeological site, to admire a monument constitutes an added value to the knowledge of the work. The technology favors this type of process by providing tools that involve the user, increasing the ability to obtain information, details, that otherwise would be difficult to find and consult in real time. The teaching experience with the contribution of Augmented Reality contributes to improve the effectiveness of the learning process by producing scenarios enriched with content that can be easily found and used in flexible and interconnected ways. The information provided by the teacher is then enhanced through a psychological and gestural involvement that can not be transmitted by technology. On the other hand, the wealth of interrelated information is mediated by versatile devices that create experiences in which the students find a response to methods, that, nowadays, they are familiar with. The first data provided by this research leads to the conclusion of a mediated use between new technologies and traditional teaching. One cannot undertake innovative educational programs without validating their long-term effectiveness. It is therefore necessary to verify another aspect, namely that of experiential learning, that is, "learning by doing". From the data collected so far it is clear that the didactic action has greater value through the intervention of the teacher who, through an interrelationship with the students, succeeds in transmitting the contents in a more incisive manner. The contribution of Augmented Reality is edifying for a greater involvement of the students in the training activity, and demonstrates that increases the learning ability of the students, as demonstrated by the increasing number of correct answers.

6 Conclusion and Future Works

In this work, a comparative test to assess the benefits of using AR for learning processes has been presented. To achieve this result, we made use of an existing project, namely SmartMarca. The project aims to propose the implementation of omnichannel strategies targeted for each main territorial feature through the use of innovative technologies that can be inserted into paths for the enhancement and dissemination of the landscape/cultural heritage in order to expand (in terms of innovation and quality) proposed offers, promote them on a global scale to finally generate economic value. The same contents conveyed through the project have been used as a flywheel to test students when using these multimedia solutions. As a first output of this study, we can state that AR can contribute in the learning process, even if it cannot be used to completely replace the teacher, which still remains the main driver of the knowledge for the students. This research is a preliminary, but promising test, that will be enforced in the future work. First of all, we will evaluate the long-term effectiveness of AR in the learning process, by providing the same test at different times. Beside this, it will be necessary to consider the use of more intellectual AR systems where context to the students is brought through gamification scenarios and bidirectional interaction. Moreover, we will expand the research even for Virtual Reality (Table 3). In fact, the course of study and research then provides a second verification phase aimed at the creation of a 3D model of an archaeological site (see Fig. 2) by the students, with the aid of the modelling tools. In the second part of the research we will examine the value of teaching impact of new technologies through a path that sees the creation of an app by the students within an educational activity that includes the development of the teacher's frontal lesson, the direct participation of the student in the transmission of the contents of the lesson itself. A monument or part of an archaeological site will be surveyed in order to return it with a computer graphics program. Realized the three-dimensional model of the artifact will apply information overlay. The results in terms of learning will be a further element of knowledge of the potential of new technologies in the field of education and training. What

Table 3. Second step of the research path: learning effect of VR by creating 3D models by the students.

Second step				
Realization of a 3D model of an archaeological site and/or a monument (with the use of autoCAD and SketchUp)	Tagging the 3D model	Check online with the *Socrative* support	Data collection and statistical definition	Analysis, data comparison and conclusions
Creating an Aura with HP Reveal (Aurasma)	Application to the monument or to the archaeological site			

will emerge from the study will contribute to enrich the pedagogical research aimed at the introduction of Augmented and Virtual Reality in the educational learning scenario.

A Appendix 1

Table 4. Survey administered to students upon completion of the teaching experience on "Adorazione dei Pastori" di P. P. Rubens

Adorazione dei Pastori		
Code	Question	Answer
Q1	What are the elements present in the mantle of the Madonna that recall the late-ancient Christian tradition?	4 options only 1 right
Q2	In representing the face of the Madonna, Rubens was inspired by...	
Q3	The sense of vitality of the Madonna's face comes...	"
Q4	The open mouth of the Madonna alludes...	"
Q5	The hands of the Virgin are...	"
Q6	The hands of the Virgin move for...	"
Q7	The hands of the Madonna...	"
Q8	The Child is the protagonist of the painting. The painter paints him...	"
Q9	The light that comes from the Baby Jesus illuminates the face of the Virgin and of the other characters...	"
Q10	The straw on which the Baby Jesus is laid, full of light, seems to be burning while...	"
Q11	The figure of St. Joseph is confused with the colors of the background of the painting, because...	"
Q12	The landscape on the background of the painting and the figure of Saint Joseph...	"
Q13	The shepherd with sheepskin is poorly dressed, leaning on a stick and has the face of an old man. It is confused with the bottom of the painting and is placed in the extreme part of the painting. The Rubens wanted...	"
Q14	The elderly pastor puts his hand on his forehead...	"
Q15	The red of the young kneeling shepherd's tunic represents...	"
Q16	The pose of the kneeling shepherd recalls for the Rubens...	"
Q17	The old woman with raised hands represents...	"
Q18	In realizing the character of the old woman, Rubens imitates a great master of painting...	"
Q19	The four angels that accompany the shepherds are positioned high up in the canvas and dominate the scene. The composition allows to appreciate...	"
Q20	The composition of the angels made by Rubens testifies to the passion of Rubens for...	"
Q21	The hands of the different characters in the painting represent...	"
Q22	Among the different characters which seems to be a stranger to the composition...	"
Q23	The painting was intended for the Oratory of the Church of...	"

Table 5. Survey administered to students upon completion of the teaching experience on Osvaldo Licini

Paesaggio		
Code	Question	Answer
Q1	The "Paesaggio" by Osvaldo Licini is donated to the Municipality of Monte Vidon Corrado in 2015 in memory...	4 options only 1 right
Q2	The painting the "Paesaggio" represents a view...	
Q3	The birthplace of Osvaldo Licini is...	"
Q4	The artist usually paints "en plein air", that is...	"
Q5	The rich colors of the painting recalls the works of...	"
Q6	The clouds seem to transform...	"
Q7	The hills and the sky converse with each other...	"
Q8	The leafy tree in the foreground...	"
Q9	The small farmhouse...	"
Q10	The sign on the canvas...	"
Q11	The line has the purpose...	"
Q12	The painting the "Paesaggio" is made by the artist...	"

References

1. Pierdicca, R., Paolanti, M., Frontoni, E.: eTourism: ICT and its role for tourism management. J. Hospit. Tour. Technol. **10**(1), 90–106 (2019)
2. Yuen, S.C.Y., Yaoyuneyong, G., Johnson, E.: Augmented reality: an overview and five directions for AR in education. J. Educ. Technol. Dev. Exch. (JETDE) **4**(1), 11 (2011)
3. Wu, H.K., Lee, S.W.Y., Chang, H.Y., Liang, J.C.: Current status, opportunities and challenges of augmented reality in education. Comput. Educ. **62**, 41–49 (2013)
4. Chen, P., Liu, X., Cheng, W., Huang, R.: A review of using augmented reality in education from 2011 to 2016. Innovations in Smart Learning. LNET, pp. 13–18. Springer, Singapore (2017). https://doi.org/10.1007/978-981-10-2419-1_2
5. Pierdicca, R., Frontoni, E., Pollini, R., Trani, M., Verdini, L.: The use of augmented reality glasses for the application in Industry 4.0. In: De Paolis, L.T., Bourdot, P., Mongelli, A. (eds.) AVR 2017. LNCS, vol. 10324, pp. 389–401. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-60922-5_30
6. Yin, C., Sung, H.-Y., Hwang, G.J., Hirokawa, S., Chu, H.-C., Flanagan, B., Tabata, Y.: Learning by searching: a learning environment that provides searching and analysis facilities for supporting trend analysis activities. J. Educ. Technol. Soc. **16**(3), 286 (2013)
7. Pascucci, A., et al.: Science education research for evidence-based teaching and coherence in learning. In: Proceedings of the ESERA 2013 Conference. ISBN: 978-9963-700-77-6
8. Di Serio, Á., Ibáñez, M.B., Kloos, C.D.: Impact of an augmented reality system on students' motivation for a visual art course. Comput. Educ. **68**, 586–596 (2013)

9. Naspetti, S., Pierdicca, R., Mandolesi, S., Paolanti, M., Frontoni, E., Zanoli, R.: Automatic analysis of eye-tracking data for augmented reality applications: a prospective outlook. In: De Paolis, L.T., Mongelli, A. (eds.) AVR 2016. LNCS, vol. 9769, pp. 217–230. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-40651-0_17
10. Dede, C.: The evolution of distance education: emerging technologies and distributed learning. Am. J. Distance Educ. **10**(2), 4–36 (1996)
11. Dunleavy, M., Dede, C.: Augmented reality teaching and learning. In: Spector, J., Merrill, M., Elen, J., Bishop, M. (eds.) Handbook of Research on Educational Communications and Technology, pp. 735–745. Springer, New York (2014)
12. Kounavis, C.D., Kasimati, A.E., Zamani, E.D.: Enhancing the tourism experience through mobile augmented reality: challenges and prospects. Int. J. Eng. Bus. Manag. **4**, 10 (2012)
13. Pierdicca, R., et al.: Cyberarchaeology: improved way findings for archaeological parks through mobile augmented reality. In: De Paolis, L.T., Mongelli, A. (eds.) AVR 2016. LNCS, vol. 9769, pp. 172–185. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-40651-0_14
14. Garau, C., Ilardi, E.: The "non-places" meet the "places:" virtual tours on smartphones for the enhancement of cultural heritage. J. Urban Technol. **21**(1), 79–91 (2014)
15. Etxeberria, A.I., Asensio, M., Vicent, N., Cuenca, J.M.: Mobile devices: a tool for tourism and learning at archaeological sites. Int. J. Web Based Communities **8**(1), 57–72 (2012)
16. Santos, M.E.C., Chen, A., Taketomi, T., Yamamoto, G., Miyazaki, J., Kato, H.: Augmented reality learning experiences: survey of prototype design and evaluation. IEEE Trans. Learn. Technol. **7**(1), 38–56 (2014)
17. Arduini, G.: La realtà aumentata e nuove prospettive educative. Educ. Sci. Soc. **3**(2), 209–216 (2012)
18. Dunleavy, M., Dede, C., Mitchell, R.: Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. J. Sci. Educ. Technol. **18**(1), 7–22 (2009)
19. Eastman, J.K., Iyer, R., Eastman, K.L.: Interactive technology in the classroom: an exploratory look at its use and effectiveness. Contemp. Issues Educ. Res. **2**(3), 31–38 (2009)
20. Makransky, G., Terkildsen, T.S., Mayer, R.E.: Adding immersive virtual reality to a science lab simulation causes more presence but less learning. Learn. Instr. **60**, 225–236 (2017)
21. Osaba, E., Pierdicca, R., Malinverni, E., Khromova, A., Álvarez, F., Bahillo, A.: A smartphone-based system for outdoor data gathering using a wireless beacon network and GPS data: from cyber spaces to senseable spaces. ISPRS Int. J. Geo-Inf. **7**(5), 190 (2018)