ARLectio: An Augmented Reality Platform to Support Teachers in Producing Educational Resources

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Abstract: In this article we present a learning platform named 'ARLectio' based on Augmented Reality (AR) technology that aims at supporting teachers in promoting AR experience at school. The ARLectio platform has been developed in the framework of the FabLab SchoolNet project, funded by the European Commission under the Erasmus+ programme. With the use of Augmented Reality, Educational robotics and 3D printing, the objective of the project is to develop a new learning model based on the design and implementation of "objects" that can promote creativity and innovation, communication, collaboration, critical thinking and computational thinking skills in students.

1 INTRODUCTION

Recent technological developments make modern technologies such as Augmented Reality, Educational Robotics and 3D printers particularly appealing for school contexts, and easily integrated into teaching activities. A common feature of these technologies is their ability to activate *learning-by-making* experiences based on the constructivist paradigm and focused on the design and creation of tangible and sharable "objects", where students become active promoters of knowledge (Ferguson et al., 2019).

In this paper we introduce ARLectio, an Augmented Reality educational platform designed to support teachers and students in the production and consuming of AR educational resources.

The ARLectio platform has been developed in the framework of the FabLab SchoolNet project, funded by the European Commission under the Erasmus+ programme. The objectives and structure of the project will be described in the next section, together with a review on the advances in AR research mainly focusing on educational settings. In section 3, we will introduce related work on AR tools specifically designed for teachers and students in school settings, and highlight the innovative features introduced with the ARLectio platform. In section 4, after a brief presentation of the actions we have carried out within the FabLab SchoolNet project to support teachers to implement AR at school, we will describe the ARLectio tool in details. Finally, some conclusions are drawn.

2 THE FabLab SchoolNet PROJECT AND AR IN EDUCATIONAL SETTINGS

The FabLab SchoolNet project is the result of a strong transnational initiative and multidisciplinary experience of partners from five European countries: Lithuania, Italy, Greece, Bulgaria and Romania. The consortium is built on a strategic collaboration between research institutions (National Research Council, Institute for Educational Technologies, Palermo, Italy), universities (University "Dunarea de Jos" University of Galati, Romania), secondary schools (Siauliu Didzdvario gimnazija, Siauliu, Lithuania; 2 EPAL TRIKALON of Trikala, Greece; Varnenska morska gimnazia "Sv. Nikolai

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Chudotvorec" Varna, Bulgaria) and SMEs (FabLab Palermo, Italy). The transnational approach allows participants to deal with different cultures, thinking and producing new ideas in a global market context. The FabLab SchoolNet project intercepts an Erasmus+ horizontal priority and two sectorial priorities in the school education field. The horizontal priority is related to the promotion of innovative and open practices in the digital era through:

a) the learning materials that will be developed in the project, available in open format,

b) the development of innovative approaches to education, aimed at promoting effective use of the technologies adopted in the project.

Amongst the sectoral priorities, the project focuses on the problem of early school leaving (ESL) and the promotion of the acquisition of new skills, introducing a STEAM-based (Science, Technology, Engineering, the Arts and Mathematics) approach to teaching. The project aims to develop and implement a training program based on three modules addressing the latest modern technologies and tools: educational robotics, 3D printing and mobile technologies using augmented reality (AR) applications. The modules will be enriched with elements in the field of Entrepreneurship Education, encouraging participants (teachers, students, etc.) to develop new ways of thinking and act dynamically in a global market economy. In addition, the training program includes a specific module on the integrated use of the three technologies. The training program will be finalized with various contests aimed at encouraging participants to approach the real business environment and acquire the ability to think and develop models and ideas closely related to the real market.

In education, Augmented Reality is one of the emerging technologies, which has expanded in recent years. The concept of Augmented Reality (AR) dates back to the 1960s, when Ivan Sutherland developed the first head-mounted display system (Sutherland, 1965), and is based on improving user's perception and interaction with the real world. As described by Azuma (1997), Augmented Reality is a technology that combines the real world and virtual images and provides for simultaneous interaction between them. Through Augmented Reality, users can add virtual elements (textual information, images, videos or 3D elements) to the surrounding environment by displaying them in real time through the camera of the device used, whether it is a mobile device, or a viewer specifically designed for A.R. In recent years, various studies (Sayed, Zayed, & Sharawy, 2011; Wu, Lee, Chang, & Liang, 2013) have demonstrated the potential of Augmented Reality in strengthening students' motivation and making learning a more engaging, stimulating and dynamic activity. In addition, it can stimulate creativity, collaborative skills and critical thinking in students.

AR applications can be found across many areas of education, such as medicine, mathematics, geometry, biology, history and further educational fields. Salinas and González-Mendívil (2017) integrate AR technology in mathematics education to support the students to understand solids of revolution and to improve spatial visualization skills. The mobile system enables the interaction with the solids of revolution making them tangible to the students, and it promotes peer collaboration making students work in pairs. In language learning, this technology can be used to support the students on reading comprehension and learning permanency (Godwin-Jones, 2016). In fact, Bursali and Yilmaz (2019) show that, by using augmented reality applications, students perform better when compared to students who read with traditional methods. In anatomy, Argo et al. (2019) have developed an AR system that allows the study of human organs in a simple way, through the printing of a 3D model of a scanned organ and a mobile device that visualizes all the information related to the composition of the organ under examination, simply by framing it with the camera. In physics, AR can be used to demonstrate various properties of kinematics, dynamically evaluating an object that varies its speed and acceleration over time (Lee, 2012); besides, it can be used to scan a picture-marker and visualize a video of lecturer demonstrating a laboratory installation, its basic components and commenting on the experiment procedure (Hruntova, Yechkalo, Striuk, & Pikilnyak, 2018). In history education Raghaw, Paulose and Goswami (2018) have developed an AR system with the intention to support students and helps the community of tutors to make the class activities more appealing; their proposal is based on videos related to the historic lesson which are displayed on the mobile devices when a the target image is scanned. .

Although the use of these technologies is rapidly increasing and their usefulness in education has been widely proved, not all schools are inclined to use them. The main problems encountered by schools are the lack of technological tools (both hardware and software) and the lack of skills to use them, often related to teachers' resistance to adopting new educational technologies. These difficulties are amplified by specific factors; amongst the others:

- the cost of AR devices
- low usability of applications

- poor quality of available content and use cases
- lack of awareness of the benefits of augmented reality in education.

Moreover, the hardware features of most of the portable devices limit the use of this technology. In fact, the use of AR applications on mobile devices requires high computing power, sensors, cameras, accelerometer, gyroscope, digital compass, GPS.

The FabLab SchoolNet project aims to provide a solution to these problems through the implementation of innovative aspects:

- a syllabus about augmented reality, educational robotics and 3d printing for teachers
- a learning repository of educational resources on the use of these technologies in educational field
- a new tool, named ARLectio, to easily create AR experiences at school.

3 RELATED WORK ON AR TOOLS IN EDUCATION

There are several Augmented Reality applications for teaching both for iOS and Android platforms. HP Reveal (also known as Aurasma), until recently was the most used and popular. It allowed teachers or students to create or view AR experiences that blended the physical and virtual worlds using a mobile device's camera. This application was very useful in education (Marcel, 2019) because it was very easy to use and enabled the creation of augmented contents, called Aura. It could be used, for example, for the effective acquisition of geographical knowledge in high schools (Bondarenko, Pakhomova, & Zaselskiy, 2019), to provide information to hearing impaired students wishing to study Information Technology (Luangrungruang & Kokaew, 2018), or to acquiring and retaining mathematical knowledge in an informal learning environment (Sommerauer & Müller, 2014). According to the application portal, the HP Reveal tool is no longer supported. Another example of AR application in educational field is Google Expedition. It is an immersive learning and teaching tool that lets users go on VR trips or explore AR objects. Google Expedition can enhance students' motivation to learn and is particularly useful in STEM education (Shapovalov, Bilyk, Atamas, & Shapovalov, 2018). GeoGebra Augmented Reality is an educational software that allows to place math objects on any surface detected. In this application there are several examples of 3D math objects that students can analyze and use and, moreover, they can model new objects (Lavicza, 2019). The Smartify application can be used in museums and art galleries. It is an AR application that allows users to scan artworks in order not only to identify them but also to access instant art commentary on own mobile device. In fact, this system uses augmented reality and artificial intelligence to help improve the wearer's experience each time s/he visits the museum (Armfield, Hill Duin & Pedersen, 2018). Curiscope is an AR application designed for the study of human body; it allows to scan a marker printed in a special t-shirt and see the circulatory system, skeleton, muscles, and internal organs (Fuchsova, Adamková, & Pirhacova Lapsanska, 2019). Finally, a last example of augmented reality is CoSpaces Edu. With this application user can build their own 3D creations, animate them with code and explore them in virtual or augmented reality (Han, 2018). The main goal of CoSpaces is to improve the critical thinking, the collaboration, the creativity, the communication and the digital literacy of the students.

This brief introduction on the state of the art of tools to produce educational content using Augmented Reality has highlighted the lack of interesting, simple and fairly complete solutions suitable for our needs. Consequently, we have designed ARLectio, a tool that enables teachers to easily create and exploit AR educational contents; ARLectio will be usable on most of the mobile devices and will be freely available for all teachers interested in using AR solutions with their class. The ARLectio tool will be described in the next section.

4 SUPPORTING TEACHERS TO IMPLEMENT AR AT SCHOOL

Within the framework of the FabLabSchoolNet project several actions have been carried out in order to support the introduction of the Augmented Reality learning topic in secondary school contexts.
In particular, these actions are logically organized into the following phases:

- Defining a Learning Model
- Designing the evaluation strategy
- Developing a learning objects repository
- Designing the learning tools

4.1 The Learning Model

The methodological approach for teaching with innovative technologies adopted in the project is based on the *learning by making* paradigm.
Specifically, a teaching methodology has been defined with the aim of:

- supporting teachers in identifying the most relevant activities that can be implemented with the use of mobile devices, robotics and 3D technologies, to stimulate students' creativity;
- guiding teachers in supporting learners during all learning phases.

Moreover, in this phase the most appropriate tools that can sustain the methodological approach have also been identified.

The activities carried out during this phase of the project will produce a teacher book including guidelines to promote learning strategies based on the technologies of FabLab Schoolnet.

4.2 The Evaluation Strategy

The second phase of the project consists in the design of an assessment strategy aimed at evaluating the learning model.

To this aim, a questionnaire related to the initial students' skills and competences in FabLab SchoolNet technologies has been produced. Specifically, it includes items to assess: the familiarity of students with the general topics; their knowledge of related technical terms such as modelling, design, rapid prototyping; their attitude towards business opportunities in applying the FabLab SchoolNet technologies in real contexts. This data has been gathered at the beginning and at the end of the project activities, and the questionnaire will be re-administered also and at the end of the activities (pre- and post- tests), in order to measure the knowledge acquired during the training programme. This represents an important strategy to measure the quality of the project and its impact on teachers and students.

A TAM (Technology Acceptance Model) questionnaire will be also submitted to the students. TAM is considered a valid and robust model that can be used to explain potential users' intention to adopt a technological artifact (Almenara, Andez-Batanero, & Osuna, 2019). In the framework of the project, the TAM questionnaire will be used to predict teachers' and students' behavior with the project technologies as a function of their intention and attitude to use

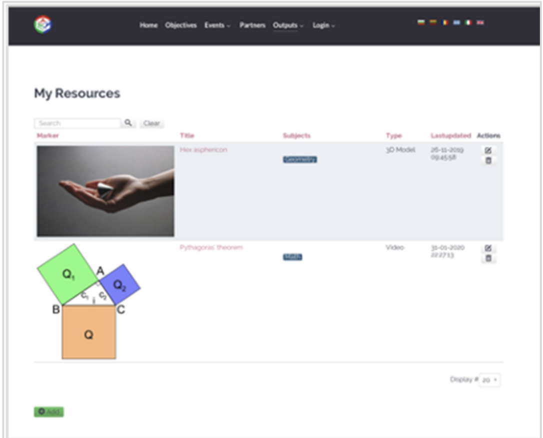

Figure 1: Educational resources list.

them. In particular, the TAM questionnaire will be used to measure the following dimensions:

- Perceived usefulness
- Perceived ease of use
- Perceived enjoyment
- Intention to use
- Personal innovativeness

On January 2020 a pilot has been started in the schools of the partnership, using the three technologies during STEAM lessons. At the end of the pilot, a report on the results of the evaluation phase will be elaborated and published, in order to inform the scientific community.

4.3 The Learning Objects Repository

A learning objects repository is designed to store, organize and share all the learning modules and materials developed during the project activities.

An initial set of learning modules that leverages mobile, robotics and 3D technologies has been created.

On this platform the output created by students during the pilot course in Greece and the cascading courses in Lithuania and Bulgaria will be collected and shared.

The learning materials collected into the repository will be described through metadata to improve their searchability; furthermore, a rating system will be implemented to activate an internal quality assurance mechanism.

Materials and courses will be released as Open Educational Resources.

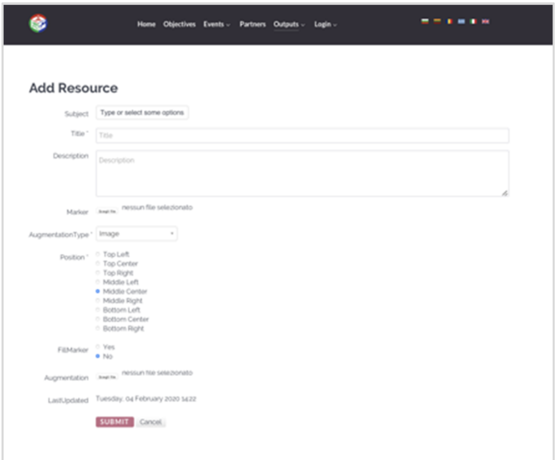

Figure 2: Create a new AR educational resource.

4.4 The Learning Tools – The ARLectio Platform

As introduced above, a tool for the creation and exploitation of AR educational content has been designed and developed. The main aim of this tool is to provide an easier way to produce and consume AR educational resources. Moreover, the idea is to provide a simple user interface to facilitate the human interaction with the mobile system. This system allows users to implement AR education contents on most media channels (images, video, text and 3D model). ARLectio is composed of a server part, a web application addressed to teachers, for the creation of educational contents implementing by AR technology, and a client-side mobile App, for students, to consume the AR educational resources.

By accessing the web application each teacher can provide a list of students to be involved and can create the AR educational resources. Teacher can create, edit delete and organize the resources by managing these main fields: subject, title, description, marker (photos, picture or QRCode), augmentation type (text, image, video, 3D model), augmentation, position.

The mobile application has been developed for students who need to login in order to access the educational AR resource created by their teachers. Resources are grouped by subject and an interactive visual scanner is available to consume the educational contents associated to markers.

In particular, the web platform is accessible from the FabLab SchoolNet project website: https://www.fablabschoolnet.eu/en/login.html.

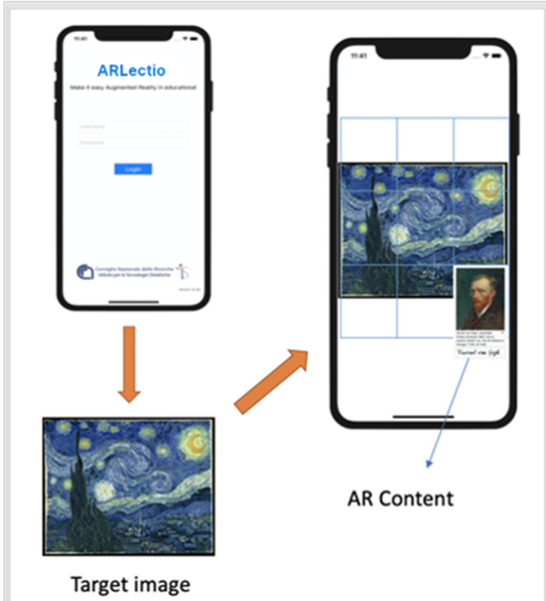

Figure 3: ARLectio mobile App.

After logging, the teacher will be able to view their resources (Figure 1), edit them and add new ones (Figure 2). The web platform is designed to be easy to use and to manage content easily. In order to create a resource, the teacher must select the category in which he/she wants to insert it, which corresponds to the name of the subject (ICT, Mathematics, Geography and other school subject), and enter a title and a description of the resource. Then, teacher can choose the marker.

This application is marker-based, so by focusing the device camera on the specified marker, such as an image or QRCode, the application is able to retrieve the information stored to display the augmentation object accurately.

After the marker has been added, the teacher can choose the type of augmented content to add: text, video, image or 3D model. The position of the augmented resource can be chosen from the nine options on the list (Top Left, Top Center, Top Right, Middle Left, Middle Center, Middle Right, Bottom Left, Bottom Center, Bottom Right). In fact, the marker is considered as if it were a 3x3 matrix, and each box in the matrix correspond to one position (Figure 3). So, for example, the teacher can choose to add the content at the top right or bottom centre or choose to have the content overlaid on the marker choosing the middle center position and selecting the fill attribute.

When the resource is saved, it is stored on a server and can be used by the AR mobile application. To develop the Augmented Reality mobile application, we first tried to understand the target device on which the application would be used. Our goal was to make the application usable on most possible devices that are not necessarily of the latest generation. In fact, there are lots of augmented reality development kits, so the choice wasn't that easy. We have analyzed the main features of framework such as ARKit, ARCore, Vuforia, EasyAR and Kudan and their device requirements and pricing and license key pricing. Since teachers and students do not always have high quality devices, we chose to use the Kudan framework, a free framework that works on both iOS and Android devices even with older operating system versions. Kudan framework (https://www.xlsoft.com/en/products/kudan/ar-sdk.html) can recognize 2D and 3D images and it relies on the use of natural features like the edges, corners, or textures of the chosen marker.

5 CONCLUSIONS

The ARLectio platform presented in this paper aims to contribute to help teachers to produce educational contents for their students and, more generally, to adopt new Augmented Reality technologies as a methodology to promote knowledge acquisition. The idea has been developed within the FabLab SchoolNet project, a project funded by the European Commission, with the general aim to provide teachers with innovative, easy to use and free IT tools that can support them in their teaching activities. Firstly, we have introduced the state of the art about AR tools available in the market, with special focus on those that can support teachers and students in educational settings. The results of this analysis have highlighted the scarcity of free and easy to use tools for the creation and exploitation of AR educational contents; consequently, we have designed and developed ARLectio, a free of charge client-server platform that will be made available to the teachers' community. Specifically, ARLectio provides teachers with tools to create educational contents based on AR technologies; furthermore, an ARLectio app allows students to access the AR educational resources through their own mobile devices. By means of the tools developed in the framework of the FabLab SchoolNet project, school teachers will have the possibilities to develop AR educational resources with their classes, and activate exciting learning by making strategies. The system has been introduced to all teachers of the FabLab SchoolNet network at the end of 2019 in the Staff Training Event held in Palermo (Italy) from 25th to 29th of November in an intensive teacher training meeting. On that occasion, ARLectio has been used by a group of 15 teachers to develop AR educational materials and the realization of learning units for high school. Teachers have widely appreciated the ease of use of the system as well as its versatility. In the following months a pilot has been started in the schools of the partnership, using the system also for the production of educational content to be offered to students in the classroom. At the end of the pilot phase, a wide test phase with school groups was supposed to start but the advent of COVID-19 emergency has interrupted the didactic activities, and therefore the experimentation activities. Nevertheless, the preliminary analysis of the feedback coming from first pilot phase has been used to improve the system; by taking into account that the system is still in pre-testing phase, the new iOS and Android versions of the software have been directly delivered to all the teachers involved in the pilot, by using the iOS Apple TestFlight platform, and a direct private download repository for Android devices. Finally, the current and future developments of ARLectio include new features for the production of interactive AR educational content as well as features for the timely management of the class group by teachers.

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REFERENCES

Almenara, J., Andez-Batanero, M., Osuna, J. (2019). Adoption of augmented reality technology by university students. Heliyon. 5.

Argo, A., Arrigo, M., Bucchieri, F., Cappello, F., Di Paola, F., Farella, M., Fucarino, A., Lo Bosco, G., Saguto, D., Sannasardo F., Lanzarone, A. (2018). Augmented Reality Gamification for Human Anatomy, GALA 2018: Games and Learning Alliance, Springer, 11385, 409-413.

Armfield, D.M., Hill Duin A., Pedersen, I. (2018). "Experiencing Content: Heuristics for Human-Centered Design for Augmented Reality," *2018 IEEE International Professional Communication Conference (ProComm)*, Toronto, ON, pp. 241-247.

Azuma, R. (1997). A survey of augmented reality. Presence: Teleoperators and Virtual Environments, 6(4), 355–385.

Bondarenko, O. V., Pakhomova, O. V. & Zaselskiy, V. I. (2019). The use of cloud technologies when studying geography by higher school students. *CoRR*, abs/1909.04377.

Bursali, H., Yilmaz, R. M. (2019). Effect of augmented reality applications on secondary school students' reading comprehension and learning permanency. *Computers in Human Behavior*, 95, 126-135.

Ferguson, R., Coughlan, T., Egelandsdal, K., Gaved, M., Herodotou, C., Hillaire, G., Jones, D., Jowers, I., Kukulska-Hulme, A., Mcandrew, P., Misiejuk, K., Ness, J., Rienties, B., Scanlon, E., Sharples, M., Wasson, B., Weller, M., Whitelock, D. (2019). Innovating Pedagogy 2019: Open University Innovation Report 7. Milton Keynes: The Open University.

Fuchsova, M., Adamková, M., Pirhacova Lapsanska, M. (2019). Uses of Augmented Reality in Biology Education. Augmented Reality in Educational Settings. pp. 168-194

Godwin-Jones, R. (2016). Augmented reality and language learning: From annotated vocabulary to place-based mobile games. *Language Learning & Technology 20*(3), 9–19.

Han, J.-W. (2018). A Study on Effects of AR and VR Assisted Lessons on Immersion in Learning and Academic Stress. International Journal of Internet, Broadcasting and Communication, 10(2), 19–24

Hruntova, T.V., Yechkalo, Yu.V., Striuk, A.M., Pikilnyak, A.V. (2018). Augmented Reality Tools in Physics Training at Higher Technical Educational Institutions. In Proceedings of AREdu 2018, Kryvyi Rih, Ukraine, October 2, CEUR, vol. 2257, pp. 33–40.

Lavicza, N.B. (2019). Teaching Advanced Mathematical Concepts with Origami and GeoGebra Augmented Reality. Proceedings of Bridges 2019: Mathematics, Art, Music, Architecture, Education, Culture, pp 387-390

Lee, K. (2012). Augmented Reality in Education and Training. K. Techtrends, vol. 56.

Luangrungruang, T., Kokaew, U., (2018). Applying Universal Design for Learning in Augmented Reality Education Guidance for Hearing Impaired Student. 250-255.

Marcel, F. (2019). Mobile augmented reality learning objects in higher education. Research in Learning Technology. 27.

Raghaw, M., Paulose, J., Goswami, B. (2018). Augmented reality for history education. International Journal of Engineering and Technology (UAE). 7. 121-125.

Salinas, P. & González-Mendívil, E. (2017). Augmented reality and solids of revolution. International Journal on Interactive Design and Manufacturing (IJIDeM), 11, 829-837.

Sayed, N. A. M. E., Zayed, H. H. & Sharawy, M. I. (2011). ARSC: Augmented reality student card. *Computers & Education*, 56, 1045-1061.

Sommerauer, P., & Müller, O. (2014). Augmented reality in informal learning environments: A field experiment in a mathematics exhibition. Computers & Education, 79, 59–68.

Sutherland, I. E. (1965). The Ultimate Display. Proceedings of the Congress of the Internation Federation of Information Processing (IFIP) (p./pp. 506-508).

Shapovalov, Y. B., Bilyk, Z. I., Atamas, A. I. & Shapovalov, V. B. (2018). The Potential of Using Google Expeditions and Google Lens Tools under STEM-education in Ukraine. *CoRR*, abs/1808.06465.

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62, 41-49.