Integrating xAPI in AR applications for *Positive Behaviour Intervention and Support*

Mariella Farella
National Research Council of Italy - Institute for Educational Technology
University of Palermo, Department of Computer Science
Palermo, Italy
mariella.farella@itd.cnr.it

Marco Arrigo
National Research Council of Italy - Institute for Educational Technology
Palermo, Italy
http://orcid.org/0000-0003-2545-2049

Giuseppe Chiazzese
National Research Council of Italy - Institute for Educational Technology
Palermo, Italy
giuseppe.chiazzese@itd.cnr.it

Crispino Tosto
National Research Council of Italy - Institute for Educational Technology
Palermo, Italy
crispino.tosto@itd.cnr.it

Luciano Seta
National Research Council of Italy - Institute for Educational Technology
Palermo, Italy
luciano.seta@itd.cnr.it

Davide Taibi
National Research Council of Italy - Institute for Educational Technology
Palermo, Italy
https://orcid.org/0000-0002-0785-6771

***Abstract*— The spread of new technologies like Augmented Reality and recent technological developments, provide innovative techniques and tools that show increasing potential in education. In this paper we will showcase the work implemented within the Horizon 2020 European project ARETE (Augmented Reality Interactive Educational System). One of the pilots of this project aims to investigate for the first time the introduction of AR to support a behavioral lesson in schools where Positive Behaviour Intervention and Support (PBIS) methodology is adopted. In particular, we present the study conducted to track user interactions with augmented reality objects through the use of the Experience API standard.**

Keywords—Augmented Reality, Experience API, Positive Behaviour, Learning Analytics

I. INTRODUCTION

In recent years, the spread of new technologies [1] such as Augmented Reality (AR) and its applications provide innovative approaches and tools with increasing potential in education. Augmented Reality is a growing technology in education [2][3][4] that has led to the introduction of new educational scenarios to support teaching and learning processes in the classroom. There are different studies in the literature showing that the correct use of AR can have positive effects in collaborative experiences and social integration [5][6]. AR is useful in enhancing student motivation through an attractive and functional learning environment [7] and can make learning a more engaging activity [8]. AR supports "learning by doing" [9], i.e. developing knowledge in an active and autonomous way and, in addition, can stimulate creativity and critical thinking in students [10]. When applied to behavioural education, that concerns the study of how the environment influences changes in students' behaviour, AR technologies are suitable to visualize directly in a real context the correct behaviour to be assumed in specific situations.

The use of Augmented Reality in behavioral education is the main topic explored inside the pilot #3 of the EU funded project ARETE [11] that aims to build a collaborative AR ecosystem with multi-user interaction to enhance educational processes. In particular, the pilot #3, named Augmented Reality for promoting Positive Behaviour Intervention and Support (PBIS), has the purpose of integrating an innovative AR solution within the PBIS framework that promotes student behavioral and cognitive growth. PBIS [12] is a multi-tiered data-driven support, assessment, and intervention system that has a potentially broad application range. PBIS systems and procedures use empirical decision making to stimulate appropriate behaviors and successful outcomes for students. Schools using PBIS are different from traditional schools. In a PBIS school, behavior is conceived as a form of communication.

In the ARETE project AR experiences, related to various PBIS scenarios, will be developed and piloted. These experiences will be used to investigate the effective value of integrating AR technology within PBIS interventions and supports to encourage positive behaviors school-wide and classroom-wide. To support the assessment of this scenario, the ExperienceAPI (xAPI) standard for monitoring and recording behavior will be adopted to integrate the AR ecosystem with a cloud-based learning record repository and PBIS analytics tools. This paper will present the creation of an xAPI profile to support PBIS methodology in the specific context of AR based learning experiences.

II. DESIGN OF AR BASED APPLICATION FOR PBIS

In the framework of the pilot #3 of the ARETE project, at an early stage, we designed an application for smart devices (mobile phone and tablet), specifically oriented to support students and teachers of the PBIS School during the behavioural lessons. This application envisages two different sections with different functionalities for students and teachers according with their role within the PBIS methodology. Specifically, students'

2161-377X/21/$31.00 ©2021 IEEE
DOI 10.1109/ICALT52272.2021.00129

area consists of three subsequent phases named: teach, practice and reinforce. Students are guided through a learning path that from the teaching of PBIS concepts, led the students towards the practice of the PBIS methodology in a real context, to finally reinforce their experience with PBIS.

The teaching phase consists of a PBIS procedure which is modeled by a didactical sequence of expected or unexpected behaviour (e.g. expected/non-expected/expected) according to the PBIS methodology. The procedure is implemented by means of animations of 3D objects rendered by Augmented Reality in context. In the practice phase, students will experiment the PBIS scenario in the school contexts. in groups they will carry out the procedures learned in the previous phase. The students can video record each other and evaluate reciprocally on whether or not the procedures have been carried out correctly. Finally, once the practice phase is over, students move to the reinforcement phase, where the peer evaluation will be conducted on a five-point scale with emoticons ranging from not well executed to well executed. In the reinforce phase students can also reinforce each other with tokens. Teachers use the application to monitor students' activities, and to evaluate the outcomes of the students during their practice phase.

III. xAPI FOR PBIS AR EXPERIENCE

To increase the accessibility, reusability and interoperability of AR Learning Objects one of the standards used is the IEEE xAPI (or Experience API) also known as Tin Can API. The xAPI specification is developed by an open community lead by the Advanced Distributed Learning Initiative (ADL) and is used to capture a variety of experiences that a user may have using different technologies or tools. This standard supports emerging technologies such as mobile learning, serious games, augmented reality and in general innovative technologies related to computer-based learning. When applied to AR, the xAPI provides a way to track students' interactions with augmented content to get a complete view of an individual's learning and its impact on his/her performance.

Each event tracked in a learning activity is defined as a Statement. The format is also derived from Activity Streams, and the main attributes of a Statement are *actor*, *verb* (action) and *object* [13]. The Actor attribute is unique information describing a specific subject, also named agent, or a group. The Actor identifies who performed the action. The Verb identifies the type of activity performed by the actor and is often linked to a human readable description of the event. The Object is related to what the Actor experiences. It may be of type activity, agent or group. Each Activity has a type, name and description and a URL with additional information. A statement can have additional attributes with more information about the experience: *result*, which contains the results of the statement; *context*, which represents the learning environment; *authority*, which specifies who ensures the veracity of the statement; *timestamp* that stores the date and time when the statement is created; *extensions* consist in the definition of the activity, context and result; *attachments* allow us to define a list of files that can be attached to the statement.

As a standard, xAPI helps to capture data without any limitations, preventing reporting errors. Creating a taxonomy is a fundamental step to identify which data points are important, to inform the design of robust reporting, and to decide which xAPI profiles, if any, can be reused.

Verb for the Teach phase		
Verb	***Source***	***Description***
Selected	id.tincanapi.com	Indicates that the actor selects an object from a collection or set to use it in an activity.
Searched	activitystre.ms	Indicates that the actor is or has searched for the object. If a target is specified, it indicates the context within which the search is or has been conducted.
Found	activitystre.ms	Indicates that the actor has found the object.
Launched	adlnet.gov	Starts the process of launching the next piece of learning content.
Consumed	activitystre.ms	Indicates that the actor has consumed the object.
Completed	activitystre.ms	Indicates that the actor has completed the object. Starts the process of launching the next piece of learning content.

TABLE I - Verb for the Teach phase

To support the tracking of user interactions with augmented objects related to PBIS, it is necessary to have a vocabulary to describe them. In the xAPI, a vocabulary profile describes a collection of verbs that are used to define a specific use case.

In the literature there are few examples of the use of xAPI in combination with Augmented Reality [14]. In [15] are reported some examples of verbs that can be used in the domain of AR such as:

- "Viewed" extracted from the tincanapi.com registry that can be used to record user action when viewing augmented content such as videos, images, text, animations, and so on.
- "Initialized" extracted from the adlnet.gov registry that can be used for example in the marker calibration phase for spatial anchors recalibration.

The application AR-PBIS App traces the activities performed by the students to allow teachers in monitoring the process and promptly intervene if at risk situations are detected. Therefore, it has the need of tracing activities related to PBIS, in conjunction with AR environments. To achieve this objective the standard xAPI vocabulary have to be extended and a specific xAPI profile has to be defined. In an initial phase, the w3id.org, activitystrea.ms, adlnet.gov, id.tincanapi.com, brindlewaye.com registries were analyzed in order to find useful profiles for the AR-PBIS app. These registries were used as examples of best practice guidelines. From these registers we extrapolated all the possible verbs and objects that can be used in this kind of AR based application. For example, if the student selects a specific setting the statement used to track this action is "Student Selected Area", where "selected" is extracted from the list of verbs in Table I and "Area" is extracted from the list of objects in Table II.

From the analysis of these registers, there is a lack of verbs and objects that better describe the user's interactions with augmented reality components.

Object for the Teach phase		
Object	***Source***	***Description***
Area	w3id.org	An identified area inside the game world.
Scenario	id.tincanapi.com	Scenario - scenario based learning - is delivering the content embedded within a story or scenario rather than just pushing the content straight out.
Level	w3id.org	A level of a game or of a gamified learning platform.
Resource	id.tincanapi.com	A resource is a generic item that the actor may use for something. It could be a video, a text article, a device, etc.

TABLE II - Object for the Teach phase

For example, when the user searches for a marker in the environment used to display augmented content. The main elements of such a statement are:

Actor: User - Verb: Looked for - Object: Marker

Where:

- the verb "Looked for" to identify the action the user does when having to search for a Marker in the environment.
- the object of type Activity "Marker" represents a target for an Augmented Reality content. For instance, an image, a QR code, a flash card etc... This type of AR is marker-based and add the AR content after the device found the marker.

IV. CONCLUSIONS AND FUTURE STEPS

The xAPI standard offers an interoperable layer to track students' activities, and to facilitate the development of learning analytics tools that support teachers in making decisions concerning educational processes in school contexts. One of the advantages of the xAPI standard is the possibility to define specific profiles, including verbs and objects, related to a domain of interest. For this reason, it is particularly suitable also in our context in which innovative approaches based on AR are used in learning and practicing positive behavioural intervention and support (PBIS) methodology. Therefore, in our proposal, the use of xAPI standards will promote the development of Learning Analytics approaches to monitor PBIS experiences. However, the current definition of our AR-PBIS xAPI profile is limited to verbs and objects related to the three specific scenarios of teach, practice and reinforcement designed so far. Indeed, PBIS is a methodology that would need a wider range of verbs and objects to be applied in more general contexts. Nevertheless, in this work we moved a step forward towards the definition of a comprehensive xAPI vocabulary for modeling PBIS experience based on AR. Further developments have been already planned in order to leverage cutting-edge Augmented Reality technology and integrate multi-user interaction and communication features.

ACKNOWLEDGMENT

The following paper has been supported by European Union's Horizon 2020 research and innovation programme, ARETE project under grant agreement No 856533.

REFERENCES

[1] Fulantelli G., Taibi D., Arrigo M. (2013). A semantic approach to mobile learning analytics. In Proceedings of the First International Conference on Technological Ecosystem for Enhancing Multiculturality (TEEM '13). Association for Computing Machinery, New York, NY, USA, 287–292. DOI:https://doi.org/10.1145/2536536.2536579

[2] Pochtoviuk, Svitlana and Vakaliuk, Tetiana and Pikilnyak, Andrey, Possibilities of Application of Augmented Reality in Different Branches of Education (October 27, 2020). Available at SSRN: https://ssrn.com/abstract=3719845

[3] 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

[4] Farella, M.; Arrigo, M.; Taibi, D.; Todaro, G.; Chiazzese, G. and Fulantelli, G. (2020). ARLectio: An Augmented Reality Platform to Support Teachers in Producing Educational Resources.In Proceedings of the 12th International Conference on Computer Supported Education - Volume 2: CSEDU, ISBN 978-989-758-417-6, pages 469-475.

[5] D. N. E. Phon, M. B. Ali and N. D. A. Halim, "Collaborative Augmented Reality in Education: A Review," 2014 International Conference on Teaching and Learning in Computing and Engineering, Kuching, Malaysia, 2014, pp. 78-83, doi: 10.1109/LaTiCE.2014.23.

[6] Alhumaidan, H., Lo, K. P. Y., & Selby, A. (2018). Co-designing with children a collaborative augmented reality book based on a primary school textbook. International Journal of Child-Computer Interaction, 15, 24-36. ISO 690

[7] Tosto, C.; T. Hasegawa; E. Mangina; A. Chifari; R. Treacy; G. Merlo; and G. Chiazzese. 2020. "Exploring the effect of an augmented reality literacy programme for reading and spelling difficulties for children diagnosed with ADHD." Virtual Reality , 1-16.

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

[9] Schank, R. C., Berman, T. R., & Macpherson, K. A. (1999). Learning by doing. Instructional-design theories and models: A new paradigm of instructional theory, 2(2), 161-181.

[10] Chiazzese, G., Fulantelli, G., Pipitone, V., Taibi, D. (2018). Engaging primary school children in computational thinking: Designing and developing videogames. Education in the Knowledge Society, 19(2), 63-81.

[11] Masneri, S., Dominguez, A., Wild, F., Pronk, J., Heintz, M., Tiede, J., Nistor, A., Chiazzese, G., & Mangina, E. (2020). Work-in-progress-ARETE-An Interactive Educational System using Augmented Reality. In D. Economou, A. Klippel, H. Dodds, A. Pena-Rios, M. J. W. Lee, D. Beck, J. Pirker, A. Dengel, T. M. Peres, & J. Richter (Eds.), 2020 6th International Conference of the Immersive Learning Research Network (iLRN): Conference Proceedings (pp. 283-286). [9155186] Institute of Electrical and Electronics Engineers Inc.

[12] Chiazzese G., Mariscalco E., Chifari A., Merlo G., Goei S. L., Mangina E., Giammusso I., Sanches-Ferreira M., and Seta L. (2019). The BASE system: a digital behavioral assessment tool for school environment. In Proceedings of EdMedia+ Innovate Learning 2019, pages 349–354, Amsterdam, Netherlands, June 2019. Association for the Advancement of Computing in Education (AACE).

[13] Manso Vázquez M., Caeiro Rodríguez M. and Llamas Nistal M. (2015). Development of a xAPI application profile for self-regulated learning requirements for capturing SRL related data. 2015 IEEE Global Engineering Education Conference (EDUCON), Tallinn, Estonia, 2015, pp. 358-365, doi: 10.1109/EDUCON.2015.7095997.

[14] Angeloni M.P.C., Saliah-Hassane H., da Silva J.B., Alves J.B..M. (2021) Model to Evaluate Users' Engagement to Augmented Reality Using xAPI. In: Auer M., May D. (eds) Cross Reality and Data Science in Engineering. REV 2020. Advances in Intelligent Systems and Computing, vol 1231. Springer, Cham.

[15] Secretan J., Wild F. and Guest W. (2019). Learning Analytics in Augmented Reality : Blueprint for an AR / xAPI Framework. 2019 IEEE International Conference on Engineering, Technology and Education (TALE), Yogyakarta, Indonesia, 2019, pp. 1-6, doi: 10.1109/TALE48000.2019.92259