Collaborative Augmented Reality Tools for Behavioral Lessons

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Abstract. Multi-user Augmented Reality experiences have proven useful in increasing user engagement and facilitating the learning of new concepts. Thanks to the new generation of Augmented Reality frameworks for smartphones and tablets, their daily use in the classroom is becoming more common. In this paper, we present the work done towards the implementation of classroom-based behavioural lessons based on collaborative Augmented Reality environments. We have developed a library that enables multi-user Augmented Reality applications and have used it to implement some scenarios developed in the context Positive Behaviour Intervention and Support framework.

Keywords: Augmented Reality · Collaborative learning · Multi-user applications · Education · Behavioural lessons · PBIS

1 Introduction

Augmented Reality (AR) experiences are thriving and becoming increasingly important in the educational landscape to increase student motivation, engagement and knowledge retention. In fact, AR can be a breakthrough in education by transforming the entire learning experience. AR makes it possible to visualise computer-generated objects on a device while viewing the real world with a camera in real time. This allows students to learn in an immersive environment where 3D augmentations and rich visual animations complement textbooks with interactive content. AR makes learning more engaging and effortless by simplifying concepts. All this makes students' attitudes more positive and increases their willingness to collaborate with other students and the teacher.

Given the above benefits and its increasing popularity, AR has become an active research topic. However, the possibilities for interaction and collaboration

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still need much improvement. In this context, the ARETE[1] H2020 project is working on a set of tools and applications with a strong focus on interactivity, collaboration and multi-user capabilities. The project is investigating the impact of AR in different subjects, including the acquisition and learning of behavioural routines in the classroom. In this paper, we describe novel multi-user AR activities that relate collaborative behaviour lessons developed within the framework of Positive Behaviour Interventions and Support (PBIS[2]). PBIS, often referred to as School-wide PBIS (Sw-PBIS) when implemented as a school-wide approach, is a framework originating in the United States for creating positive school climates. It has also been implemented in many other countries such as Australia, Canada, Norway, and the Netherlands [1]. Collaboration and interaction are essential factors in the achievement of behavioural skills as they allow students to reach a goal as a team. This work demonstrates the potential of multi-user mechanisms in the augmented space, that enable students to interact and practise a behaviour lesson together.

The remainder of this paper is structured as follows. Section 2 describes the related work. Section 3 presents the PBIS framework and the PBIS AR learning experience designed in the project. Section 4 describes the mechanisms that enable students collaboration through three examples. Finally, Sect. 5 presents the conclusions and future work.

2 Related Work

A systematic literature review [2] on interactive, multi-user and collaborative apps for education shows that AR apps are used in many settings. This is due to the importance of the intrinsic motivation of students that comes from playing the applications [3,4]. Some of the applications focus on promoting positive behaviour in kids, like SeAdventure [5], which focus on environmental education and management, while others focus directly on a specific school subject (e.g., ASTRA EAGLE [6,7] for math, or [8] for learning properties of light). Other examples include the work of [9], where students take turns moving the pieces of a jigsaw puzzle and solving it together, or [10], which describes a whole-body interactive learning game for children with Autism Spectrum Disorders (ASD) where participants work together to find a solution.

However, most of the studies neglect the human collaboration factor and very few AR apps focus on proactively promoting positive behaviour. To address this gap, we identified, designed and implemented a set of classroom-based behavioural lessons that could foster interaction and collaboration.

3 PBIS and Behavioural Lessons

PBIS supports schools in creating (school-wide) systems that establish the social climate and individualized behavior supports needed for a safe and effective

[1] https://www.areteproject.eu/.
[2] https://www.pbis.org/.

learning environment for all students [11]. Research has shown that PBIS contributes to a better classroom learning climate, reduced student segregation and improved academic achievement [12–14]. Behavioural expectations are taught directly and continuously in the same manner as academic skills. They are defined, modelled, practised, provided with corrective and positive feedback, and encouraged in the natural and applied setting. In addition, behavioural expectations are taught using real-life behaviour examples that are observable, relevant, and doable, in real contexts or settings within the school.

The template we propose for a scripted behavioural PBIS lesson is described in Table 1 and is based on the practises defined in [15]. This template is also the basis for the technological affordances of PBIS lessons using the AR application developed in the ARETE project, described in Sect. 3.1.

Table 1. Behavioural PBIS lesson structure

(Schoolwide) Behavioural expectation (expected behaviour): This entails the following specific behaviour in this setting:
Lesson objective: Subgoals:
PBIS value:
Starter/prompt/remind Short and tangible, attract attention by showing/telling (approx.1 min).
Teach: instruction and explain Includes stating lesson objectives and making them visible.
Modeling Teacher models expected behaviour: 3 example behaviour, 1 non-example behaviour.
Practice A set of evidence-based interventions and strategies used to teach, supervise and monitor both non-classroom and classroom settings.
Reflection/review Give and solicit the students feedback and deliver consequences as necessary.
Acquirement and retention Post-lesson: call attention to practice behavioural expectation daily during one week.
Evaluation Post-lesson: evaluate learned behaviour with students after one week

3.1 The PBIS AR Learning Experience

The PBIS AR learning experience consists of embedding AR in the learning process of the behavioural lessons explained above and use it as a support for behavioural teaching, practice and reinforce phases. Figure 1 shows the principal characteristics of the PBIS AR learning experience. The student is facilitated in using AR to gain autonomy in managing expected behaviours in school settings and applying different social skills according to the school values. In our vision, AR technologies can be effectively integrated in PBIS learning phases to allow a new PBIS AR Learning experience.

To achieve this, we introduce the concept of AR Behavioural Learning Space (AR-BLS), a physical learning space enriched with AR Behavioural Learning Resources (AR-BLRs) specifically created by the teacher and uploaded to the ARETE 3D digital repository[3] for behavioural teaching. The PBIS AR learning experience, is supported by the following equipment: XR ready-to-use mobile devices, a PBIS-AR mobile App and support for the ARLEM-compliant [16] Authoring toolkit MirageXR[4] for the creation of AR-BLRs by teachers. These AR-BLRs are created in specific school settings to provide a more realistic learning experience for students. The PBIS-AR mobile App allows students to play marker-less AR-BLRs collected in the ARETE repository and created through the MirageXR Autoring toolkit but also to engage them in AR marker-based quiz games for practising and reinforcing the behaviour learned. The AR-markers required by this second activity are distributed among different settings of the school allowing student to retain the behaviour in the right context, and gain points and badges, according to a reward system. The app also provides students with interactive and collaborative learning activities with multiple users to improve their behavioural skills. Finally, student interactions and experiences are tracked using the Experience API (xAPI)[5], which tracks students interaction with the system and provides feedback on the learning process [17].

The combination of these technologies creates an example of a technological ecosystem for the creation of AR behavioural lessons. Section 4 presents the first prototypes of AR-BLRs for the creation of interactive and collaborative multiuser activities that allow students to test and reinforce the behavioural skills they have learned.

4 Multi-user Activities Within Behavioural Lessons

In order to give the students the opportunity to practice the behavioural skills described in Sect. 3 and to analyse the benefits of collaboration in the learning process, three AR multi-user examples were developed:

- **Greeting others**: Greeting others is a role-play game in which students learn how to greet others through a quiz (see Fig. 2 (A)). Two students participate in the same session with their own devices, one as a teacher and the other as a student. They then scan a marker and see the augmented characters along with a question asking them to choose how to greet the other. Only when both have chosen their answer the characters show the greetings through synchronised animations. If the animations are played and the answer is wrong, they are asked to try again. Otherwise, students are rewarded and the game is completed.

[3] https://arete.ucd.ie.

[4] Enriched Mirage XR for creating AR-BLRs https://wekit-ecs.com/documents/miragexr.

[5] https://xapi.com.

PBIS AR Learning Experience

Learning outcomes

The ability to manage one's expected behaviour in accordance with the school's values. An improvement in social skills. A decrease in the emission of problem behaviour. A more relaxed and calmer attitude in the school settings.

Equipment

- Tablet/mobile devices XR ready.
- **PBIS-AR mobile App**.
- **MirageXR Authoring toolkit**.
- Internet connection.

Media production

Building of **Augmented Reality Behavioral Learning Resources** (AR-BLR), scenes in the school location according to good and bad story-boards of behaviour, using 3D characters with atomic action associated.
The teacher could create new AR behavioural contents according to the behavioural lesson publish them in the ARETE repository and organizing them according to their group of students.
Multi-user interaction activities on specific behaviours integrated in the **PBIS-AR mobile App**.

Audience

Professional training of teachers in the creation of AR-BLR. Creation of new skills in the use of the MirageXR Authoring toolkit. About five meetings were held to train the teachers. The PBIS-AR mobile App can be used by students without any specific technological skills. Apps can be used in collaborative activities. Supported languages: Italian and English.There are no security risks.

Ux Design

Self-paced and multi-user. Used at school by a student during the lesson studies. Playing of a scene to model expected behavior. Examples of behavioral scenarios specifically used in the actual school setting in which AR characters perform good or bad example of behavior. Using AR marker-based quiz games for practicing and reinforcing the behaviour learned and multi-user interactions tasks between users, where two students can interpret a character's role to perform expected behavioral actions.

Success metrics

Scales about teacher experience, sense of efficacy, usability; teacher ratings of students' behaviors; # of expected behaviors emitted; # of interactions with AR contents; # of successful AR multi-user interaction activated; xAPI data.

Distribution

PBIS-AR mobile App install required. The AR contents can be distributed in the ARETE AR repository.

Expectations

The learning of behavioral expectations playing different 3D AR behavioral learning resources, practicing behavioral learning engaging in AR quiz games and performing multi-user interactive AR behavioral activities It's possible to think about the possibility to realize in real-time behavioral scenes localized in specific setting at the schools. The author of the scene will thus be able to demonstrate effective mastery of behavioural practice and be able to compare himself with his peers engaged in other similar activities. It is necessary to think about the possibility of making AR objects interact with each other in order to increase the possibilities of implementing more complex and realistic scenarios.

ROI

The opportunity of creating new open and reusable educational behavioural resources, the AR-BLRs, to be included within behavioural lessons. The use of the application makes it possible to enrich behavioural lessons without having to resort to rather expensive and complicated video modelling techniques. It also allows examples of behavioural expectations to be disseminated easily and cheaply.

Fig. 1. The PBIS AR Learning Experience canvas covers all the aspects related to the PBIS Learning experience, including the skills that the students achieve, the equipment needed to carry out the lesson, the target audience and the creation of the media content. It also describes the user experience, the distribution of the content, the metrics used to evaluate the students, the expectations and the benefits of implementing the experience.

– **Stand up for others**: This is another role-play activity in which two students learn how to behave when they see a group of students laughing at other (see Fig. 2 (B)). First, both students choose a character and scan a marker to visualise some animations showing a group of students laughing at a victim. Both students are considered as helpers and decide through a quiz how they would help the other. When both choose an answer, the characters show their choice through synchronised animations on both devices. If the answer is wrong, they are asked to try again. Otherwise, the students are rewarded and the game is over.
– **Keep the workspace organised**: The third scenario differs from the previous ones both in the type of interaction and in the resources needed. In this case, two students learn how to organise the workspace by interacting with virtual objects that they visualise on a real surface (see Fig. 2 (C)). First, they choose a surface on which they can place a drawer with different objects stacked on it. Then, they are asked to take the Maths book that is at the bottom of the drawer. So to take it, they have to take out all objects. Therefore, the students take turns to drag the objects and put them on the surface. Then, they answer a quiz and think about how much time it took them to find the materials they need because of the lack of order in the drawer. When they both answer the question, they are requested to tidy up the unnecessary items and they take turns again to put them away. Finally, when only the maths book is left on the surface, the application tells them they are ready for the lesson.

The complete sequences can be visualised in this demo videos[6] and the code of each example can be found in GitHub[7]. As can be seen, these examples have been designed to allow students to work in pairs, each with their own device, to allow multiple users to interact in the augmented space. This is done through the Orkestra library [18], which provides technology-agnostic communication between users connected to the same session. The library is based on web technologies and uses websocket server to manage all connections and provide data persistence. However, most of the logic is on the client side, and a Unity port is available to simplify its use in different mobile devices.

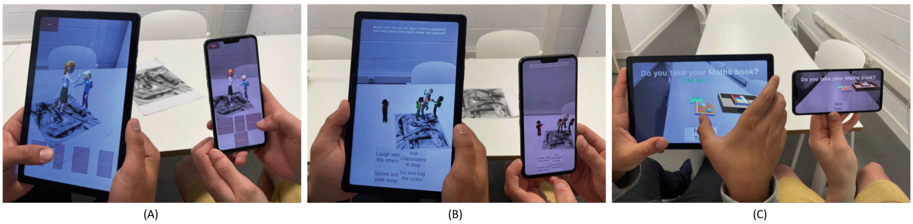

Fig. 2. Multi-user scenarios

[6] https://vicomtech.box.com/s/rws1er6dp0uum3ei0x9ren4n42ircwu7.
[7] https://github.com/tv-vicomtech/PBIS-AR-Demos/.

The mechanisms necessary to enable communication between the students' devices and maintain data coherence are: detecting the connection of both users, adapting the visualisation of the characters to the respective user perspective, synchronising the interaction and animations, and tracking the movement of the scene objects. In order to enable all these requirements, Orkestra sends specific notifications between the users at different dispatch rates. In this sense, the third scenario represents much more complex interactions, as the second student has to perceive the movement of the dragged object in real time, which requires a high number of messages per second. Therefore, it was necessary to find a balance between the smoothness of the object movements and the number of messages to avoid low performance of the application. The tests carried out have shown that Orkestra is able to generate and receive events up to a rate of 30 times per second with an average latency (time between sending and receiving) of 205 milliseconds, allowing users to experience fluid interactions. In addition, the library can be used on both Android and iOS devices without any significant difference in performance.

5 Conclusions and Future Work

In this work we described an application of multi-user AR technology in the context of the PBIS framework. The examples developed are used to promote positive behaviour between students by letting them to interact with each other and by showing them the expected behaviour when they do not perform the appropriate and expected action. The activities described here are currently being integrated into a single AR app, which will be validated in a pilot with several PBIS schools in the Netherlands and Italy by comparing the progress of pupils with a control group not using the AR application.

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