MyScore – Avatar-Based Teaching and Learning

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Abstract

This paper describes the implementation of the MyScore - "Avatar-based teaching and learning in higher education" virtual reality project using the game engine Unity. General and specific approaches are presented in detail and by means of use cases, contents of the developed scenarios are showcases and explained in regard of their application in teaching. First results of student testings in general and during teaching lessons, promise a potential for future uses as well as illustrating challenges.

Keywords**:** MyScore, Virtual Reality, Education, Avatar, Open Source

1 Introduction

The modern form of virtual reality (VR) is a concept formerly invented in the mid-20th-century, which describes the usage of technology to simulate experiences, that are based or derived from real life experiences [SBH98]. After a stagnation in usage of VR technology [RBT98] and the introduction of new devices [LYK14], nowadays, virtual reality hardware is more marketable and accessible for the broad public [KZ22]. Current VR headsets (Meta Quest [MP22] or HTC Vive [HC22]) are available as standalone or connected to base stations like PCs, where users use standardized controllers to interact with the virtual world [HC21]. Due to the accessibility of the new hardware, a wide range of applications and use cases are available as well, which touch topics of medicine [BLB21], culture [GWL21], entertainment [S21], the working area [FW20] and education [FO15].

In regard of education, besides three-dimensional virtual reality approaches, in the last two years, classical tools like videoconferencing (widely used Zoom [Z22]) and file sharing systems (Moodle – [DM22]) were used extensively in regard of remote teaching and working [ET21]. In the context of the digital transformation in higher education, as well as the experiences of the pandemic showed us, that there are boundaries in classroom teaching as well as hybrid approaches such as blended learning [ML21].

The greatest disadvantage is the location-dependency of these concepts. The widespread use of videoconferencing software and file sharing systems bridges the distance between lecturers and students, but these approaches have their own limitations as well [ML21]. Therefore, new digital approaches and methods are needed to offer lecturers and students enriching extended reality experiences in a virtual environment for learning purposes, besides the classical tools offered [MT22].

Avatar-based teaching and learning in higher education (AVE) which is part of the RWTH-project "Mobility System Cooperation in Higher Education (MyScore)", is one of these suggested digital tools, which is currently in our development. The open source and open educational approaches offer a template for institutions in higher education and features the creation of general and specific virtual reality scenarios and use cases, based on a set of pre-developed and modular components (see section 2). MyScore offers open collaboration and communication in the virtual space, where lecturers and students can join with their virtual representatives, so called avatars (see section 3). Offering the users, the ability to use 3D spatial audio and in case of the lecturers, real face data for custom avatar creation, enables high immersion in the virtual scenarios (see section 2). In addition, a menu (see section 2.6 for more details) with different features, like an integrated VR web-browser or specific admin functionalities, offer different tools for collaboration and lecture moderation (see section 4). Special use cases like the flood protection scenario or the role play scenario, showcase first impressions on how to integrate learning methods into an VR environment, to achieve certain training effects in haptic movement or presentation skills (see section 4).

AVE, as open-source and open-educational approach, will officiate as template for customization of own educational content, with a set of pre-developed components and inspirational ready-to-use scenarios.

In the following sections, available use cases, used tools, features and results of student tests will be presented and discussed in the conclusion.

2 Scenarios and Features

AVE offers several virtual scenarios which are tailored to suit the different situational needs of lecturers and students alike. The list of available scenarios will be expanded on in the future. Depending on the use case, a classification between general and specific scenarios is described. General scenarios are made for use cases regarding communication and presentation, whereas specific scenarios are created for educational or training purposes. General scenarios like the welcome scene (offline scene) offer the home location or hub, where the users will find themselves upon starting the VR application. Here the choice of personal settings or selection of online scenarios can be made, where in a specific scenario, like the role play scenario (online scene), can be used to train the presentation skills of the students (see section 4).

2.1 General scenarios

In the group of general scenarios, AVE offers the welcome scene, the tutorial and conference cube scenes. Whereas the welcome scene and the tutorial are offline scenarios, the conference scene(s) have online functionality. In the welcome scene, which can be seen as the hub, is the scenario which the user enters after the start of the application. Here, he can choose the avatar, change the personalized settings (e.g., user height, movement speed, language choice), switch to the application tutorial and select, create or join an online scene.

2.2 Specific Scenarios

The specific scenarios provided, will offer different use cases in the topics of education, communication and training. For example, the role play room, which enables students to train their communication skills with interactively controlled NPCs. The Laboratory for Machine Tools and Production Engineering **(**WZL) hall offers students a first orientation of the real space with visiting 360° spheres presenting real life images, as well as the interactive building of a mobile flood protection unit.

2.3 Eye Tracking

With eye tracking technology, student and user behavior can be tracked for research. In the role play scenario and the building of the mobile flood protection unit, it is possible to use eye tracking methods to track objects seen during the sessions. The provided data will be exported as .csv file with information like the seen object name, the timestamp, looking duration and amount to analyze further.

2.4 Individualized and general Avatars

Providing individualized and general avatars in AVE offer lectures the possibility to use their own image for their own recognizable visual presentation, while students and other users can select a generally generated avatar. The personalized avatars in this approach provide a certain familiarity by increasing the sense of comfort and immersion [Par22].

2.5 User Settings

The user settings, which can be changed in the welcome scene, as well as in the user menu of the online avatars, contain the vignette, language and general settings tab. The vignette effect (depending on the intensity of the angular velocity and linear acceleration of the user), is a method for reducing motion sickness [NBW18], can be changed separately. A language choice provides different translations of the UI elements, whereas the general settings offer the change of the avatar height, the acceleration and rotation speed of controller input. As an assistance, the 3D controller models (Meta Quest and HTC Vive) can be activated with UI information of the button mapping. Additionally, the user can enable the haptic UI elements as well as audio feedback.

2.6 User Menu

In the online scenarios, the users are given the ability to use additional functionalities. Besides the described user settings, the users can choose to enable different tools (Figure 1) for productivity like the notepad, the draw pad and a fully functionally web browser. An extra menu sections offers the ability to log out from the online scenario as well as hide / unhide the user menu as well as the VR keyboard. Every tool can be shared on specific screens in specific scenarios, to provide other users with individualized data (e.g., screen-sharing of browser content, like a presentation). The admin menu provides the users with authority with specific functions, as seeing the attendance list of the users online in the scenario, or scene specific functions like the NPC behavior control in the role play scenario.

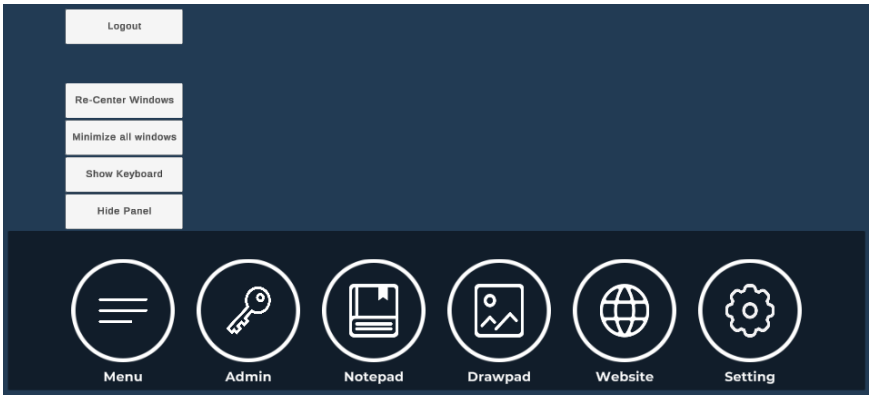

Figure 1: User Menu with active Menu UI element

2.7 360° Media (Images and Videos)

For additional use cases in the scenarios, AVE enables the functionality to use customized 360° media spheres. These spheres can showcase 360° images and videos, whereas videos contain an additional menu for media stream control. The spheres itself are modular and can be enriched with 2D UI elements like texts and additional images. The spheres can be set to different sizes, as background spheres or inside the 3D environment, where the users can choose to walk into them, to enable a scaling effect.

3 Tools and Methodology

The use of a game engine is very often needed in developing a VR application, in which MyScore is no exception. A game engine provides a framework and functionality for developing an application [Gre18]. There are various game engines such as Unreal [EG22], Unity [UT22] or Godot [LM22]. In the MyScore development, we choose Unity3D (2020.3.20f1) due to the familiarity of the game engine and the suitability for individual or larger teams [UT22]. Unity also uses C# scripting language which is one of the most preferable programming languages [UT22]. In addition, an extra plugin from Unity, called XR SDK is also integrated to the project. The XR SDK is intended to ease the VR development by equipping the developer with pre-programmed VR features such as user input, controllers and rendering to build immersive VR experiences for the user [UT22].

To create 3D assets, such as the scenarios, avatar models or props, Blender (3.1) [BF22] is our modeling software of choice, due to the software being free and enabling to support the entirety of the 3D pipeline (modelling, rigging, UV wrapping) of asset creation [BF22]. The created 3D models later on will be exported in the .fbx format, which is used as a general 3D format data exchange to Unity [UT22].

3.1 Avatar Implementation

As is the norm with most recent VR applications MyScore provides the user with a player character model as a virtual representation of themselves, respectively called avatar. This avatar gives the user the ability to move within and interact with the virtual environment. Their models, as stated before, originate in the 3D modelling tool Blender, where they are rigged to translate the movement of the user in real time. Rigging is the process in which a model receives an internal skeletal structure that defines the transformation, which needs to happen when the user moves around within the VR environments [Bri21]. This basically means that when the user moves his hands, the hands of his 3D avatar will move and/or distort in the same way. A correct rigging approach will therefore translate the input from the users' movements into realistic transformations of his virtual body.

Early approaches saw us draw upon the aid of Mixamo [M22] to help perfect the rigging of the avatars within MyScore. Mixamo is an online rigging tool developed by Adobe where you can upload models and have them rigged via an automated process [M22]. More recent approaches however see us making use of Blender add-ons such as Human Generator [PL22] and FaceBuilder [K22] to perfect the models and player movement. Human Generator is used as a template from which the current rigging starts, albeit manually simplified to better suit our needs. FaceBuilder on the other hand is used to translate a set of photos (Figure 2) into a personalized avatar (Figure 3) resembling the user. Later iterations of the software will also provide the user with the ability to construct their own avatar within the app via the selection of premade models, such as glasses, clothes and a wide array of options.

Figure 2: User photo for avatar creation

Figure 3: Individual avatar result

3.2 Virtual Environment Implementation

Virtual environments, or so-called scenarios, are designed and programmed to further immerse the user during the VR lecture. Certain add-ons such as GIS for Blender, which allows the usage of real-world geographical data [Dom22], may be employed but in MyScore the virtual environments are generally created manually to ensure the best performance and control over detail.

At the start, the concept and use case for the scenario is defined. Afterwards the corresponding 3D environment and interactive elements will be designed in Blender. The 3D data is later imported into Unity. At the same time, depending on the use case of the interactive elements needed in the scenario, further scripts are programmed to fulfill its intended functionality. After testing and feedback by the development team and scenes´ commissioner (which can vary depending on the cooperation with different universities) the scene is optimized to run on the demanded frames per second to ensure a quality experience. Finally, the finished scenario will be uploaded to our server, where the user later can download and access the scenario on the preferred device.

4 Use Cases and Practice

As introduced in section 2, there are general and specific scenarios available in the AVE application. In this section, we go into detail of the functionalities of these scenarios as well as present some results of the student tests afterwards.

4.1 General Scenario: Welcome Scene

One of the first scenarios a user gets contact with, is the welcome scene. This scene can be seen as the hub section of the application, where users can change their avatars (Figure 4), user settings and select, create or join online scenarios. For users unfamiliar with VR or little experience, an individually created tutorial section is provided. For the first impression of the welcome scenario, a robot character greets the user in the selected language and provides additional information about the scene.

Figure 4: Welcome scene Avatar choice menu

4.2 General Scenario: Tutorial

For users new to VR, we provide an individual tutorial scene, besides the solution from the used hardware. This scene offers a step-by-step introduction of the controls of the application as well as a sneak preview of the latest features like a 3D whiteboard. The tutorial steps itself can be skipped anytime, so the users don't need to start from the beginning, when they want to refresh just a specific control.

4.3 General Scenario: Conference Cube / Katschhof

For communication and presentation purposes, the conference scenario can be used. A conference room is set up with a modular part and an individual part. The modular part, is the conference cube, which can be used in different scenarios.

Depending on the use case the scenarios can be modelled with individual 3D environments (e.g., a 3D model of the Aachen Katschhof, an area in the center of Aachen) or in case of the conference360 scene (Figure 6), a 360° sphere background can be used to project an individual 360° background. The conference cube provides the functionality to project the individual windows of the user menus, like the web browser and offers a group of attendees a good base for discussions (Figure 5).

Figure 5: Conference cube scenario

Figure 6: Conference 360° cube

4.4 Specific Scenario: WZL Hall

The 3D model of the WZL hall is an abstract version of the Laboratory for Machine Tools and Production Engineering of the RWTH Aachen. Users can get a glimpse of the real-world hall by the placed 360° spheres (Figure 7) inside the scene. The spheres are positioned in a way to provide different angles to achieve a realistic feeling of the space of the real hall. This feature is specifically offered to international students, which could not visit the real site, during the pandemic, to familiarize themselves with the environment. Additionally, the WZL hall offers a learning component for students of the hydrology department. Building up a mobile flood protection unit in 3D (Figure 8), is one of the first defined educational scenarios of the AVE application. Students can check the manual for the building steps, assemble the flood protection wall and sending in virtual flood particles to test their construction. According to Marks et. al. [MT22] there are beneficial effects in the learning process of students, that had training sessions in VR and repeating a similar test in the real world. In that case, the research of the effect of building up the flood protection unit by students in VR and in comparison, to real-world assembly will be conducted in the future.

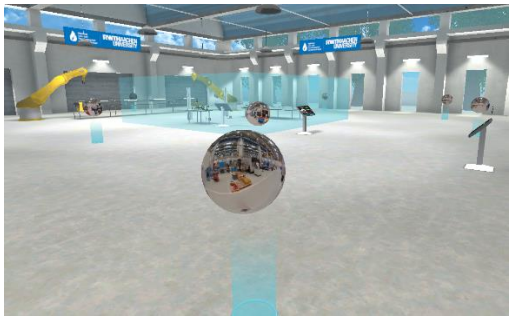

Figure 7: 360° spheres in the WZL hall

Figure 8: Flood protection wall scenario

4.5 Specific Scenario: Role Play Room

The role play scenario deals with the learning content of conversation and presentation training. Student's improvisation and adaptation skills will be tested during a session. This scene provides NPC (non-playable characters) avatars (Figure 9), which can be controlled by UI elements inside the admin panel in the user menu (Figure 1). This panel offers the selection of feedback behaviors (-5 discouraging to +5 cheering animations or general distractions) (Figure 10), which represent an intensity of the animations of the NPC characters. Depending on the situation, lecturers can manually decide how the NPCs can behave, so the student will get direct feedback of his behavior during e.g., his presentation.

Figure 9: Role play scenario

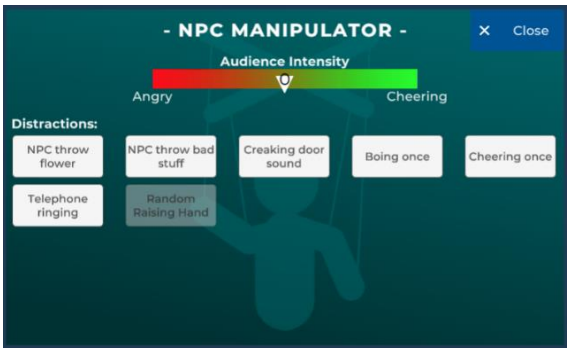

Figure 10: NPC control window

5 Feedback, Challenges and Conclusions

MyScore AVE was tested and presented during events and lectures since the start of the development. Our target groups are mainly lecturers and students, though, regarding events (with topics of social interaction, gaming, media and education) the user base differs broadly. Besides general challenges like the technical setup (stable internet connection, access to devices, virtual boundaries and ground recognition, as well as controller tracking and energy sources) there are user experience specific challenges.

In general, the feedback of users regarding the usability, the provided content and the idea behind the project is positive. However, the most striking challenge we encountered during our presentations, is the technical know-how of the users itself. Depending on the user group, this know-how connected to the lack of possibility to test the application or in a more general term, test VR devices beforehand, leads to the challenge, to spend more time for instructions and introducing users to the virtual experience. The general unsteadiness of first-time VR users leads to a general lower motivation and acceptance of the provided content, whereas more experienced VR users, directly start to explore the scenery and feel more confident in using our application.

According to KZero [KZ22] the number of active VR users 2018 was forecasted to be around 171 million worldwide, considering the upward trend, it is likely higher nowadays. However, the number of users reflect, that the adoption of VR has not arrived in the broad public. This is also in alignment with our experiences during the testings and presentations. Nevertheless, we observed, that most of the first-time users, get comfortable after the first hurdles of understanding the VR controller mapping and functionality. After an average of approx. 10 min most of the users could make significant progress in the usage of the VR device as well as the application.

Our specific use cases like the WZL hall and the role play hall, were used in student testings mainly and offered valuable insights. Building up a real-life mobile flood protection wall is part of the lectures for hydrology students. Due to the pandemic, building up the real-life wall was not available in the last years. Our aim was to provide students with a virtual experience and research further the effects on building up the real-life wall, while comparing with a reference group, which doesn't use the VR experience and if there are beneficial effects. This research is still ongoing. However, the general adoption of the students regarding the VR experience is positive and showcase first understandings on how to build up a flood protection wall. In regards of the role play scenario, students could give a presentation under exam conditions, while being exposed to the NPC reactions (section 4.4). This scenario and use case in general were well received. The students reported that the immersion during the NPC reactions was very high, while being under conditions of a real exam situation, thus leading to higher attention on the situation and learning situation.

In conclusion regarding our findings, we can say, that more research has to be done on how to provide users with little to none VR experience, with enough content beforehand, to ease the first-time usage of VR. Once given these first steps, the users will independently discover the provided content. Once, the users get more confident with VR, the general and specific use cases are perceived more constructive. Use cases regarding educational content were perceived positively in general by the students, whereas the learning effects (WZL hall and role play room) need more research and evaluation to support our findings.

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