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Design of a virtual tour (journey) for teaching Room Acoustics

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Abstract

The development of new ways to teach different and complex topics has reached new grounds through video games. The modern state of computer processors leads to better and realistic simulations. The acoustics field is not indifferent to this. Better auralization models to represent the acoustics of different geometries have been developed. An accurate auralization model can represent the acoustics of a room and how it shapes sound. This can be used to teach acoustics concepts like Reverberation, by allowing the learner to listen to the space. Based on this state of the art, it is proposed the design of a Virtual Tour, with the main goal of teaching Reverberation and Speech Intelligibility, both fundamental concepts in Room Acoustics. It is proposed that the concepts are taught in a linear way through a selection of activities, in which the learner has to participate in their learning process, and more importantly, to listen and compare how different rooms affect sound (for example: two rooms with different kind of reverberation as from lower or higher tones are presented in the sound tour). The final product was tested for technical and pedagogical feedback, in which students of Sound Engineering gave their impressions. The results for the Tour were positive, the technical feedback allowed an improvement in performance, and the pedagogical aspects had positive reception from the students. This is reflected in the virtual characteristics of the tour and in the potential to improve and expand it to other concepts in Room Acoustics or even Psychoacoustics. It is expected that this work will lead the way for other gamification projects in other areas of knowledge.

Keywords: Reverberation, Gamification, Virtual Trip.

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1. INTRODUCTION

The COVID-19 pandemic marked a new way to interact virtually. Works, meets and classes became virtual. Teachers had to find new ways to teach in this virtual environment, both theoretical and practical. Because of the restrictions, spaces for practical experience were not available, measurements could not be made or hearing the natural response of a room.

In practical teaching of Room Acoustics, certain topics are very important, such as Reverberation. Nevertheless, their listening aspects are fundamental to the perception of the sound field, especially in undergraduate students.

Historically the videogame industry has remained their focus on entertainment. However, since its inception, many developers have seen the potential of video games for teaching interactively a variety of different topics, designing an experience for the student. [1]

In this work, a virtual trip is proposed to teach the main concepts of Room Acoustics, through listening and interaction with the user.

2. FRAMEWORK

Rooms Acoustics is a branch of Acoustics which studies the sound propagation in enclosures [2]. To this definition we can also add semi closed spaces.

Three main theories have been proposed to explain the behaviour of the sound in enclosures: Geometric Theory, that represents sound as a ray trace; Statistical Theory based mainly in sound energy; and Wave Theory, that represents sound as a wave and helps to understand the modal behaviour of a room.[2, 3] Each of these has their pros and cons regarding the exactitude of analysis, the data needed and the time used for these calculations.

To set a basis in this virtual trip, two concepts were chosen, Reverberation and Speech Intelligibility. These two are fundamental concepts for the comprehension of Room Acoustics and they have a straight relation to the listening development of a Sound Engineer.

Reverberation is an acoustics effect caused by

the space in which the sound is propagated. Carrión [3] defines reverberation as *"the degree of permanence of sound once the sound source has been disconnected"*.

Speech Intelligibility is about the comprehension of a spoken message, allowing to evaluate when a message has a higher or lower level of comprehension.[3] This has a relationship with reverberation, because the level of reverberation of a room can improve or deteriorate the speech intelligibility. [3]

The theoretical models give the basis for simulating any design space, but these simulations only give numerical data, then to get something listenable, it is necessary to auralize this data.

Auralization can be defined as *"...the technique to create audible sound files from numerical (simulated, measured, synthesised) data."*[4], consequently the simulation data of a bedroom, a theatre or any closed space, can be used to transform a sound, and emulate how that sound would sound in that closed space. This is made possible by different methods depending on the objective and the theoretical model based upon.

2.1 Engagement and Gamification

Engagement is defined as *"the heightened simultaneous experience of concentration, interest and enjoyment in the task at hand."* [5] Thus, it is proposed that the students will learn if they are engaged with the content or the given task. But the difficult question is, how can the student get engaged on the given topic?.

It is proposed that the flow state is the optimal way to learn and be engaged.[5] This flow state is based on two parameters, the skill of the subject and the challenge of the activity. Being the flow state, an activity of high skill and high challenge, as seen in the figure 1.

In this problem, gamification comes to propose a way to engage students. This is all made through the use of game mechanics, giving the student a clear objective and a framework of rules in which he can learn safely.[5]

This has been tested showing a common pattern: video games do not get better grades for the stu-

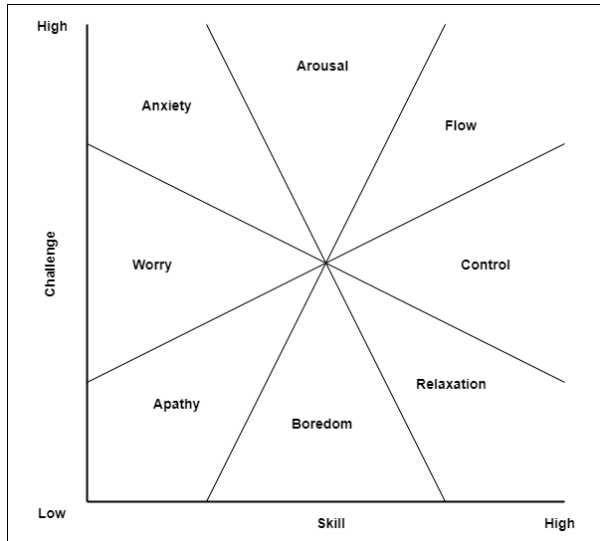


Figure 1: Mental state of any given activity, regarding skill and challenge. (Adapted from Csikszentmihalyi [6])

dents, but they feel more engaged and entertained when learning through a video game [7–9]. In this way, students connect to and delight the process of learning.

Therefore, this virtual trip is not designed to replace traditional classes, but to complement it, giving students new learning tools.

Virtual field trips are a common solution to the multiple problems that a field trip can have in its organisation, providing a safe space for students. [10] Several field trips have been tested in different knowledge areas, showing that it can serve as a useful help for the students. [11, 12]

3. DEVELOPMENT

Figure 2 presents a flowchart to work on the development of the virtual trip, starting with the creation of the 3D virtual world, which includes buildings and decoration accessories. In this virtual world, each space is auralized in real time, thus simulating the acoustics of the virtual space.

Once the space has been auralized, the activities for the teaching of the two concepts already discussed are scheduled. In this process, feedback is necessary, therefore, the virtual trip was evaluated on Sound Engineering students. Getting the final product after these evaluations.

For the implementation of this virtual trip, the

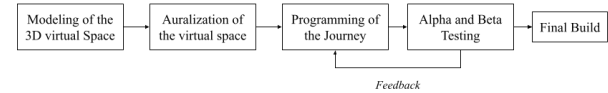


Figure 2: Flow diagram of the methodology for the journey development.

Unity game engine was chosen, due to the wide set of tools and its compatibility with Steam Audio, the auralizer to be used.

3.1 Main Activities inside the journey

Two main game levels were designed to teach each one of the concepts proposed. The first level focuses on Reverberation, and starts with a brief tutorial about the game controls. After that, the reverberation concept is introduced through the comparison of different rooms with distinct kinds of preset reverberation parameters.

The second game level focuses on students evaluating 3 different speaking experiences. The first, to assess the speech intelligibility of a room using monosyllabic pseudowords; the second, to assess how background noise can affect sentence comprehension; and finally, one to compare how intelligibility is affected by the sound level of speech across sentences.

4. RESULTS

The virtual trip was evaluated in two classes during the programming development: its technical performance and the design of its activities.

The focus group was student volunteers from Sound Engineering, who made the virtual trip and then answered some questions according to the evaluated programming phase.

The first test, called Alpha version, focused on testing the technical performance of the software, evaluating its stability. Also, it was used to obtain the first impressions of the students about the space and how it is perceived by them.

To evaluate the progress in programming, a checklist was designed. The students had to play the Alpha version and answer the checklist. There were four categories evaluated: technical aspects, spatiality of the trip, instructions and



controls, and sound quality.

The results were positive for the 4 categories, as seen on the figure 3. However, as the figure shows, the sound quality aspect was necessary to address for the next test due its low results.

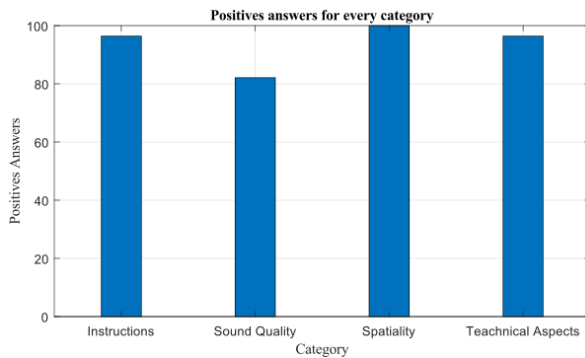


Figure 3: Checklist results for the alpha testing. Sample test of 7 students.

The second test, called Beta version, redirected its focus to testing the designed activities, evaluating engagement and gamification. Like the first test, the student had to play the Beta version and then answer the questions included in an assessment tool.

The results of the gamification can be reviewed in the following graph that contains students' answers for each activity. (See Figure 4)

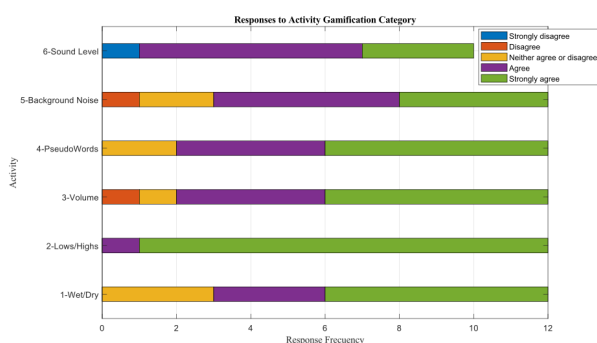


Figure 4: Students evaluation for the 6 activities proposed. Sample test of 11 students.

To assess engagement, students were asked how complex and how much attention the trip demanded of them. (See Figure 5)

Finally, in both versions (Alpha and Beta) the students were asked if they would recommend

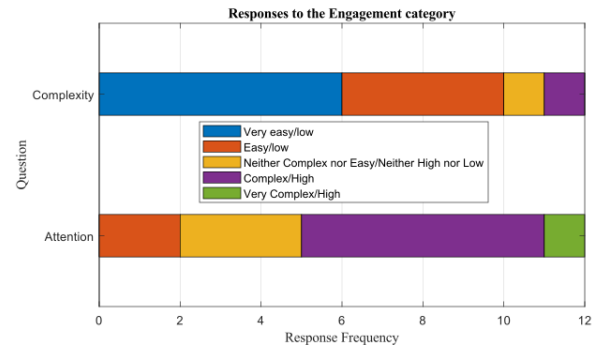


Figure 5: Students' responses to how complex and how much attention the virtual trip needed.

the trip to be used in an undergraduate class. Positive responses were obtained in both versions. (See figure 6 and 7).

Would you recommend the software as support material in class? - Alpha Version

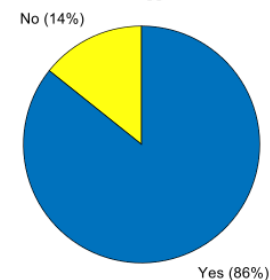


Figure 6: Answers to the question, would you recommend the software as support material in class?. For the alpha version.

Would you recommend the software as support material in class? - Beta Version

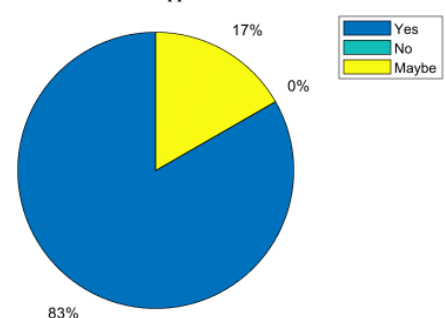


Figure 7: Answers to the question, would you recommend the software as support material in class?. For the beta version.

5. DISCUSSION

The results show a positive reception from the students, in which they highlight the new environment to learn and the possibility to expand even

more. This can be seen mainly in the question, Would you recommend the software as support material in class? (See figure 6 and 7). Getting a positive reception from the students for both versions.

This is also supported by the alpha test (See figure 3), in which the students gave a positive response to the 4 evaluated categories, all getting over 80% of positive answers. However, sound quality has the lowest rating, allowing to improve the sound quality for the next test.

The beta test was successful in showing how students react to the activities, their feedback is necessary to improve on the way of teaching both concepts. This beta version also was well received by the students, and the activities were the main focus of evaluation.

As seen in the figure 4, students evaluated every activity in the virtual trip. Centering on the achievement of the activity to teach the proposed concepts. This allowed the test to show which activities should be improved. For example, the last activity marked a major disagreement in its effectiveness for teaching the concept. And the direct comments of the students, also reflect that problem.

Figure 5, shows the students' responses to how complex the virtual journey, and how much attention they think it needs. This graph shows that the virtual trip has low complexity, but it needs high attention, this can be attributed to the importance of listening and taking attention to the activities. This opens the possibility to add more complexity, to improve the experience of the students, avoiding a state of apathy or boredom.

With this feedback, new and improved activities can be designed, always focusing on the students' learning experience.

6. CONCLUSIONS

The journey was well received among the students, showing that they are excited about new ways of learning, highlighting the possibilities for expanding on this journey. This is a very important aspect because this project it's only a start for teaching Room Acoustics concepts through

gamification, this can be expanded to other concepts or even topics, like Psychoacoustics, Sound Reinforcement or Soundscapes. Even the activities can be redesigned to get to other groups outside the Sound Engineering, like high schools students, Architecture students or any interested people on the topic. Finally, it is also possible to redesign the activities to Virtual Reality, getting a new level of immersion.

7. ACKNOWLEDGMENTS

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