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O1D4 - REPORT ON LEARNING IN VIRTUAL WORLDS & GAMIFICATION

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Executive Summary

This report gives an overview of the use of virtual worlds and gamification for VET education. After a review of the effectiveness of using these new methodologies and tools, the report will show some use cases and experiences of using virtual worlds and gamification in VET education and training.

Finally, the report proposes educational and technological solutions for the development of virtual worlds that are suitable with the training/education in VET schools.

1 Introduction

In recent years, many research papers have demonstrated the effectiveness of using Virtual Worlds as an educational tool. Virtual worlds are highly immersive and interactive multi users three-dimensional (3D) environments in which users, through the use of avatars, can cooperate, create, design, explore and interact in simulated realities. Following the constructivist approach, virtual worlds allows users to "construct" their own knowledge through an internal re-elaboration of sensations, knowledge and activities experienced within the world.

Into a Virtual World is possible to implement formal and traditional learning sessions, however Virtual World express their pedagogical potential as tool for Informal Learning where the user is free to do his own experiential path and the instructors are facilitators of knowledge and no longer "knowledge holder". Including game mechanics and gamifications approach to the virtual world offers new opportunities to engage and motivate the users.

In the next paragraph is conducted an in-depth analysis of the scientific literature in the Virtual Worlds for Education in order to evaluate the effectiveness of their use.

2 Virtual Worlds for education: A literature study

The objective of this section of the report is the analysis of the effectiveness of Virtual Worlds in Education. We have been carried out this study through the review of the literature of the sector.

The topic of Virtual Worlds is undoubtedly widely debated in the literature. A simple search carried out through specialized search engines such as Scopus, using the keywords "Virtual Worlds," returns over 12,000 articles. Of these, over 2,000 publications make explicit reference to the educational theme.

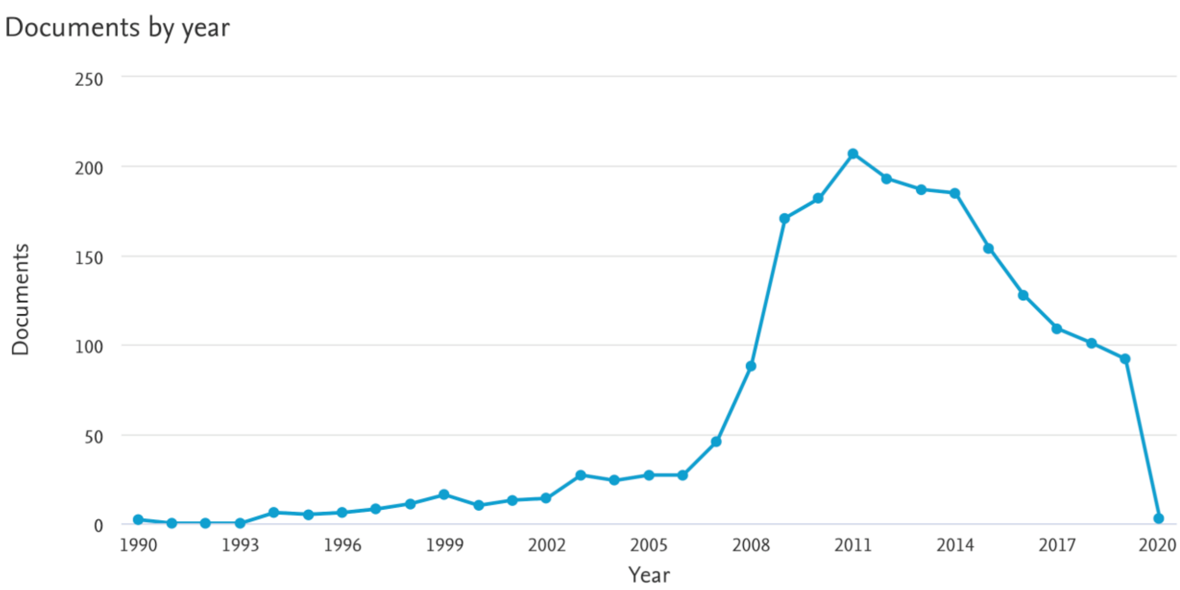


Figure 1: Number of Articles using keyword "Virtual Worlds"

The trend analysis (Figure 1) shows that, while there has been a slight decline in interest compared with the peak recorded around the years 2009-2013, the number of articles has remained almost constant in recent years. This result is a sign of a consolidated interest and widespread use of these tools in educational practices.

In particular, in this analysis, we will refer to a specific category of articles, called reviews, which generally provide a more or less exhaustive picture of the sector. Some of these reviews are limited to analysing the effectiveness of these tools concerning a specific field (social skills, language learning), others with a more descriptive approach try to give an overall picture of the sector.

In our analysis, we try to integrate the main results of these reviews to provide a consistent scenario.

The first reflection concerns the platforms used. Indeed, several platforms have been developed, such as Second Life, OpenSim, Active Worlds, On Live! Traveler, Croquet, Adobe Atmosphere, and There.

However, despite the range of solutions available, the literature analysis shows that most empirical studies in the field have been carried out using Second Life (Papadopoulos, Pentzou, Louloudiadis, & Tsiatsos, 2013; Sullivan et al., 2016; Sweigart & Hodson-Carlton, 2013; Xu et al., 2011). For example, in the study carried out by Reisoglu et al., 99 works of the 167 analyzed (Reisoglu, 2017), was conducted using Second Life. Second Life has some characteristics, not so much related to the technological aspect as to diffusion and accessibility, which is not comparable with other solutions. This evident bias makes the analysis of the following points particularly relevant for studies carried out using Second Life. At the same time, the same conclusions may not be equally valid concerning other platforms.

A first aspect to evaluate is what learning strategy to use in virtual worlds. According to Reisoglou et al., (Reisoglu, 2017) the analysis of the literature shows that generally the most used learning strategies are collaborative, exploration-based and role-playing.

Virtual worlds have unique features and affordances that cannot be found in other learning environments, precisely because they are not explicitly designed for training purposes.

A small number of works explicitly declares the use of a constructivist approach (Reisoglu, 2017; Girvan, 2019). Moreover, some of these works require the user to build digital artefacts in the virtual world, without really exploiting all the features of a properly constructivist approach. Among them, few exceptions could be highlighted like the works of Dreher et al. (Dreher, 2009a; Dreher, 2009b).

The analysis of Reisoglu et al. (Reisoglu, 2017) also shows that the collaborative approach is preferred when the virtual world is used as a problem-solving environment, while the exploration-based strategy is generally used when the goal is gameplay.

Another essential element of this analysis is to verify which educational goals could be effectively pursued within the virtual worlds. Again, the review of the literature stated by

Resi makes it clear that communication skills and language learning are generally the preferred educational objectives. Moreover, to the best of our knowledge, little is done in the field of persuasive learning and social practices training.

3 Gamification: A literature study

Gamification is a term used to refer to the use of elements of the game in non-game contexts in order to improve user experience and engagement. The gamification methods try to convert into a game something that isn't a game by applying game design models to non-gaming reality such as education.

The goal of the gamification of a process is to stimulate active behaviour in an individual, to invite people to start a path and to have certain actions taken to achieve a goal. Key role of the process of gamification is the involvement of a user in an experience that generally leverages natural needs, such as competition, status recognition but also identity and belonging to a group. It becomes easier to convey messages when people are pervaded by positive feelings in fact when we play, we are full of optimism and curiosity.

All energies are focused on solving problems and overcoming obstacles: we are pervaded by what experts call eustress, a form of positive and constructive stress.

Key elements of gamification are: mechanics, basic elements on which the game is built, and the dynamics, needs and desires that the user try to satisfy during the activity.

Mechanics and dynamics are closely related; some game mechanics and the correlation are shown below:

- Points are the main game mechanics to stimulate participation and motivate people. The Reward can be real or virtual, but it must make the idea of earning something.
- The leaderboard is a public recognition of players and their achievements in competition with their peers. It is are the most immediate element to stimulate competition.
- The mechanic of quest are the different tasks to be performed to achieve the proposed goals. Collaborative quests make you feel part of something bigger and stimulate and engage players.
- The game mechanic of levels are indicative elements of the status achieved. Life of the player is a path and they indicate the various stages and differentiate users among themselves on the basis of the experience gained.

- Customization of avatar look is also a powerful mechanic. Items can be gained, bought and exchanged within the game environment to customize avatars and characters. They are related to the self-image you want to communicate.

Many research studies have investigated the effects of game mechanics on student performance, follow a brief overview. The badge (Figure 2: http://www.gameifications.com/guida-avanzata-pratica-alla-gamification-badge/) is an effective game mechanic and responds to precise human needs such as showing their status externally and "collecting". People love to collect all sorts of things, just think of stamps or the success that albums of stickers have been for generations regardless of their type. Regarding the “Level and quality of participation”, Denny (Denny,2013) prove the use of badges in classroom environment have a positive effect on the quantity of student contribution without a reduction of the quality. Regarding “Learning outcomes”, Domìngu (Domìngu et al.,2013) state that students that complete a gamified experience with badges got better scores in practical assignments and in overall score but perform worse in written assignments. Hakulinen, (Hakulinen, 2013) study proves that the badges received can be used to influence students' behaviour even when they have no direct impact on their evaluation.

Statistically significant differences were observed in student behaviour with some types of badges, while some other badges did not seem to have such an effect. Hakuline also found that students in two courses studied responded differently to badges, so it seems to be a social interaction at group level on the value of badge.

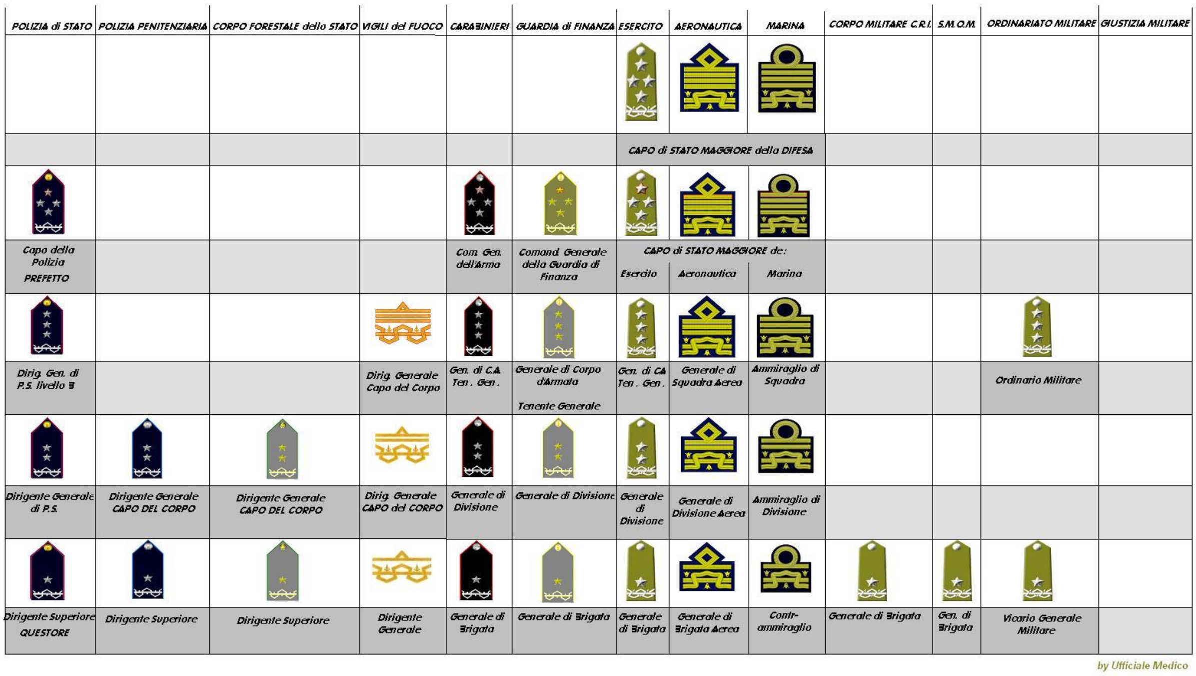


Figure 2: Badge example

Point and leaderboard have been investigated by many researchers as motivating mechanics for competition and cooperation in many contexts. Leaderboard (Figure 3 https://docs.miniclip.com/Javascript_API/leaderboards.html) is a mechanic in gamification which can represent a list of participants that compete each other (T. Bowey, 2015). The list of players is ordered regarding a variable such as Points from the highest to the lowest scores. In the education context Dominguez et al. (2013), stated that in their experiment, students who were able to visualize the ranking scored performed higher than the other students in many assignments. In web practice communities, the ranking can be added as part of an incentive system that increases motivation. In their study Farzan, (Farzan 2008) proved that after four weeks of implementation, they found that the leaderboard was able to increase user contributions in forum and wall. In work context, adding rankings to improve the punctuality of workers at work meetings has shown positive effects (Costa 2013).

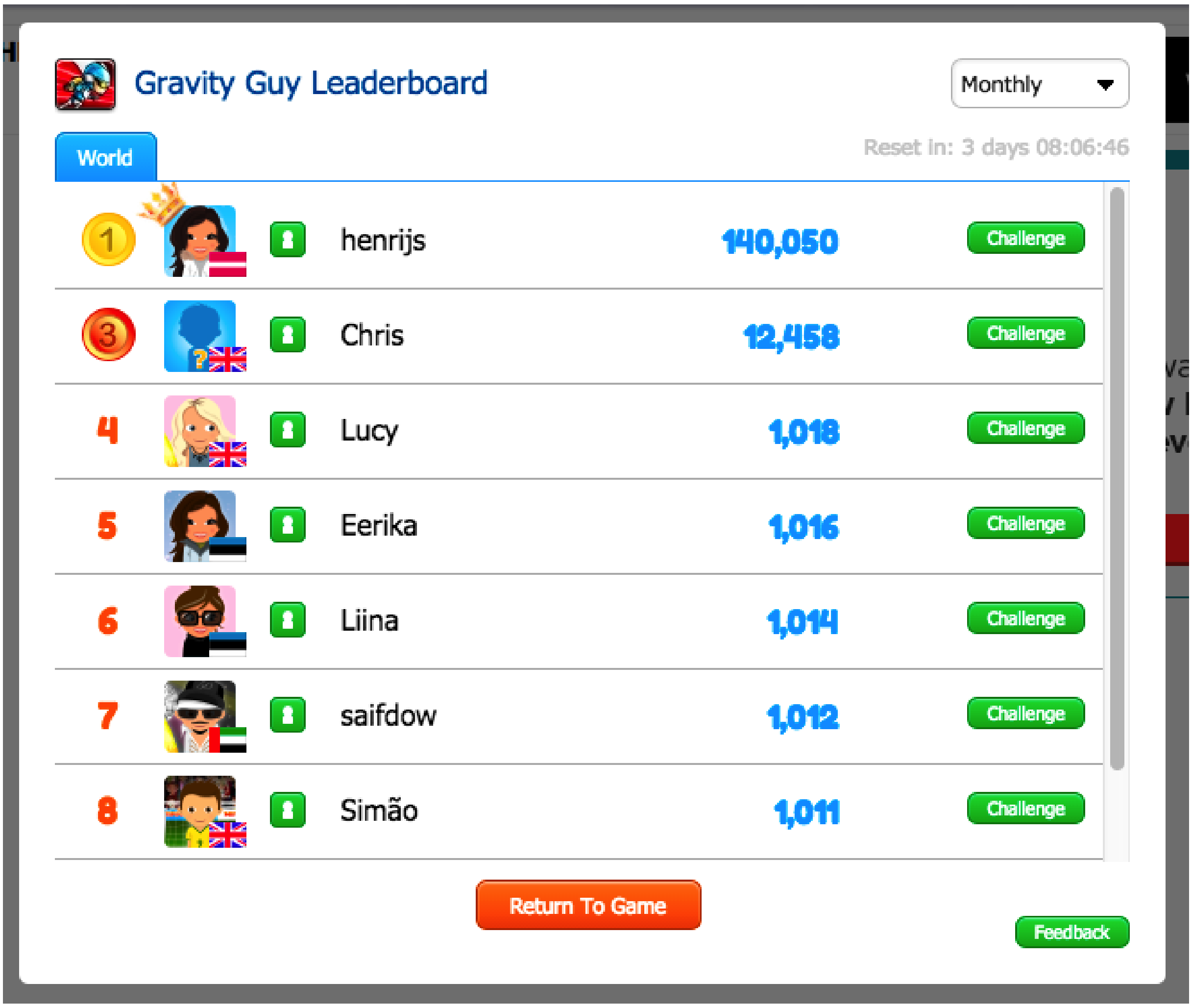


Figure 3: Leaderboard-Points example

4 Using Virtual Worlds in VET education

In this chapter we present an overview of some experiences of use of virtual worlds for education in VET schools. We start from previously implemented Virtual Worlds by members of the VR-WAMA Consortium, that utilized an opensource Virtual World platform and its many capabilities for implementing 3D scenarios (Palkova, 2015).

4.1 AVARES

The AVARES Project (financed under Leonardo Da Vinci Lifelong Learning Program), was commenced in October 2012 and was completed in September 2014. The project proposes an innovative training model created by integrating an LCMS (Learning Content Management System) platform and an open source virtual world developed. AVARES provides a hybrid educational platform creating a 3D virtual learning environment and multimedia learning materials with the aim to provide access to vocational education and training in the field of Renewable Energy Resources (RES). More specifically, the project aimed to develop a Virtual Reality environment, create innovative Virtual Reality learning methodologies and integrate them with traditional learning for teaching more efficiently the challenging field of RES.

The main courses present in the AVARES platform are:

- Solar Energy Course
- Water Energy Course
- Wind Energy Course
- Geothermal Energy Course
- Energy of Biomass Course

Each course consists of an island, in the virtual world, where students can find all learning resources, tools and materials for the specific topic (Figure 4).

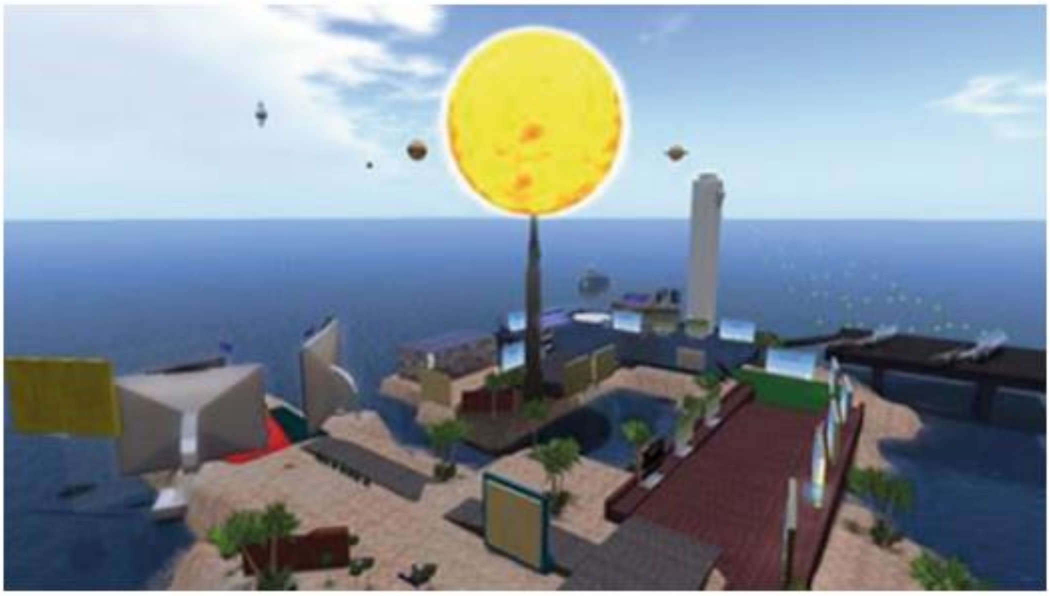


Figure 4: Solar Energy Island

Students enrolled in the course, can interact with the virtual world elements enabling an experiential learning or can deep topics study using the learning material contained on the Moodle platform. The Moodle's learning material is integrated into the virtual world (using a plugin called Sloodle) in order to provide the student with a single point of access of all learning resources (Figure 5).

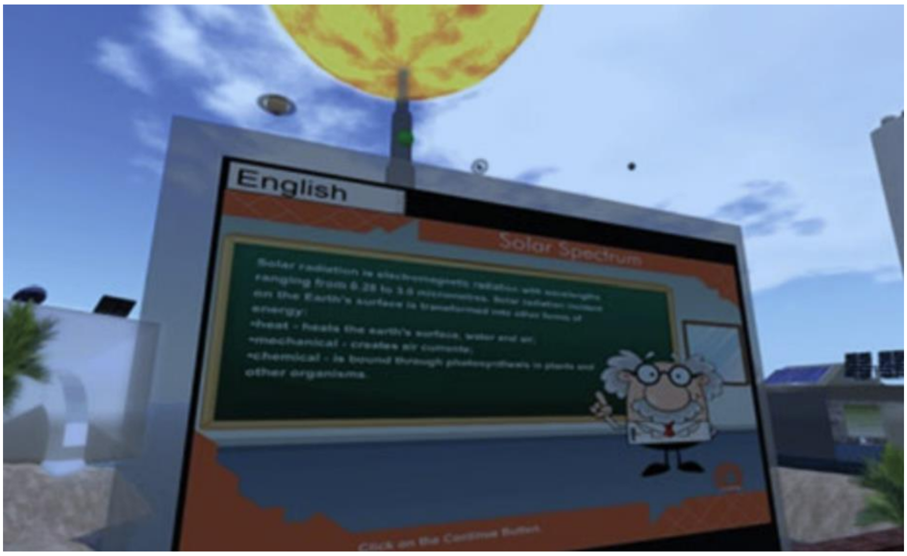


Figure 5: Solar spectrum material using Sloodle

The assessments are performed inside the virtual world too and results are integrated in Moodle to monitor students' progress. There are different types of assignments for assessments like: multiple choice, fill in the blank, true/false, single choice etc. (Figure 6).

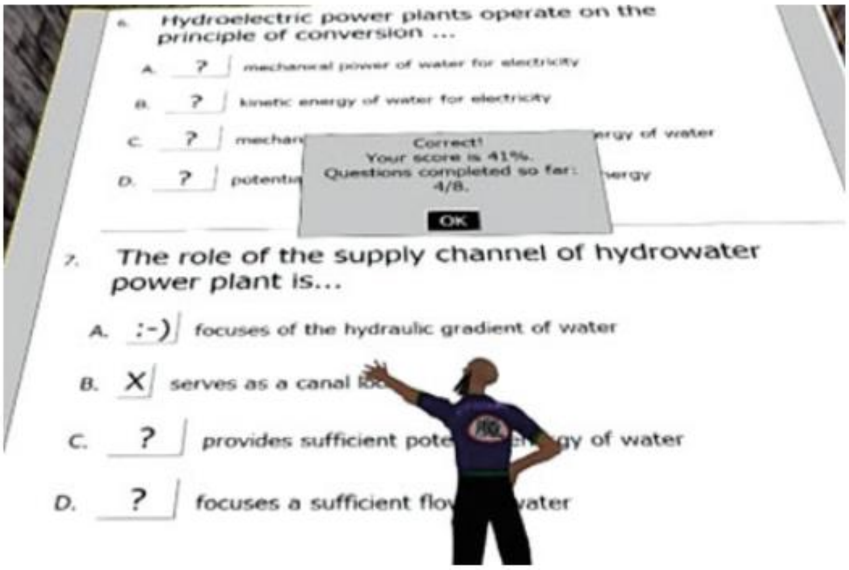


Figure 6: Assessment

Finally, students can communicate with each other and with teachers using one of the many communication tools provided by the Moodle platform or the virtual world such as instant messaging, forum or voice communication.

The Avares Virtual Word consisted of:

- **The 3D Auditorium**: Trainers giving lectures in the 3D Auditorium (Figure 7) were able to load specific presentations from the VLE or even upload their own slides.

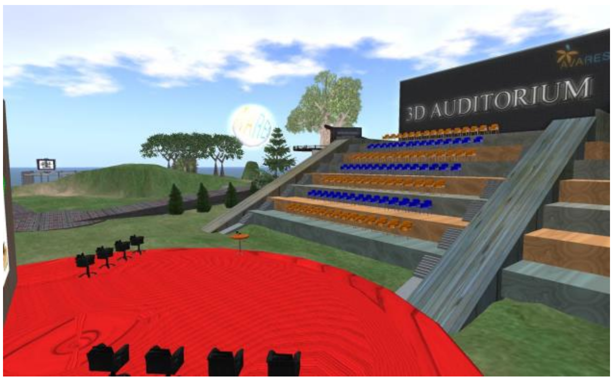


Figure 7: An auditorium in the Virtual Word

- **Classrooms/ Meeting Rooms:** These rooms (Figure 8) served both as meeting areas for project partners and as classrooms for small groups of students.

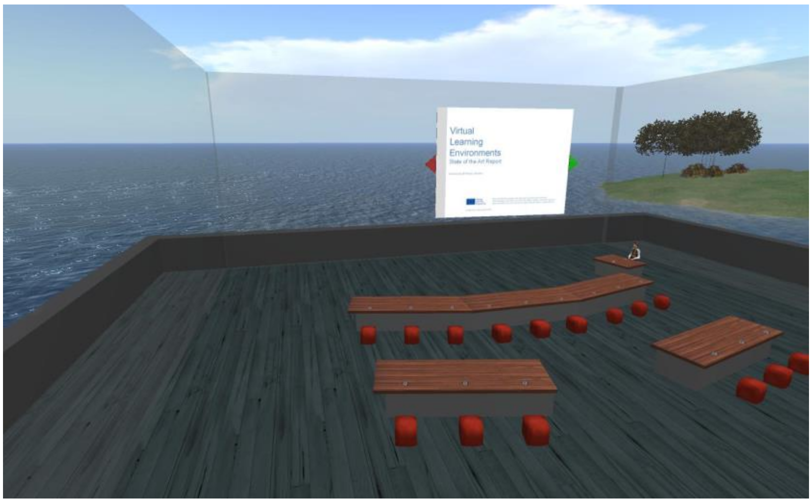


Figure 8: A classroom in the Virtual Word

The learning material consisted of presentations, flash animations and 3D objects.

- **Presentations** projected on the surface of 3D boards (Figure 9). The purpose of the presentations in the 3D world was to assist students to see briefly the key concepts of each chapter or remember terms that were studied in detail in the VLE.

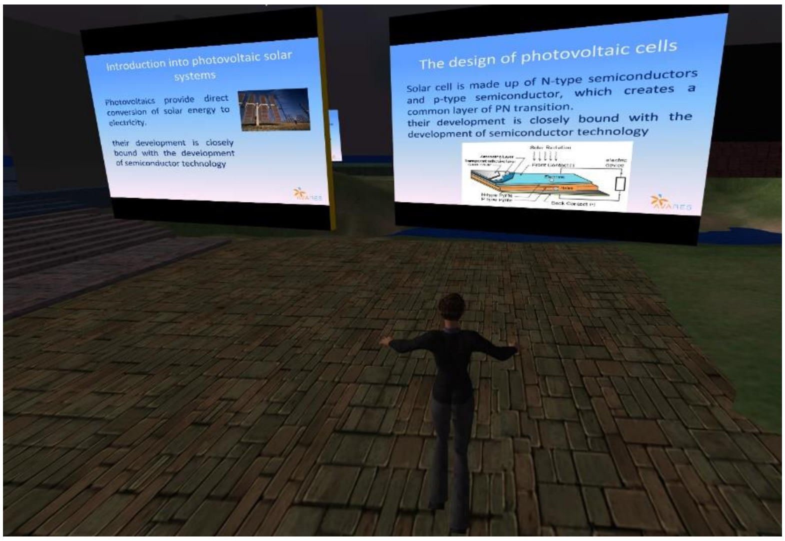


Figure 9: Presentations in Solar Energy Island

- **Flash Animations** projected on 3D boards. Various Flash Animations were developed and were projected on 3D boards in the virtual world. These interactive multimedia animations were associated with corresponding presentations and were mostly used to elicit specific topics through interactive examples

- **3D objects and constructions.** 3D models of items and constructions were used in the 3D virtual world (Figure 10). These objects included 3D models of devices and systems presented in theory and were also used to visualize some topics in an easier to comprehend way. These 3D objects aimed to assist the students to better understand concepts of the solar energy. For example, the students had the opportunity to see how a virtual photovoltaic panel works, which are its main components and what exactly is the functionality of each one component.

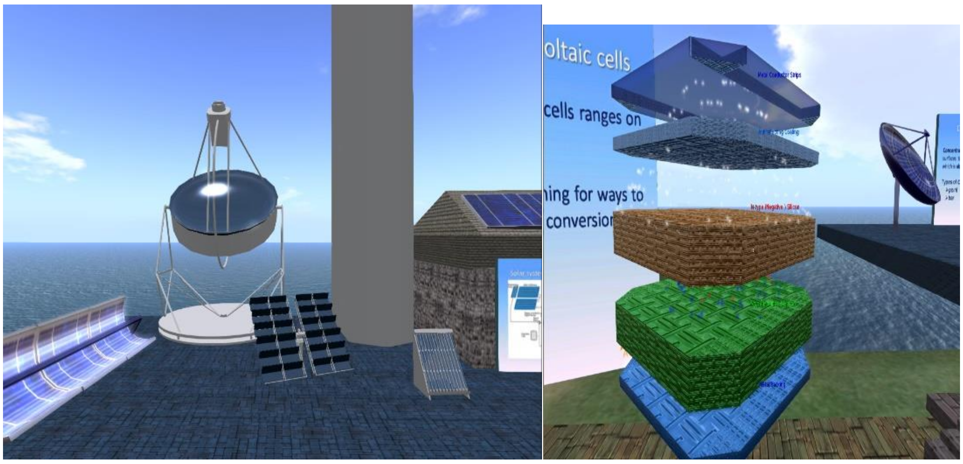


Figure 10: 3D models in Solar Energy Island

4.2 VR4STEM

The VR4STEM project (financed under Erasmus+ Strategic Partnership programme) was commenced in February 2016 and was successfully completed in January 2018. It aimed to assist young people to gain entrepreneurship skills in Science, Technology, Engineering and Mathematics (STEM) domain and the related ICT industry.

Such as AVARES project, the VR4STEM project exploits an educational environment developed inside a 3D virtual world, and some courses and educational activities that were created to train entrepreneurial skills. The project promoted learning using Open Educational Resources (OER) translated in different languages. The project's main aim was to offer an educational environment for teaching/learning STEM entrepreneurship aspects that use advanced ICT-based educational methods, like 3D virtual reality.

AVARES 3D world is composed of different areas. Each area deals with a specific topic of the learning path; below a list of the areas:

- Main Island
- Entrepreneurship
- Lasers
- Computer Architecture
- Drones
- Gamification
- Robots
- Data Mining
- 3D Printing
- Mobile Programming

A Teleportation Panel would allow the users to select one of the available areas and teleport them to that area, arriving on a predetermined landing point, located at the start of the course (Figure 11).

Figure 11: Main Islands menu

The VR4STEM project utilised many Gamification ideas. As described, gamification is simply the application of game-like elements and mechanics such as awards systems to engage and motivate people to achieve pre-determined goals such as improving performance or learning something. The VR4STEM environment is developed to be fun and entertaining exploiting rewarding and recognition for stimulate student competition. During their visit in the 3D World the user would encounter various objects that they could interact with. Relevant instructions were provided nearby (Figure 12).

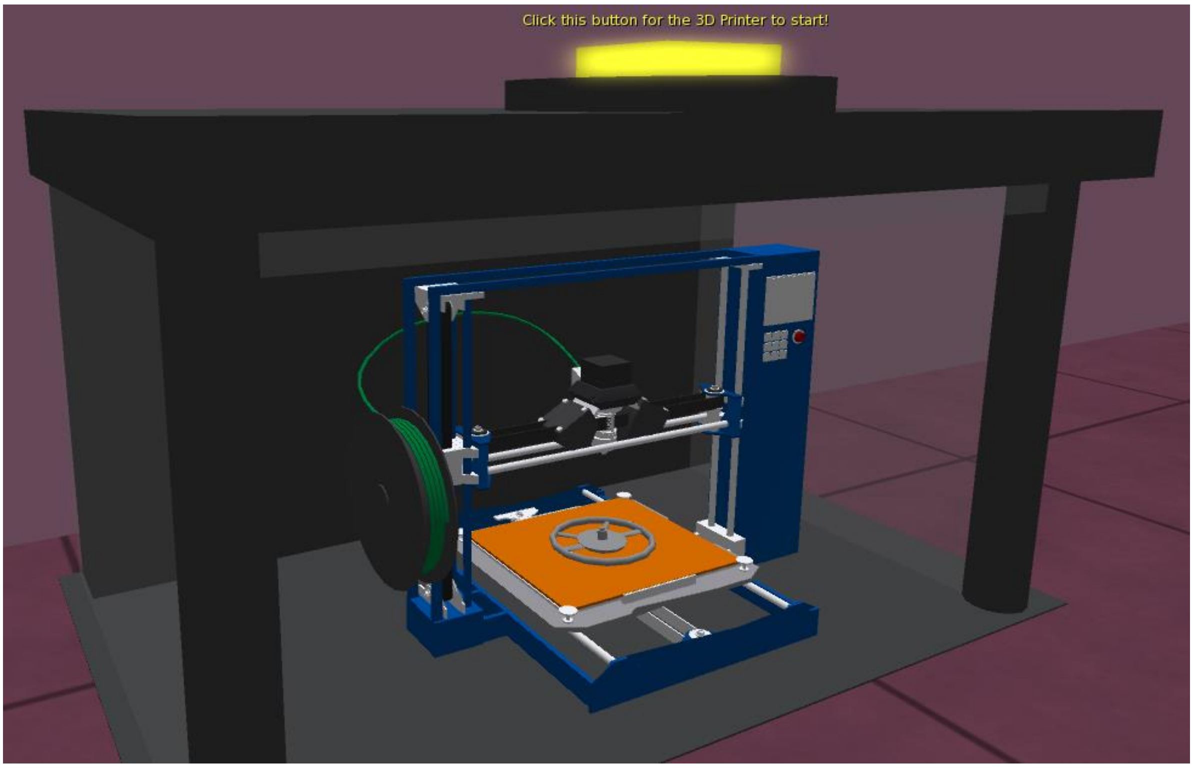


Figure 12: Interacting with 3D Objects

A common activity included a series of multiple-choice questions that the user had to answer correctly to receive some piece of information, an object or a reward (Figure 13).

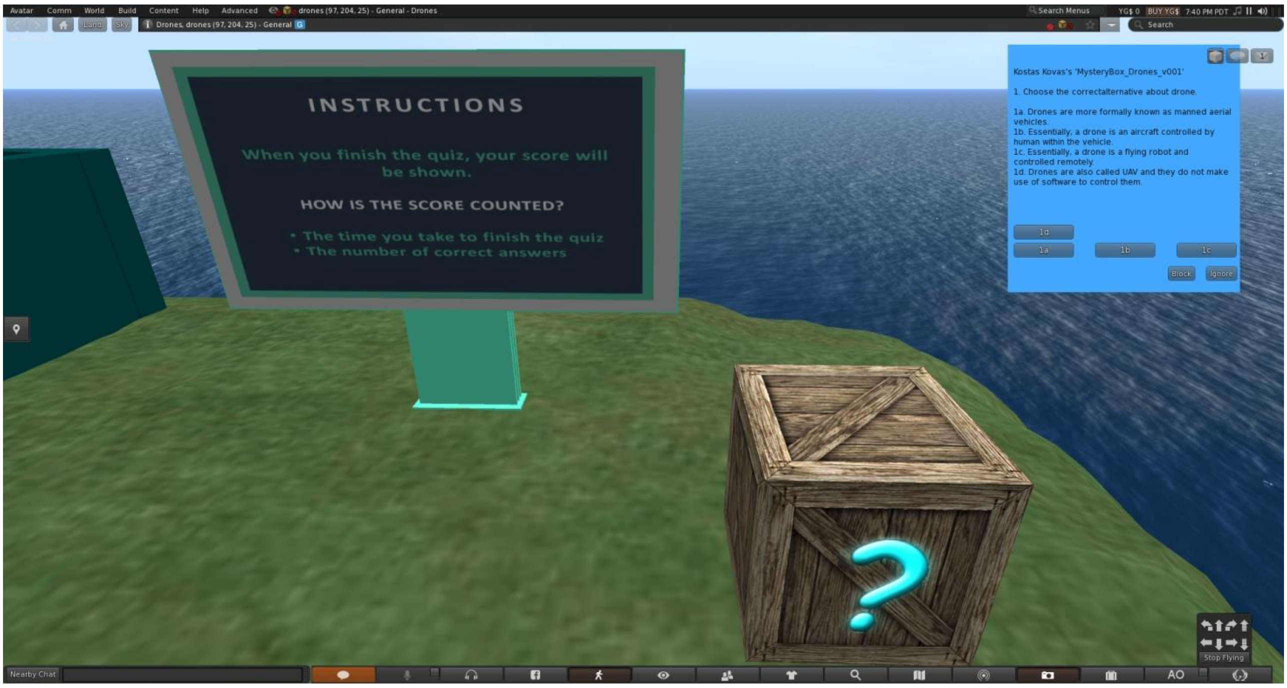


Figure 13: Example Quiz instructions

Another type of activity would require that the user selects a series of cards in the correct order to specify the steps of some procedure (Figure 14).

Figure 14: Specifying the correct order of a procedure

In another type of activity, the user would need to choose from a list of parts the suitable ones for building a specific item (Figure 15).

Figure 15: Selecting the correct parts for building something

Another example of activity was exploring an area and collecting specific objects scattered around it. The goal was to find all the parts of some complex object. A panel displays the pieces you have already found (Figure 16). When you collect all pieces, the object will appear nearby allowing you to interact with it and continue the learning activity.

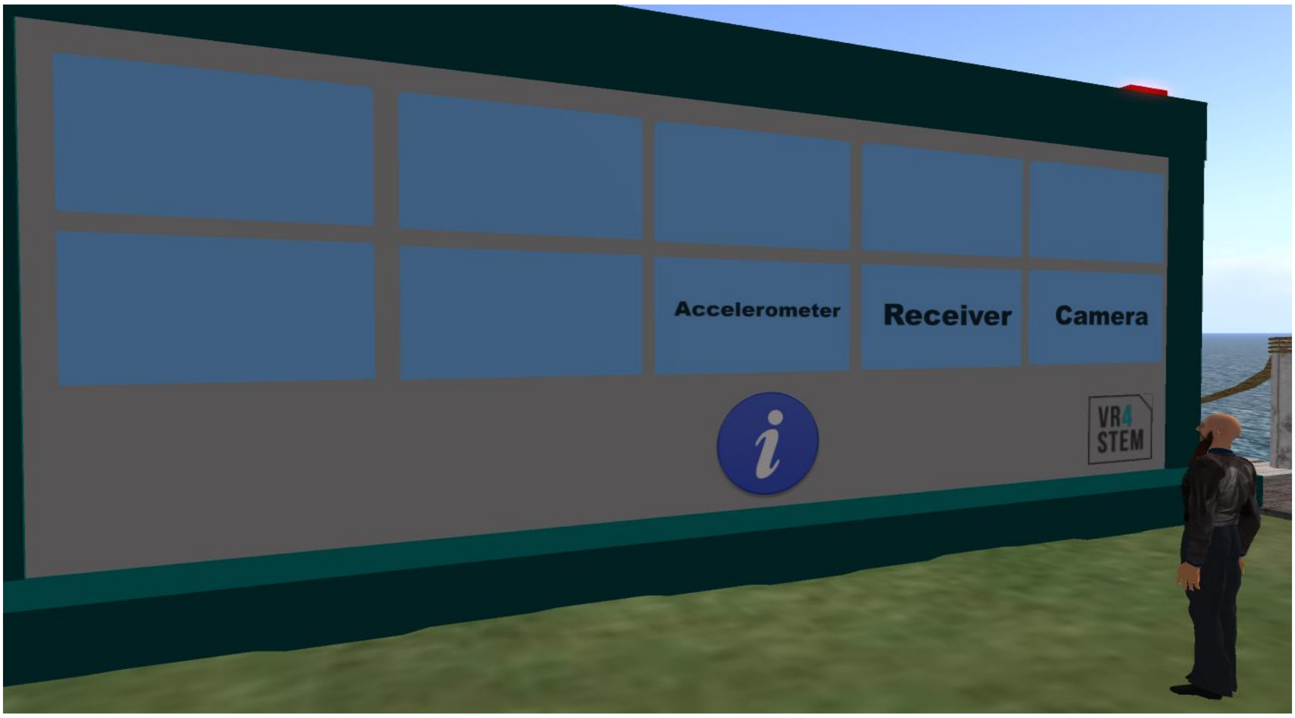


Figure 16: A panel displaying the parts you have already discovered

Some activities would give the user HUD items. HUD items are custom control windows that appear on student monitor and offer many possibilities to interact with world, user, NPC or 3D objects (Figure 17).

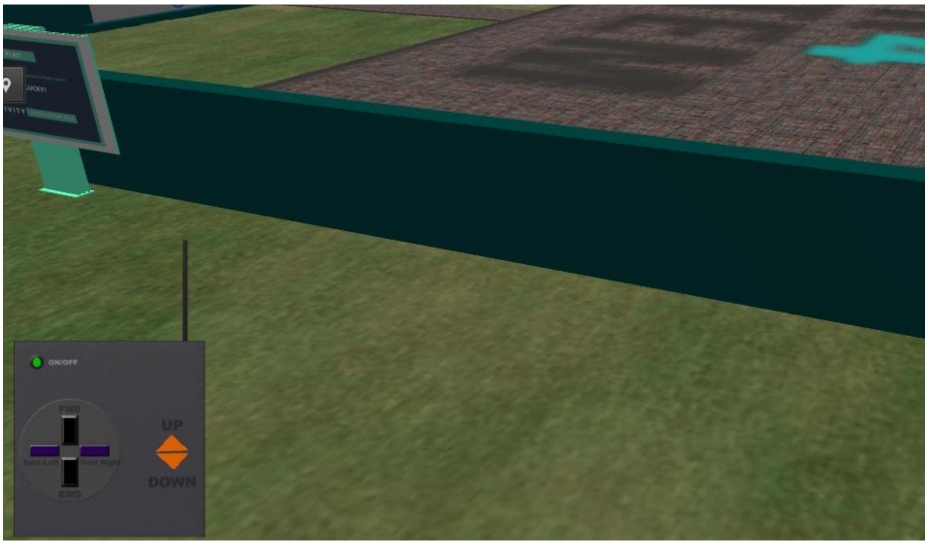


Figure 17: A HUD element (remote controller) on the screen, allowing you to navigate a drone

Similar to HUDS, user could receive attachment objects. All objects are located in specific inventory; user can interact with inventory and can wear objects to add to the avatar custom capability Figure 18.

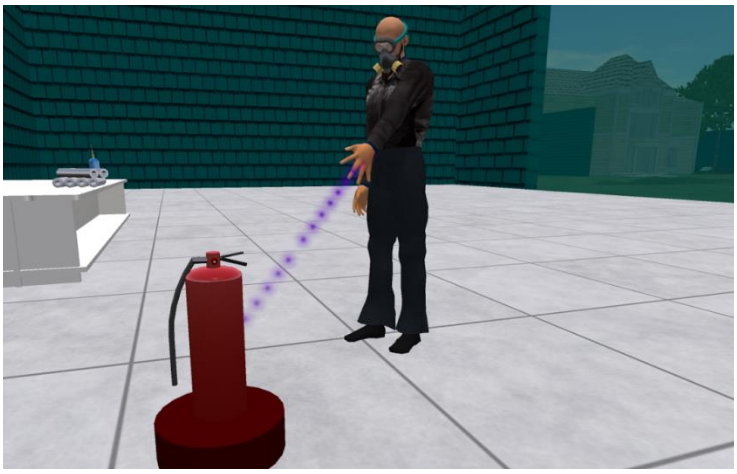


Figure 18: An avatar wearing a mask attachment

During student visit of the virtual world, they could also encounter NPC characters. These are avatars controlled through scripts, configured to execute specific actions. In most cases approaching the NPC character would trigger it to speak to you or guide you somewhere. You could have a dialogue with some NPC characters using a dialogue menu that appeared on your screen (Figure 19).

Figure 19: Dialogue with an NPC character

4.3 World of Physics

The World of Physics project (financed under Erasmus+ Strategic Partnership programme), commenced in 2016 and was successfully completed in 2018. It aimed to assist students in studying the physics domain using virtual world. More specifically, a 3D virtual reality educational environment, using 3D virtual worlds technology, was developed, possessing innovative educational infrastructure and offering immersive and efficient learning opportunities. Students were engaged in various educational activities and learning scenarios. The learning content focused on pupils and students at the ISCED 2-3 and covered three main topics:

- mechanics
- electricity and magnetism
- structure of matter

WOP is a learning environment that allows students to learn physics through a 3D virtual world in which they can experience physical laws in laboratory activities. The characteristics of this learning process are to explore the environment, ask questions, make discoveries and try to understand in order to explain the physicist's phenomena. The development of the educational path for WOP has required the collaboration of several experts and professional roles such as: physics experts, pedagogical experts, software developers and teachers. WOP exploits Open Simulator using a set of educational resources, such as: Slide show, Notecard, Quiz, Non-Player Character, Multimedia presentation, 2D Simulation, 3D Simulation and combination of these elements to create laboratory activities.

The virtual educational environment and the laboratories were designed in a way that supported students to form appropriate mental models of involved concepts, by visualizing them and allowing interactions with the virtual phenomena and processes.

The World of Physics Project utilised a self-learning approach, where the users were guided to each area and activity using Notecards with instructions and NPC characters.

The theory of the courses was displayed on interactive presentation panels, with navigation buttons and translations in 5 languages (Figure 20).

Figure 20: Presentation as a learning material in the WoP 3D Virtual World

Quiz activities were available in every course and were used to assess the students with a series of multiple-choice questions. The results were available for the teacher to check the student's progress (Figure 21).

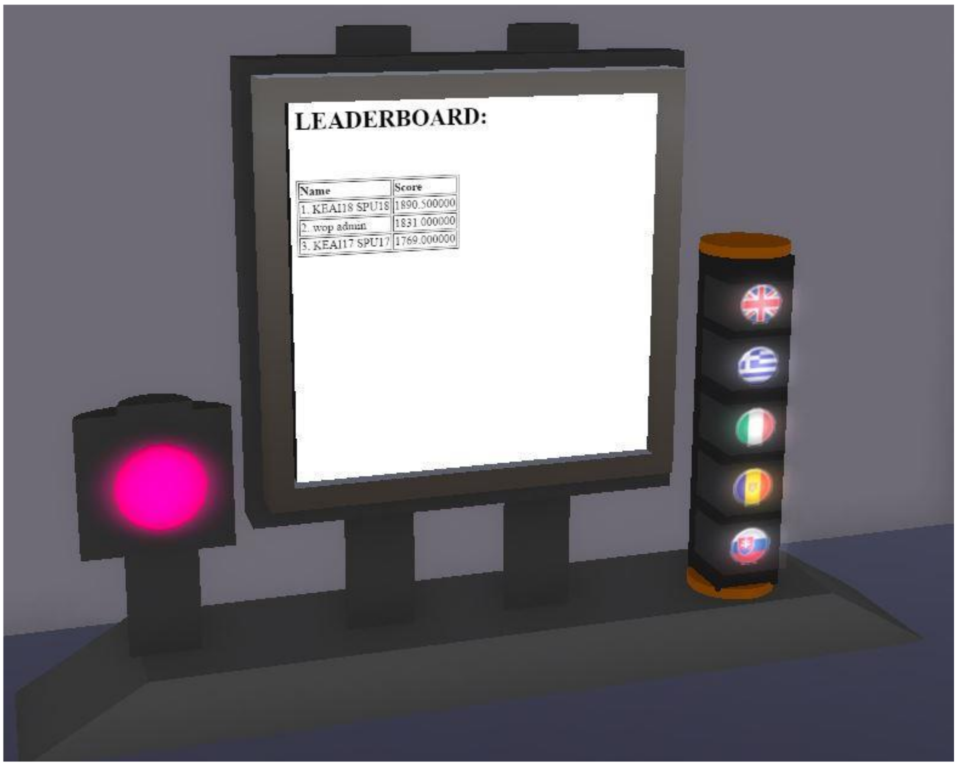


Figure 21: A Quiz activity

Each learning scenario developed in WOP, included several dialogues with an NPC character and those dialogues worked like a series of linked multiple-choice questions. The dialogue would contain parts of the theory and also instructions or explanations about the available activities (Figure 22).

Figure 22: Non-player character in the WoP 3D Virtual World

Multimedia, webpages and Videos were used in various courses (Figure 23), projected on surfaces of 3D panels:

Figure 23: Using video as a learning material in the WoP 3D Virtual Word

3D Activities were the major focus of the World of Physics project and utilised every aspect of the Virtual platform, including:

- the Physics Engine (Figure 24)
- HUD Elements
- Attachments

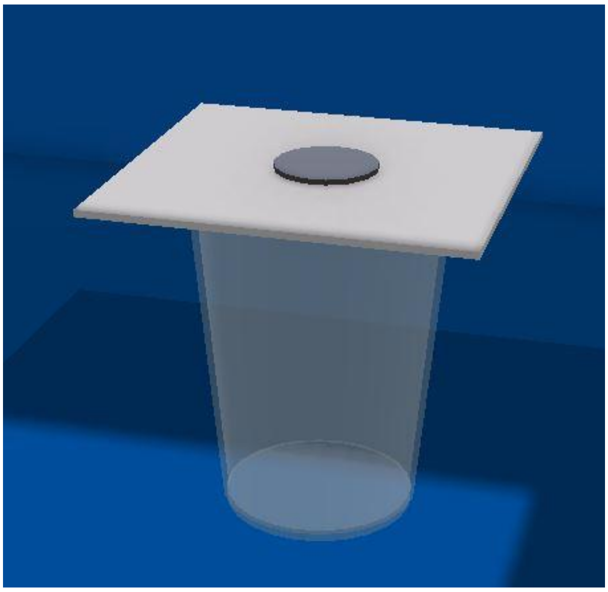


Figure 24: The Physics Engine was used to simulate the application of force on objects

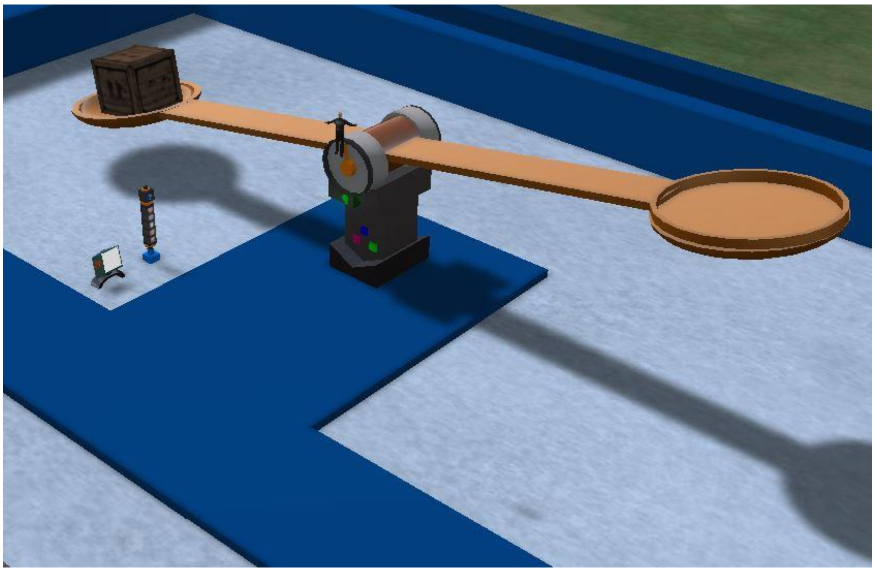


Figure 25. Interactive 3d Activity about Gravity

Figure 26: A photon gun could be equipped by avatars to throw photons on atoms and observe the results

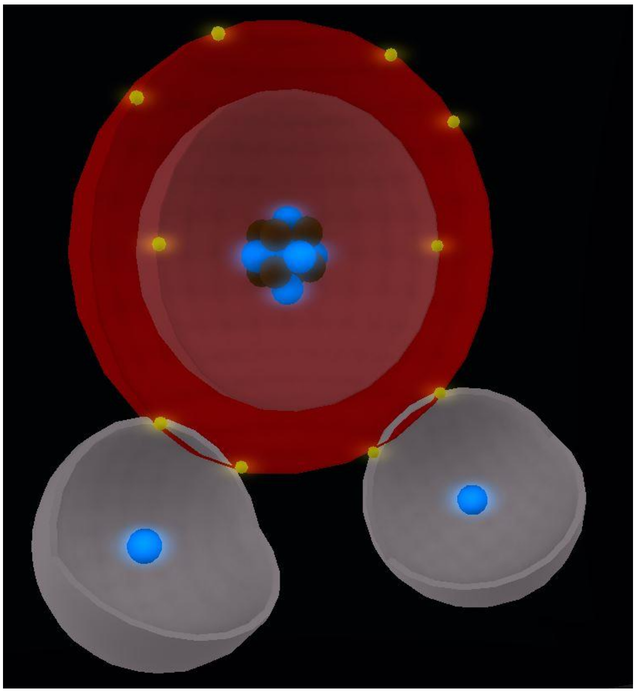


Figure 27: Inside a water Molecule

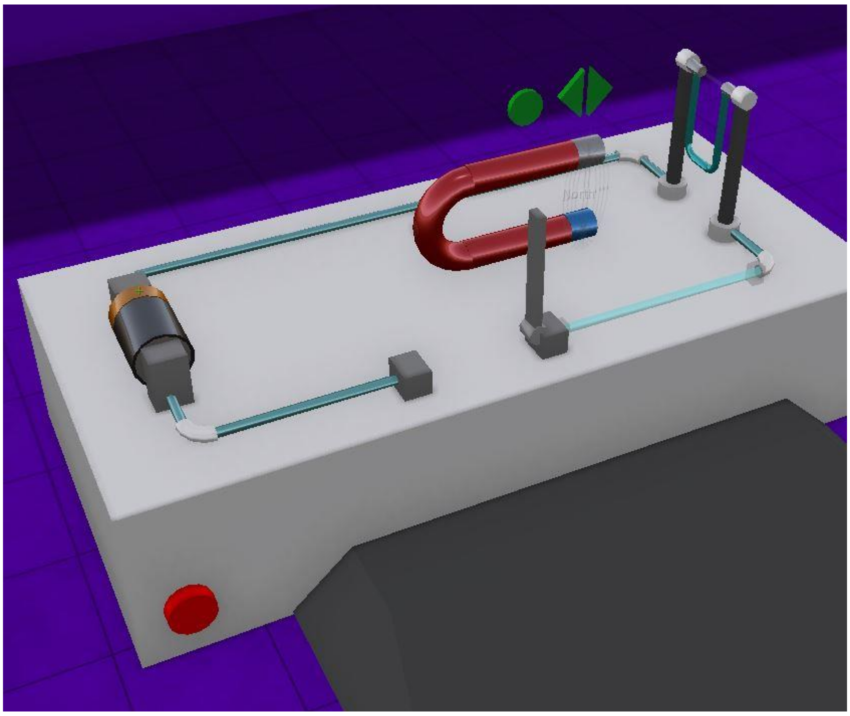


Figure 28: Interactive Lorentz experiment

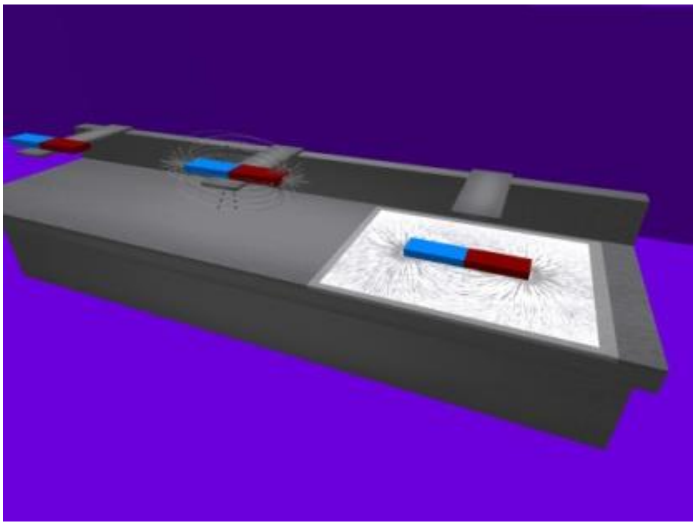


Figure 29: Interactive Experiment with magnets and iron fillings

4.4 VET Education Experiences

In Babu paper, (Babu, 2018) the use of 3D virtual reality environments is compared with 2D learning environments (traditional e-learning platforms) to study the effect on knowledge retention and recall capabilities.

The task assigned to students was labelling the parts of the motorcycle indicating the correct name and position. The study was conducted with two groups of participants: an experimental group that used an immersive 3D virtual world explored using augmented reality glasses and a control group that dealt with the same task using a tablet and a 2D environment. The images (Figure 30, Figure 31) show the virtual world created.

The world is a 3D representation of a garage in which is contained a 3D motorcycle and all its components. The students of the experimental group had the possibility to view the motorcycle in 3D and to virtual interact with it. The first result of the experimentation has been a longer time spent in the activity from students in the experimental group respect the students in the control group.

Figure 30: 3D Virtual World, zoom on a component called "Silencer"

Figure 31: 3D Virtual World, overview of the motorbike

Both students of the experimental group and the control group, after completing the analysis component task, made an assessment (developed using the software Unity) to verify what they had learned; the assessment has been repeated in the following days.

Results analysis shows how the use of immersive didactics enhances the ability to maintain knowledge and its recall compared to a didactic based on traditional 2D teaching. The students in the experimental group and those in the control group had no difference in performance in the test done immediately after the study, but this difference was evident in the following days. The students in the experimental group had better performance in the test and a higher recall of the knowledge than the students in the control group.

Jose (Jose, 2017) presents a paper in which he describes the phases of design and development of a virtual tool simulator, for VET training in carpentry (Figure 32, Figure 33, Figure 34).

Figure 32:A view of the workbench

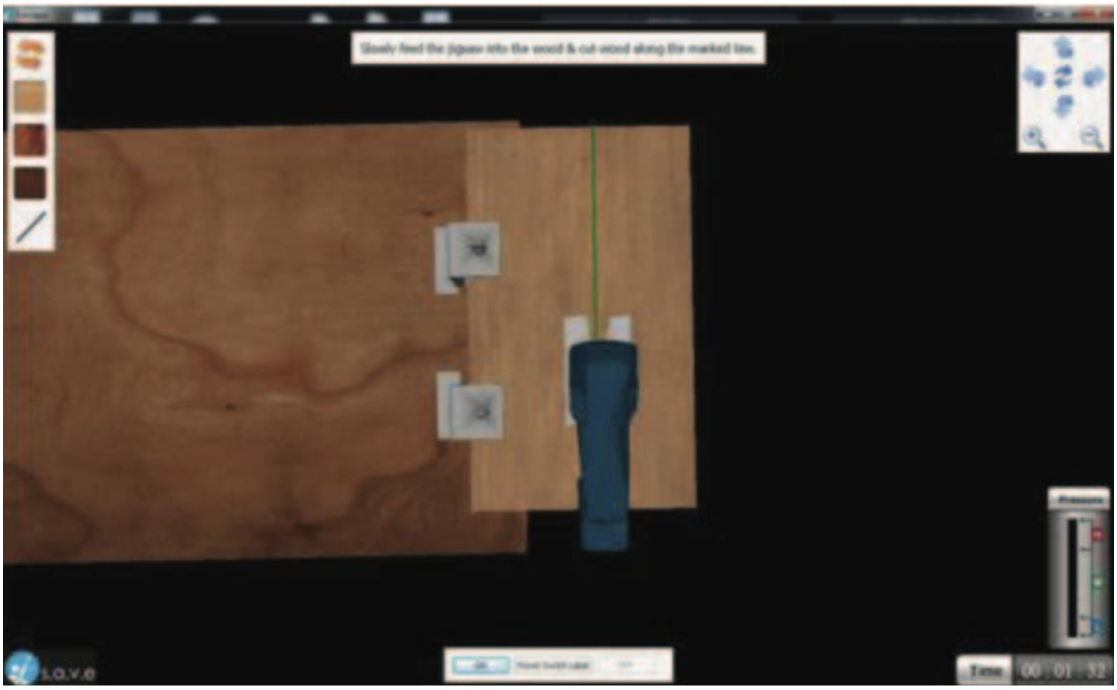


Figure 33:A view of the cut tool

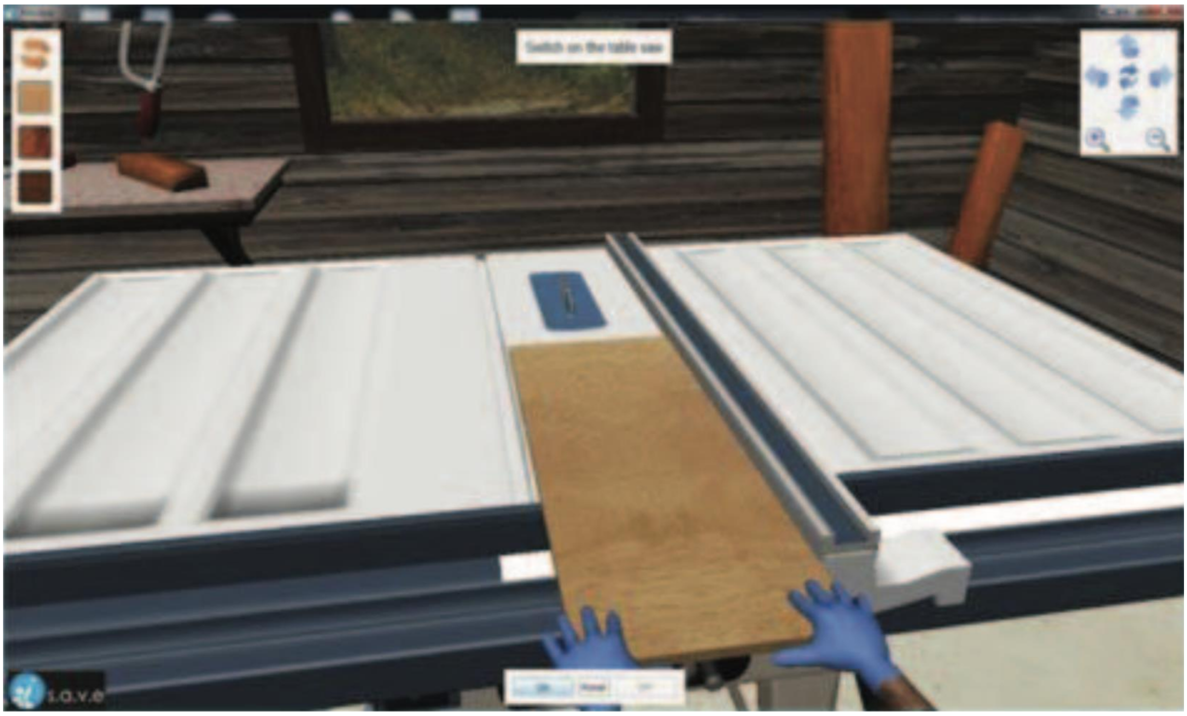


Figure 34: Cutting a sheet of wood

Authors highlights the importance of this type of tools for continuing vocational training and underline their learning potential, scalability, and economic implication. Virtual worlds and simulation of specific tools allows people in rural or remote areas to access a specialized VET education at low cost.

The virtual reality simulation system, thanks to the integration of haptic hardware, provides audio, visual, tactile feedback to trainees, offering the experience of a very realistic vocational training session.

Authors highlight the improvement in learning competences and skills of such a training system compared to traditional ones.

The solution helps to solve some of the problems including: the scarcity of trainers and classroom environments, the limited availability of materials for practice and training, and the remote location of many potential trainees. Moreover, the assessment systems track all skill parameters and provide feedback and tips for trainees that speed up the skills learning curve (Figure 35).

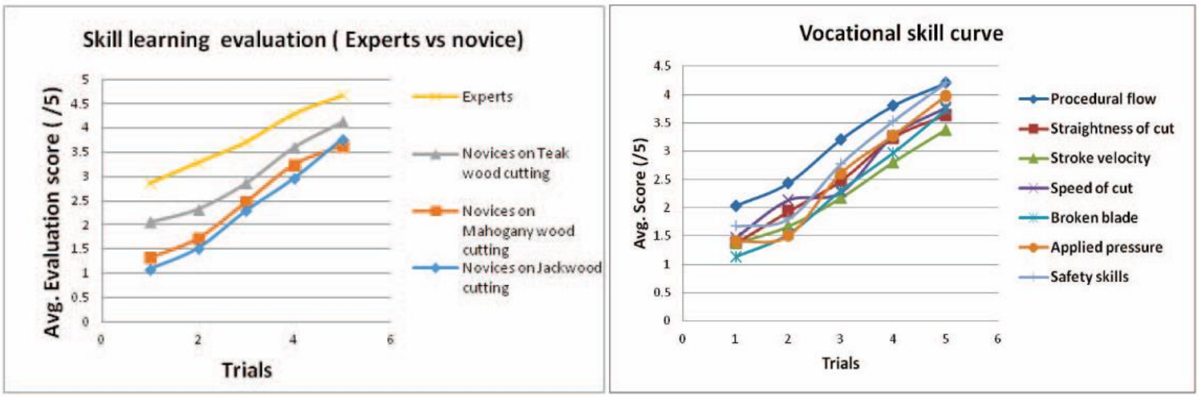


Figure 35: Skills learning curve

In Lorenzo-alvarez works (Lorenzo-alvarez, 2019), authors compare the opinions and evaluation of the quality of a radiographic interpretation course within the virtual world Second Life. Subjects who have experienced the course belong to two groups of users: one group formed by third-year students of a medical degree course and the other group formed by family doctors.

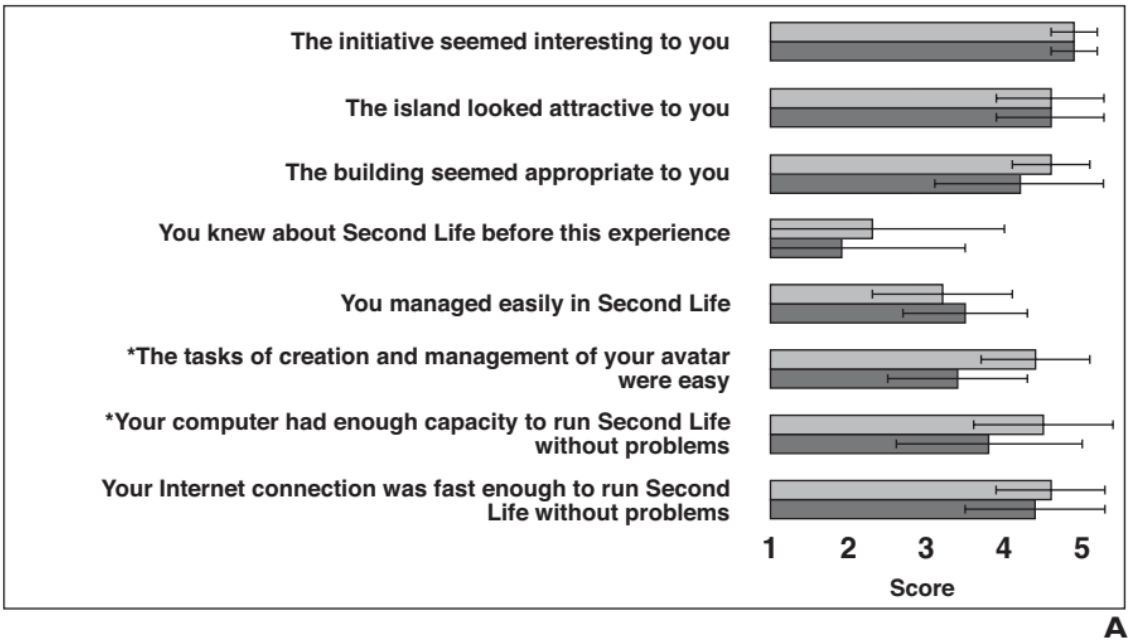
The experimental phase took into consideration 48 medical students and 14 family doctors who attended a 3-week course held consisting of 6 synchronous sessions of 2 hours and four asynchronous activities. In the 6 synchronous sessions a teacher exploited Second Life communication tools to simulate a frontal lesson (Figure 36).

Figure 36: Synchronous session - Frontal lesson

The 4 asynchronous sessions consisted of 4 tasks of interpretations of radiographs (Figure 37).

Figure 37: Asynchronous Session - Interpretation task

Course participants underwent an evaluation of their experience. In Figure 38 some of the questions subject to evaluation and the analysis of the answers are shown.



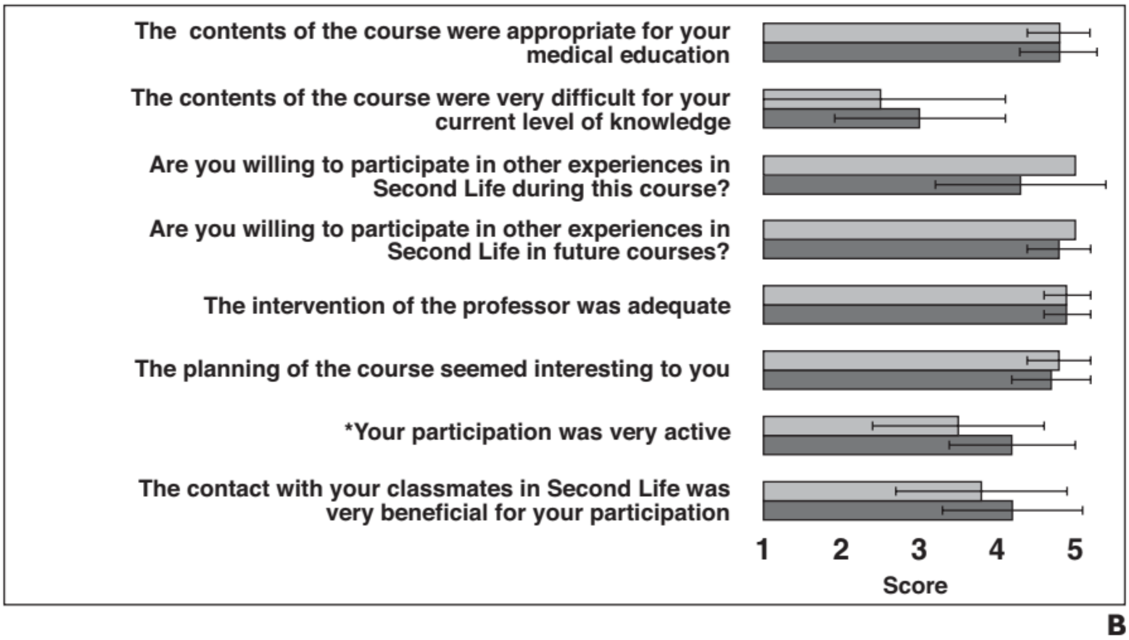


Figure 38: Satisfaction questionnaire

The analysis of the answers shows that all participants positively evaluated the experience and found the professor's intervention in the synchronous session as attractive and appropriate for their medical training. Almost all participants had little or no experience of Second Life but they had no difficulty in approaching the training in the virtual world. Family doctors rated themselves less active and interacted less with other users of the course; however, they were more likely to repeat similar training experiences again.

In conclusion, this teaching method was well received by students and family doctors and minimized travel costs for students and teachers, making the educational path cost-effective.

The final judgement expressed by the users was that the virtual world is either a useful tool to be integrated into the university course of study in radiology and in the post-graduate continuing medical education.

5 Design effective virtual world environment for VET education

When designing virtual worlds with specific learning outcomes in mind (such as those linked to VET education) it is important to consider the high-level game mechanics, also known as game dynamics, that will define the virtual world itself. One can think of these as the core dimensions around which player engagement is built. Based on the considerations drawn from previous chapters and analysis, a guideline focused on the most important elements in designing and modeling virtual worlds aimed at conveying educational content through gamified experiences will now be presented.

5.1 Competition

The dimension of competition between players, or groups of players, can result in a strong drive in achieving results and in acquiring motivation for playing inside the virtual world. Sports are a great example of a game context in which players' competitiveness is encouraged and leveraged to enhance both engagement and fun. At the same time, designers have to be careful not to alienate players: it is important to focus on positivity over negativity, on victory over defeat, on rewarding effort and success rather than punishing defeat. Both leaderboards and reward badges are examples of good competition that were already introduced in the chapter relative to gamification and will now be expanded on with a strong focus on implementation ideas and suggestions.

5.1.1 Leaderboards

Including competitive stimuli, such as a ranking among players, is a great way to encourage players to improve their performance within the gamified experience and increase the game longevity, creating more learning opportunities. The introduction of a leaderboard must of course be accompanied by the creation of a points collection system which will be the yardstick for the ranking generation. Therefore, it is needed to define specific areas or sessions within the virtual world in which the player can earn points by completing tasks. For each of these areas or sessions, a scoring method must be defined: the logic upon which both the award of points and the number of points awarded can be manifold and will depend primarily on the nature of the tasks themselves. For example, points can be awarded based on mistakes done, completion time, or the overall number of tasks completed. To appeal to as many players as possible, different leaderboards can be present at the same time, even when based on the same points system. For example, a virtual world could have three leaderboards: one based on the highest single score players have achieved on specific tasks (thus encouraging precision), one based on the average points gained by players (thus encouraging consistency) and one based on the cumulative scores obtained by players throughout all of the sessions (thus encouraging overall task completion rate).

5.1.2 Badges

Allowing players to collect items and to show their status or achievements is a powerful and effective way to enhance players' engagement. This is perfectly implemented through a badges system, where a badge is earned by the player whenever he/she completes a specific action. Every badge is collected only once by each player and all the badges are stored in the player's public profile so that the player's badges collection is visible to every other user. A badge is typically presented a with a name and an icon representative about the completed action, and its drawing should be more appealing as the difficulty of the relative task increases. Designers can choose to show the requirements to earn each badge or to hide those requirements and let the players discover how to collect them all; the first solution will ease the collection guiding players through it, while the latter instead is more challenging and can create interactions among players. A mixed approach can also be considered hiding the description of the hardest badges to earn. Traditional badges can be accompanied by a more modern reward system that consist in giving items to customize the player's avatar such as a jacket or an hat that the player can wear that is obtainable only completing the proper task.

Badges can be earned by achieving predefined results in the game such as gain the maximum score in a task completing a quest or exploring a specific world area. The collection of some of the badges should be very simple to stimulate the player to keep collecting them going on with the game.

5.2 Collaboration

As with competition, collaboration can also be seen between players and between groups of players. The use of collaboration can also achieve, beside the increase in player engagement, the fostering of critical skills such as social interaction, negotiation, and shared decision-making. A collaborative environment requires some considerations to be successful and satisfying. We will now present some examples of critical aspects to keep in mind while developing and designing such an environment.

5.2.1 Communication means

True collaboration can't exist if players are not able to promptly and efficiently communicate with each other. Multiple means of communication have to be considered depending on the learning outcomes of the specific tasks: players can not only need to communicate in real-time (synchronous communication, e.g. a chat) but also in a deferred way (asynchronous communication, e.g. a discussion forum). It is important to note that while it is strongly advised to keep the synchronous communication inside the game as a part of it, not to break the immersion flow, asynchronous communication can happen outside the game, for example in an external web platform.

Figure 39: Players using the real-time chat inside the game *Grand Theft Auto*

5.2.2 Social aspect

Being part of a group can strongly impact on players' engagement. This can be seen in many commercial games. This aspect needs to be deeply considered when designing the virtual world and has repercussions on both the dimensions of collaboration and competition: do you want the players to work in small groups? Do you want these groups to compete with each other inside the world? What is the granularity of the groups and therefore the extent of the collaboration? Do you want schools competing with each other, promoting the collaboration of all the students that are part of them, or do you want classrooms of the same schools to compete with each other? These design questions are really important and heavily depend on the proposed learning outcomes. Once the granularity of the groups is defined it is important to leverage in the social aspect with the acknowledgment of said groups: A school (or a classroom) could be identified inside the game by a banner, a name, or a symbol that players can carry on themselves to communicate their affiliation. At the same time, communication channels dedicated to the groups could be implemented as layers of interaction determined by the players' affiliation.

Figure 40: Players of a guild group inside the game *World of Warcraft*

5.3 Narrative

The presence of a narrative element can greatly improve players' engagement. It can work as an hook to get the player's interest in visiting the virtual world and/or can work as the mean that keeps the player inside the flow while carrying on the learning tasks. In fact, a good narrative thread can significantly enhance players' fantasy and therefore their desire to play the game. There are two major ways to convey and develop the narrative element: by having the classic scripted storyline and by having players develop and create their own story through a collaborative effort.

5.3.1 Scripted storyline

Having a defined, scripted storyline has the clear advantage of having a straight, predictable narrative path. It can be used as a means to guide players inside the virtual world by giving context and grounding the tasks and the activities satisfactorily. The con of this approach is that the player might not want to behave exactly as the character is supposed to in the storyline. This can be mitigated with a strategy seen in many commercial games: the player and the developer alternate in the control of the characters. Through the use of cutscenes and non-interactable moments, the designers can "force" the characters to behave in predictable ways, thus allowing the story to move on. It is important not to abuse this strategy to avoid having the player break out of the immersion flow and therefore reducing the engagement.

Figure 41: A scripted dialogue in the game *The Banner Saga*

1.1.1. Collaborative narrative

On the other hand, having a system that allows a collaborative narrative can be a great asset in enhancing immersion, flow, and engagement. This is a strategy typically used in tabletop role-playing games, such as Dungeons and Dragons: the game provides a structured canvas in which the players can freely express themselves, building the story together as they play. Through this approach and role-playing, the game can also foster important skills, such as communication, conflict resolution, and creativity, as well as stimulating empathy. Moreover, this approach makes it possible to have a compelling story that is tailored to the needs of the group of learners (e.g. a classroom) in a way that would be very difficult to obtain by standard means.

5.4 Monitoring and Assessment

While choosing the right game mechanics and dynamics is critical in the design of the virtual world, developing a system that can assist teachers in monitoring and assess students' performance and progress is equally important. These are hard tasks and teachers are not always equipped with the right tools, so it is important to include ways to facilitate these while designing a virtual world focused on educational content.

These tools can either be implemented inside the virtual environment itself or can be delegated to external tools or platforms that receive data from the virtual world and present them to the teachers. While the first solution seems the most integrated, it's the most expensive, since it has to be implemented inside the virtual world itself. It also poses the problem of User Interface (UI) and User eXperience (UX): virtual worlds and games are developed to maximise the UX of players, and as such their UI might not be the best one for teachers nor the most optimal or efficient. On the other hand, opting for integrated external tools allows the use of one of the many existing Learning Content Management Systems (e.g. Moodle), lifting most of the implementation costs of such a system. Moreover, UI and UX in these systems are designed to better fit teachers needs and habits, resulting in an easier transition into their use.

Regardless of the implementation and integration path chosen, the same considerations about the data players generate have to be made: what is important? Which is the best way to present this data to teachers? How should the data be reviewed? These are all questions whose answers lie deep in the specific learning outcomes of the virtual world itself, but we will now discuss a couple of key elements that can hopefully shed some light on the critical considerations one has to make when designing such a system.

5.4.1 Players' generated data

Players generate an immense quantity of data while inside a virtual world and collecting all of it is neither useful nor feasible. It is important to focus on the metrics tied to the tasks that are to be monitored and assessed: completion time and number of mistakes made are the most common ones, but depending on the learning outcomes metrics such as the number of accesses in the virtual world or the total time spent inside of it can be relevant. It is also important to collect this data in real-time and on the spot so as to allow a number of different types of analysis and monitoring techniques. Therefore, to outline the set of metrics and the data that can be useful for assessment and monitoring, designers have to focus on questions such as: What are the learning outcomes? What are the teachers and educators interested in? What is the right granularity, giving enough data to be useful and not overwhelming?

5.4.2 Data organization and visualization

Once the metrics are established, it is important to reason on the way the data gathered is organized and presented to teachers and educators. Sometimes teachers have the need to assess students on their own and sometimes on aggregate groups, such as classrooms and study groups. Having a system that can allow a level of freedom and flexibility around the level of data aggregation is key. Moreover, time is also an important dimension of data aggregation: teachers can have the need to assess a single play session, monitoring the tasks that are being done, as well as have an historical view of all of the sessions the player had in a specific timeframe, such as a month or a semester.

The way the data is presented to teachers is equally important: easy to use and understand tools such as graphs and charts are critical as well as, depending on the audience, giving the chance to obtain the data in a statistical friendly format, such as CSV and XML.

5.4.3 Online and Offline Monitoring

One of the most important, and often overlooked, factors in assessment and monitoring tasks is the promptness of the data accessibility. Often teachers have the need to monitor player sessions as they happen, so to help student focus on the right aspects of a task while they are actively doing it; other times they have the need to look at past sessions or at specific moments in a past task execution in order to better assess and understand players' behaviour. It is therefore paramount to allow both online (as in real-time) and offline (as in not in real-time) monitoring of the players' activities. Having a stronger need to have one of the two does not mean the other is not useful and developers should keep this in mind while designing such systems for educators.

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