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# USER GUIDE FOR TEACHERS ON HOW TO PLAN LESSONS IN DISTANCE LEARNING

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## 1 The DigiCAMP project

Science school education has strategic importance for the further development of an economy, and a society. From this point of view, science courses have particular importance in primary and secondary school education and are considered necessary more than ever before. Natural Sciences are considered by schoolteachers to be a hard domain for students to study and deeply comprehend. Indeed, the selected domain consists of concepts that traditional teaching methods cannot properly teach. Several studies indicate that students have particular difficulties in grasping topics and understanding aspects of sciences such as maths, chemistry or physics which are considered to be one of the hardest courses of primary and secondary education. As a part of the Erasmus+ project NET- New Approach in Educational Technology, a survey between teachers at the primary and secondary schools has been realized. The survey was realized in CZ, SK, IT and GR during the COVID-19 lockdown, and we consider this fact as an important point for the better evaluation of real skills and competencies of the teachers with using ICT in the education process. The findings identified the request of teachers to have training in the following topics:

- How to plan lessons in distance learning.
- How to design interactive resources and multimedia posters.
- How to use virtual learning environment and gamification principles.

### 1.1 Objectives

During the crisis caused by COVID-19, the need to teach at primary and secondary schools using digital technologies and online platforms such as e-learning has become more prominent than ever. As the actual situation around the world has showed, having online platforms and huge amounts of online learning materials are a necessary but not sufficient condition for effective online education. The **DigiCAMP** project provides a solution that can help eliminate the situation in the future, as it combines the benefits of online (or, better-said distance) education with traditional face to face classroom teaching. The concept of the DigiCAMP project is to contribute to the elimination of the negative aspects of distance education, as have been found during the COVID-19 experiences at primary and lower secondary schools. The very important is the opportunity to share the knowledge, experiences and learning sources between stakeholders from the education sector. To reach this, the project focused emphasis on the active engagement of the stakeholders to the project activities. The project main objective is to develop the methodology of how teachers can effectively teach, and parents can be involved in the education of their children through a 3D virtual world. It also offers innovative learning activities and the



virtual educational platform that was developed and support pupils' active learning, allowing learners to experiment and put theoretical knowledge into practice. A special part of the virtual reality environment concerns the virtual laboratories that was designed to facilitate students to carry experiments, explore procedures and get a deeper cognition and understanding of how procedures are conducted and things/phenomena work.

## 1.2 Results and Activities

The project produces outputs that are completely new and innovative in terms of learning methods in maths, informatics and physics education, the content of courses and school education approaches in virtual reality environments.

Through the synergic effect of international cooperation, transfer of innovation and development of innovations and additional values, the 6 partners from 4 countries set up the main project results of the project:

**R1. User Guide for teachers on how to plan lessons in distance learning** – to create and publish a Methodology on how to plan lectures and to teach avatars (students/pupils in a virtual learning environment). This focuses on "how-to" strategies for starting the implementation of advanced technologies into the education process and include the didactical methods that help the teachers to educate pupils attractively during their face-to-face lessons as well in the situation when they cannot participate personally in the classroom.

**R2. Virtual Learning Environment and Open Educational Resources for Math, Informatics and Physics** - to assist pupils in better studying and learning maths, informatics, and physics with the utilization of advanced technologies. Specifically, a 3D virtual reality educational environment was developed possessing innovative educational infrastructure, and offering immersive and efficient learning opportunities, engaging students in various educational activities, learning scenarios and offering students an attractive, entertaining, and efficient way to learn various topics of the challenging domain of maths, informatics and physics. The pupils can virtually visit living labs, perform experiments, explore procedures and phenomena, examine the ways that are conducted and be guided towards analysing and explaining them through the scientific method.

**Multiplier events E1 – E4:** Four workshops “How to Teach Avatars” to promote DigiCAMP results.

**Piloting activities** as an important part of the activities for the project results' evaluation.

## 2 Virtual Worlds, Distance Learning and Education

### 2.1 3D Virtual Worlds

The expression '3D virtual world' generally refers to a digital environment created by means of software and capable of placing one or more users in the condition of interacting in real-time with objects or with other users. Such an environment often offers users stimuli and cues capable of engaging their senses and committing their attention to a reality that, although artificial, is perceptually authentic (immersive experience) (Zhang 2020). Through immersiveness, moreover, 3D virtual worlds lend themselves to the creation of engaging educational pathways (Hull et al. 2018) within which immersiveness can be experienced in different ways. Indeed, the range of 3D virtual worlds that can be designed is very diverse in terms of type and complexity: simple virtual spaces involving a single user or multi-user, complexly structured worlds can be realised.

The building blocks of a virtual world are diverse and the roles and functions they perform are heterogeneous. The combination of these elements allows developers to design and implement learning experiences focused on the virtual world and having characteristics that can be manipulated in different ways with the aim of structuring an immersive experience that is interactive and engaging for the user. Among the different elements that can be counted as the components of a 3D virtual world, some can be described as core components: 3D space, 3D objects, textures and lighting.

'3D space' refers to a virtual environment that can be explored by the user and within which the user can interact with other users or objects. 3D objects represent a category of elements within which there are both simple geometric shapes and highly detailed models of imaginary or real objects. Textures, on the other hand, are images that are generally applied to various 3D objects in order to create their surface. Finally, lighting represents a fundamental component through which it is possible to influence the appearance of the 3D world.

Among the methodological advantages that 3D virtual worlds offer, the possibility of customisation represents a key element in implementing pathways capable of meeting the multiple needs of a wide range of users. Within the framework of a 3D virtual world that offers customisation possibilities, users can choose an avatar and, in some cases, personalise it, they can construct their virtual identity, they can select and personalise the setting of their avatar, and can choose their objects. Such a methodological option allows for the creation of unique and customised experiences that are perfectly tailored to the needs of the different users to whom they are addressed. Together with the possibility of customisation, another fundamental characteristic of 3D virtual worlds is the chance they offer the user to interact in real-time with other users and/or with objects in different ways. For example, a user can interact by moving through 3D space, manipulating it, creating new content and interacting



with other users or other virtual agents. Real-time interaction, as well as the possibility of customisation, represent two constitutive features of the immersiveness and engagement that a 3D virtual world can offer.

Thanks to the above-mentioned features, 3D virtual worlds are suitable for many applications. They are, for example, used in the context of games. In this context, a 3D virtual world enables the creation of playful experiences that can fully involve users. Other possible uses are in the field of education, to implement educational paths relevant to single or transdisciplinary disciplines or to simulate real situations in which debriefing sessions can then be activated. The fields of e-commerce and science also represent two areas of application of virtual 3D worlds.

Moreover, all these multiple applications of 3D virtual worlds have some basic advantages in common. Firstly, they can offer users greater involvement and interactivity than other solutions offering digital experiences. Secondly, a 3D virtual world also allows users to experience those scenarios and contexts that in reality are generally difficult to recreate because they are linked to events that occur rarely or because they are dangerous. In particular, replicating rare and/or dangerous events with 3D virtual worlds reduces *both the costs and risks associated with training delivered in real contexts*.

On the other hand, however, the design and creation of a 3D virtual world replicating rare and/or dangerous events/contexts involve considerable challenges, some logistical, and others related to contents. To the first category of challenges belong the need to find high-level technical skills for the creation of virtual worlds and the need to deploy significant financial resources for this purpose. On the other hand, the second category of challenges belongs to requirements that are closely linked to the first; indeed, the challenges belonging to this second category determine the magnitude of those just mentioned. Of these, the primary need to be met is the creation of environments/scenarios/contexts that are realistic and thus perceived as realistic by the user.

## 2.2 3D Virtual Worlds and Education

In education, there are many different benefits that the use of virtual worlds can introduce. Such use can lend excellent support to collaborative learning, for example. This approach with a solid pedagogical basis refers to group work, social knowledge construction and sharing.

Through the use of virtual worlds, in the context of collaborative learning, different collaborative practices can take place: creation, construction, performance of specific tasks, and experimentation. In this context, users can communicate, socialise and take part in common activities while remaining at a great distance from each other. Thus, each user, within the framework of what could be defined as a true learning community, has the opportunity to construct, but also to share, content that allows them to stimulate and express their creative



capacity, to undertake paths of reflection on acquired knowledge (metacognitive practices) and to acquire new knowledge.

Operationally, each user can test himself by performing challenging and interactive tasks that may require collaborative and/or negotiation practices with other users in order to solve specific problems. Such practices help stimulate users' motivation and involvement as a community. Moreover, such practices often result in genuine community experiments whereby each user can come into contact with different cultural and linguistic domains.

Within these communities of practice facilitated and made possible by the characteristics of virtual worlds and the actions that can be implemented within them, it is possible to initiate paths and processes aimed at facilitating the construction of users' knowledge. The latter has the possibility of immersing themselves in virtual reproductions of real scenarios that represent an excellent environment both for learning practical skills and for experimenting with complex situations that cannot be experienced in real life for different reasons (e.g. a virtual world can allow tasks to be simulated to be solved in extreme and inhospitable climatic and/or environmental situations).

In the specific educational field, the immersiveness offered by 3D virtual worlds is an integral part of the possibility that this type of tool gives to create authentic educational environments. Students can immerse themselves in detailed and precise simulations of distant geographical locations, ecosystems with well-defined characteristics, scientific laboratories, etc. Within these simulated environments, students are also allowed to experience different levels of interactivity by manipulating objects and solving practical problems (e.g. in the context of chemical reactions or simulated physical experiments).

The aforementioned sharing and/or social creation of knowledge is a tangible manifestation of the possibilities of knowledge construction that can be enhanced through the use of virtual worlds. More specifically, if we look at the communities of practice mentioned above with a more analytical eye, they can also be described as virtual environments in which people from different parts of the planet can exchange ideas, discuss concepts, solve problems, and build proposals. In short, build knowledge. A virtual environment with such characteristics makes it possible (a) to overcome the traditional limitations of the physical space represented by the classroom that can simultaneously accommodate a limited number of students and resources and (b) to rethink a new temporal dimension of learning. With reference to this, the learning of each student is no longer strictly bound to a rigid and fixed school timetable but adapts to the times and rhythms of learning of the individual who can repeat certain experiences in order to deepen and/or devote more time to topics that are more difficult in the course.



In this context, the facilitation of the construction and exchange of knowledge also materialises in the possibility that virtual worlds give each user the possibility of customising their own learning path by creating, for example, their own avatar and using it to undertake learning experiences built ad hoc on their own needs and commensurate with their abilities. This 'power' can be managed autonomously by the students but can, in more structured learning situations, be managed directly by the teachers who adapt the environment to their teaching needs of the moment by calibrating methods and contents to the level of the class or individual students.

In recent years, different virtual worlds have been developed in different fields. Some have been implemented specifically for educational purposes, while others, although designed for other purposes, have proved to be effective tools in the educational sphere as well. Both the former and the latter have traits in common: they offer immersive and interactive learning experiences within freely explorable simulated environments. Here are some examples:



**Second Life Education**<sup>1</sup>: the 3D virtual world of Second Life (<https://secondlife.com/>) is very popular and offers various educational opportunities<sup>2</sup>. The different environments within the world allow both students who can meet physically and students separated by vast distances to work synchronously or in groups. Second Life Education makes it possible to implement great flexibility in learning paths by enriching the student's experience through the simulation of spaces and/or environments specific to the learning content to be conveyed.



**Minecraft** (<https://www.minecraft.net/it-it>) is a virtual game that allows the user to explore a virtual world built with blocks. Within the virtual world, different actions of building, exploring, collecting, interacting and creating can be implemented. A specific section of Minecraft is Minecraft Education (<https://education.minecraft.net/it-it>), which offers the virtual world of Minecraft and its features as a learning tool. In this virtual environment, students/players can collaborate on projects with students in the same class and explore different teaching contents prepared by the teacher on different subjects (e.g. STEM, History, etc.) and also on interdisciplinary learning paths.

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<sup>1</sup> Second Life Education (2011). The Virtual Learning Advantage. Retrieved on June 10, 2023, <https://lecs-static-secondlife-com.s3.amazonaws.com/work/SL-Edu-Brochure-010411.pdf>

<sup>2</sup> [https://www.youtube.com/watch?v=e3KzynJzvMU&ab\\_channel=SecondLife](https://www.youtube.com/watch?v=e3KzynJzvMU&ab_channel=SecondLife)



## Virbela

**Virbela** (<https://www.virbela.com/>) is a 3D virtual world widely used by both academic institutions and companies that want to create immersive learning paths and educational experiences. In Virbela's virtual world, each student can participate, through avatars that can be customized, in lessons, meetings, and collaborative tasks. One of the strong points for educational purposes is the wide range of specific spaces that this virtual world makes available to teachers and students: classrooms, laboratories, and offices. These dedicated spaces are all part of a campus (the Virbela world) that (a) is customisable based on the needs of students and teachers, (b) is designed to involve the key players in the educational process in a virtual context where interactivity and collaborative processes are central features (<https://www.virbela.com/go/education>).



**Engage** (<https://engagevr.io/>) is a 3D virtual world platform that is widely used in the educational field also thanks to the possibility of simulating very specific learning environments in detail that it offers (<https://youtu.be/-jQQ72HISh0>). Engage, as a platform, offers users different types of scenarios and activities aimed at learning. Within the virtual environment of Engage, students can attend lessons, they can interact in the context of the lesson with other students or with the teacher, can follow customised and specialised paths (<https://engagevr.io/vr-education-learning/>). Teachers can also make use of customised content and interactive processes to communicate with students.

So far, the undoubted advantages offered by 3D virtual worlds to the field of education have been examined. However, in the final part of this section, it is also necessary to present the criticalities and limitations that these tools possess to date. Criticalities and limitations represent future challenges for further refining and enhancing these important learning tools. These are problems of a different nature (e.g. methodological, logistical) that, together, contribute to making 3D virtual mountains a tool with ample room for improvement.

On the methodological side, the critical points to be identified seem to be mainly two:

- the risk that such tools are unable to guarantee authentic learning;
- the risk that the classroom use of these tools is not supported by adequate teacher training on the subject.

In the first case, the authenticity of the experience within a virtual scenario must be supported by pedagogical techniques and instances in the design phase of learning paths. Immersivity, interactivity and representational realism have no long-term effect on learning if they are not underpinned by a pedagogical model that directs

the knowledge construction and sharing paths undertaken within the virtual world. In the absence of such a model, immersivity, interactivity and realism merely have an immediate effect on the student's astonishment but fail to significantly affect his or her preparation. Closely related to this issue is the second critical point mentioned above.

The absence of a pedagogical framework underpinning the profitable use of a virtual world in education very often mirrors a lack of training on the subject on the part of teachers, the actors whose task it is to manage and orchestrate learning paths and contents even within the virtual world. That Teachers can use a 3D virtual world wisely allows them not only to fully exploit the potential of the technological tool but also to strategically analyse and organise the possibilities offered by the tool following appropriate and well-defined pedagogical strategies of which teachers are the expert regarding.

On the logistics side, on the other hand, at least three critical elements should be emphasised:

- the risk that such tools may be difficult to access and equally available to all potential users;
- the risk that the costs of such tools may represent an objective limitation for some institutions;
- the risk that sensitive data collected in the virtual world are not managed and stored securely.

Regarding the first point, the technological requirements that allow access to 3D virtual worlds (devices that guarantee a certain level of performance, and fast and stable Internet connections) may be not met by the entire audience involved in the virtual experience. Problems of this kind can contribute to the creation of inequalities between students who can access the virtual worlds because they are equipped with the appropriate technological tools and students who are unable to access them because they do not have the same equipment. Of the same nature are the problems contemplated in the second discussion point. In this context, since the implementation of a 3D virtual world requires economic investments in terms of both hardware and software, not all institutions that would like to equip themselves with it may be able to bear the costs.

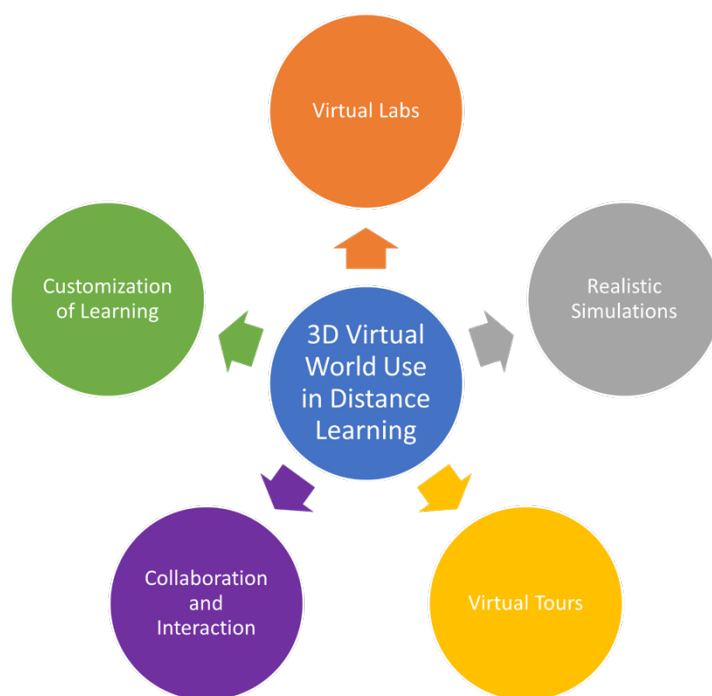
Last but not least are the risk elements arising from the management of sensitive data from the activities carried out within the virtual world. It is very important for the safety of students and teachers - as a guarantee for users - that each virtual world offers clear information and adequate solutions regarding data collection, management and storage.

## 2.3 3D Virtual World and Distance Learning

Based on the characteristics, dynamics and possibilities described above and offered in the educational sphere by 3D virtual worlds, the latter appears to be a fruitful tool in the context of methodologies regarding Distance Learning.

Distance Learning, specifically, can be defined as a learning (and also teaching) methodology implemented with the aid of digital technologies. These are used to enable students and lecturers to participate in learning sessions (lectures, workshops, practical experiments) even though it is not necessary for them to be physically present in a physical location. The advantages of distance learning are many. These include the flexibility of learning times that are not directly dependent on school hours and the pace of face-to-face classes. In this context, students have the opportunity to manage their time according to their own learning rhythms and at different geographical distances.

Bearing in mind the distinctive features of distance learning, it is easy to understand, therefore, how virtual worlds can be an important resource for this methodology. Virtual worlds, in fact, offer the possibility of creating interactive virtual scenarios that can be experienced remotely and at flexible times. By fostering user immersion in a simulated reality, they help structure a sense of presence and active participation in students. This is made possible by the use within virtual worlds of user avatars: virtual user interfaces through which users can explore, act and modify the virtual world with specific actions (taking part in discussions, performing tasks, collaborating in projects, simulating experiments).



*Figure 1 - A summary scheme on the different possible uses of virtual world in distance learning.*

Systematising the various possible uses of virtual worlds in the context of distance learning, also with regard to the previous sections, we propose below a non-exhaustive summary scheme.

However, these clear advantages of using virtual worlds in distance learning come up against specific limitations dictated by the field's lack of maturity. Apart from the problems of access already addressed in the previous section, the use of virtual worlds in Distance Learning suffers from certain problems that are probably inherent to Distance Learning itself. Two out of all:

- a possible initial cognitive load
- a limited human interaction.

Regarding the first point, both students and teachers at the beginning of virtual world-mediated learning may face objective difficulties related to the fact that they have to learn how to use the technology. Such a condition would require a considerable investment of time and mental training resources on top of that required for the actual study or design of the learning content.

As for the second point, however, one of the strengths of distance learning and the tools supporting it (in this case the virtual world) if not competently managed also represents a major limitation: limited human interaction. Technological progress in recent years has succeeded in guaranteeing increasingly interactive distance experiences which, however, are not yet able to fully replace in-presence interaction, thus characterising distance learning as different from in-presence learning (e.g. in social aspects, in aspects related to non-verbal communication). For this reason, although virtual worlds represent a valuable tool for distance learning, they cannot be the only tool deputed to training but can complement the work done in the classroom very well.

## 2.4 The benefits of using virtual worlds in educational processes

Using a 3D virtual world in the educational process can bring several benefits and make the learning experience more effective. It can evoke enhanced engagement of learners. A 3D virtual world provides an immersive and interactive learning environment that can capture students' attention and engage them in the educational content.

The realistic and interactive nature of the virtual world can stimulate curiosity and motivation, leading to increased student participation and interest in the subject matter.

Virtual worlds allow students to actively participate in simulated experiences and experiments. They can explore and manipulate objects, conduct virtual experiments, and observe phenomena in a safe and controlled environment. This hands-on approach promotes experiential learning, enabling students to gain practical knowledge and develop a deeper understanding of complex concepts.

Another key element is visualization and spatial understanding. Visualizing abstract concepts can be challenging for students. A 3D virtual world can provide visual representations of complex ideas, making them easier to comprehend. Students can visualize spatial relationships, observe objects from different perspectives, and interact with 3D models, which enhances their spatial understanding and promotes better conceptualization.

Virtual worlds can facilitate collaborative learning experiences. Students can interact with each other, work on group projects, and engage in discussions within the virtual environment. This promotes teamwork, communication skills, and the ability to exchange ideas and knowledge. Collaborative learning in a 3D virtual world can also overcome physical barriers and allow students from different locations to work together.

Virtual world can also offer personalized learning experiences tailored to individual student needs. The interactive nature of the environment allows for adaptive feedback, customized challenges, and individual progress tracking. Teachers can design learning activities that adapt to students' abilities, providing targeted support and addressing specific learning gaps.

3D virtual world can provide access to a wide range of educational resources and simulations that may not be available in traditional classrooms. Students can explore virtual libraries, attend virtual lectures, and access multimedia content.

Additionally, virtual world can support remote learning, enabling students to participate in educational activities from anywhere, overcoming geographical limitations.

It is important to note that while virtual worlds offer many benefits, they should be used in conjunction with effective pedagogical strategies and guidance from educators to ensure meaningful learning outcomes.

## 2.5 The use of 3D virtual world in education as a good practice

The biggest challenge in education after the coronavirus crisis is represented by the overcrowded curriculum and the question of how to motivate students to learn. Distance learning and lack of social interactions have led to a subconscious loss of interest in studies. Many school subjects have lost meaning in the eyes of students, negatively altering their attitude towards studying. On the other hand, teachers have sought tools to make their subjects, including computer science, physics, and mathematics, more appealing.

One of the best examples of how the educational process can benefit from the 3D virtual world is represented by the DigiCAMP project - ([www.digicampproject.eu](http://www.digicampproject.eu)), which proposes a 3D virtual learning environment focused on the fields of computer science, physics, and mathematics.

The DigiCAMP virtual learning environment has been designed to support students in forming appropriate mental models of involved concepts by visualizing them and allowing interactions with real-life phenomena and

processes. The 3D virtual learning environment and the visualization of procedures aim to help students connect abstract concepts and procedures to concrete experiences and examples.

The DigiCAMP Game-based 3D Virtual World Educational Platform hosts all the OER (textbooks, presentations, multimedia, 3D objects, and constructions) as well as the learning scenarios. The basic idea of the game involves the creation of a treasure hunt, in which the key elements to be searched and collected in the virtual world are represented by specific symbols related to the different topics addressed in the courses.

Practical activities and assignments are considered an integral part of science teaching and learning; the Inquiry-Based Science Education (IBSE) method is usefully introduced during computer science, physics, and mathematics lessons. The IBSE method relies on the fact that students work independently during problem-solving, and the teacher becomes a mere observer. Laboratory experiences provide opportunities for students to interact directly with the material world.

The DigiCAMP 3D virtual world educational platform reflect the principles of the IBSE method and lead students to independent observation, discovery, and drawing of possible solutions and conclusions, developing scientific reasoning and practical skills, and cultivating interest in science and interest in learning computer science, physics, and mathematics.

Feedback from students and teachers using the DigiCAMP 3D virtual world highlights the following advantages:

- Engaging and immersive learning
- Active participation and experiential learning
- Personalized learning environment
- Global collaborative learning
- Accessibility and inclusiveness

### *2.5.1 Engaging and immersive learning*

3D virtual worlds provide an immersive environment that captures students' attention and encourages active participation. By simulating real scenarios and settings, students are intensively involved in the learning process. In these environments, abstract concepts can be visualized and experienced, making learning more tangible.

### *2.5.2 Active participation and experiential learning*

Students are not passive recipients of information; instead, they actively participate in their learning. They make decisions, solve problems, and engage in practical activities. This active learning approach improves critical thinking, problem-solving, and decision-making.

### *2.5.3 Personalized learning environment*

The 3D virtual world can be customized to meet individual learning needs. Learning materials, content, and pace can be adapted to suit different learning styles and abilities. Personalization extends to feedback and ratings. Students receive immediate feedback and track their progress, allowing for a more personalized learning experience.

### *2.5.4 Global collaborative learning*

The DigiCAMP Virtual World breaks down geographical barriers and facilitates collaboration between students and teachers from all over the world. This global approach exposes students to different perspectives and cultural awareness. Joint projects become more engaging and effective in 3D virtual environments. Students collaborate in real-time, working on joint projects and learning from colleagues in different locations. This global perspective prepares students for an increasingly connected world and promotes skills in teamwork, communication, and cross-cultural understanding.

### *2.5.5 Accessibility and inclusiveness*

The DigiCAMP 3D virtual world can make education accessible. Individuals with physical disabilities were able to participate on an equal level because they did not have to physically walk through the spaces. Access to education was possible even from remote or underserved areas. Students in rural areas or regions with limited educational resources can benefit from high-quality virtual education.

## **2.6 3D virtual world and knowledge evaluation**

Evaluating knowledge obtained through 3D virtual world activities requires a thoughtful approach that takes into account the unique characteristics of this learning environment. Here are some strategies that can be employed:

- Designing assessments that require students to apply their knowledge and skills within the virtual world. This could include completing tasks, solving problems, or demonstrating specific competencies relevant to the subject matter. Observing students' actions and interactions within the virtual environment can provide valuable insights into their understanding and proficiency.
- Developing virtual simulations and scenarios that present real-world challenges or scenarios related to the learning objectives. Assess students' ability to navigate and make decisions within these simulated





environments. Their actions and choices can be evaluated based on their understanding of concepts, problem-solving skills, and critical thinking abilities.

- Incorporating reflection activities where students can evaluate their own learning progress and identify areas for improvement. Encourage students to reflect on their experiences within the 3D virtual world, their achievements, and challenges faced. Self-assessment can help students develop metacognitive skills and take ownership of their learning.
- Implementing ongoing formative assessments throughout the learning process. These can include quizzes, interactive activities, or short assignments embedded within the virtual world. Formative assessments provide timely feedback to both students and teachers, enabling adjustments and improvements in teaching and learning strategies.
- Fostering collaboration and peer evaluation within the virtual world. Encourage students to engage in group projects or problem-solving activities where they can assess each other's contributions, provide feedback, and evaluate their collective understanding. Peer assessment promotes communication skills, critical analysis, and a deeper understanding of the subject matter.
- Creating authentic assessments that mirror real-world applications of knowledge. This could involve creating presentations, reports, or portfolios based on students' experiences and achievements within the virtual world. Authentic assessments assess students' ability to transfer knowledge and skills gained in the virtual environment to real-world contexts.
- It is essential to align assessment strategies with the learning objectives and the specific competencies targeted in the 3D virtual world activities. Additionally, consider using a combination of assessment methods to provide a comprehensive evaluation of students' knowledge and skills acquired through their engagement in the virtual world.

## 3 The virtual world of DigiCAMP - “PIM’s World”<sup>3</sup>

### 3.1 The structure of DigiCAMP world

The DigiCAMP program consists of three courses situated on different islands:

- World of Mathematics
- World of Physics
- World of Informatics

Access to each island is facilitated through Teleportation Panels. Each student can simply click on the arrow button next to the desired island and is instantly transported there.

Within each course, there are multiple topics, each housed in a separate building. These buildings are further divided into 5 distinct areas, each dedicated to one of the 5 subtopics. In these areas there are a presentation panel and an assessment activity. The presentation panels provide an overview of the theory related to a subtopic. For each subtopic, there is at least one assessment activity, such as quizzes, matching, sorting, or classifying. Instructions for these activities are typically included to guide students through the process (see section 6.2).

### 3.2 Focus on content structure

Individual main subjects represent Mathematics, Physics and Informatics. Each of these subjects is divided into 4 or 5 main topics, and each topic is then divided into 5 subtopics. The learning content structure is described below:

**Subject:** Mathematics

**Topic:** Geometric shapes

**Subtopics:**

- Area units
- Triangle
- Prisms

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<sup>3</sup>The title of the 3D world is a word game. PIM is an acronym that stands for Physics, Informatics and Mathematics. However, it is also the name of the player character who, according to the proposed game logic, has to search and collect symbols in the treasure hunt to explore an unknown land that metaphorically represents the three areas of knowledge addressed by the DigiCAMP project. Why the name PIM? Because it is freely inspired by the adventure novel "The Narrative of Arthur Gordon Pym of Nantucket" by Edgar Allan Poe. The protagonist, in the second part of this novel, has to explore the lands of an unknown island just as the protagonist of the virtual world of DigiCAMP has to do.

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- Circle
- Cylinder, pyramid, sphere
- Properties of geometric shapes

**Topic:** Functions

**Subtopics:**

- Functions and its properties
- Coordinate system (rectangular coordinate system)
- Linear function
- Quadratic function
- Use of functions

**Topic:** Symmetry

**Subtopics:**

- Central symmetry
- Central-symmetrical shapes
- Axial symmetry
- Axial-symmetrical shapes
- Translation (movement) and rotation

**Topic:** Fractions

**Subtopics:**

- Fraction, definition and basic properties
- Complicating and simplifying of fractions
- Addition and subtraction of fractions
- Multiplication and division of fractions
- Comparison of fractions

**Subject:** Physics

**Topic:** Dynamics

**Subtopics:**



- Force
- Gravitational force and acceleration
- Center of gravity
- Throw
- Movement

**Topic:** Mechanical properties of liquids and gases

**Subtopics:**

- Hydraulics
- Hydrostatic pressure
- Archimedes' law
- Atmospheric pressure
- Atmosphere

**Topic:** Optics

**Subtopics:**

- Beam optics
- Lenses
- Mirrors
- Optical instruments
- Optical interface of two environments

**Topic:** Introduction to atomic physics

**Subtopics:**

- Atom models
- Crystal structure
- Molecules
- Radiation (Alpha, Beta, Gamma and how to protect yourself from them) - radioactivity
- Fission reactions

**Topic:** Electromagnetism



**Subtopics:**

- Electrostatics
- Magnetism
- Magnetic field around the conductor and coil
- Transformer
- Engines

**Subject:** Informatics

**Topic:** Information and data, data types

**Subtopics:**

- introduction to ICT
- information & data
- data types
- boolean algebra
- information and database system

**Topic:** Software and hardware components

**Subtopics:**

- operating system
- computer software
- computer hardware and Input / Output devices
- The Internet
- online applications

**Topic:** Algorithms and control structures

**Subtopics:**

algorithm and properties of algorithms,  
variable, constant  
simple commands and control structures  
writing algorithms and programming languages

simple algorithmic problems (roots of quadratic equations, determination of prime numbers, greatest common divisor (GCD) and Lowest Common Multiple (LCM ), etc.)

**Topic:** Virtual space security

**Subtopics:**

- Cybercrime
- Cyberbullying
- social networks
- viruses
- principles of safe use of online applications

**Topic:** Virtual reality

**Subtopics:**

- basic conceptual apparatus in the field of virtual reality
- technical means - hardware and software for virtual reality
- languages to describe VR
- virtual world
- use of the VR in practice

### 3.3 Focus on logic and game dynamics

In this section, we will provide an overview of the game logic and game elements that have been incorporated into the PIM's World developed in the context of the project. The entire game logic involves the different activities and various contents related to the 15 topics and 75 subtopics developed within the DigiCAMP project. It, in essence, acts as the glue in the exploration that the user can make of the PIM's world.

In fact, the selected topics (and their subtopics), although related, have their own peculiarities. This has required the development of a game logic capable of managing the heterogeneity of the content and, at the same time, linking the different topics while highlighting their common aspects.

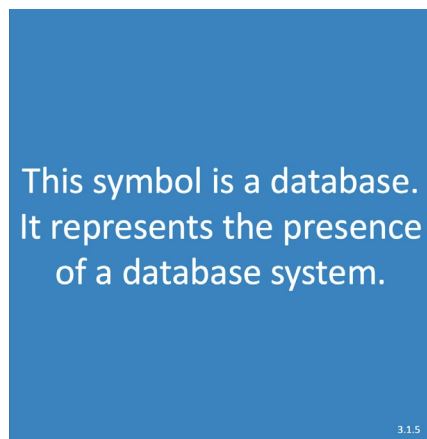
Within PIM's World, it was therefore decided to exploit the use that Mathematics, Physics and Computer Science make of scientific symbolism and formalism to build the core of the game logic.

The user of the virtual world is asked to perform five tasks per topic (one for each subtopic), each of which, when completed, rewards him/her with a collectable key element. This item is a symbol generally used within the specific subtopic (see Figure 2).



*Figure 2 – The collectable key element representing a database.*

In addition to the symbol, the player/apprentice also receives a brief description of the symbol (see Figure 3).



*Figure 3 – The description of the symbol representing a database.*

The collected symbols place the player/apprentice in an overall ranking where he/she can compare his/her 'achievements' in the virtual world with the 'achievements' of other players.

Each symbol earned and its description, once acquired, becomes part of an inventory that the user can explore whenever he/she wants.

## 4 Scenario Development Methodology

### 4.1 The elements that “PIM's World” enables to experience

By developing a learning methodology that makes use of learning scenarios as independent and self-consistent learning units within the virtual world, PIM's World entrusts learning to the exploration of the player's virtual space. Each learning content to which the theoretical part of the subject matter is entrusted is accompanied by an assessment activity. The assessment activities are of different types to stimulate the user's knowledge retrieval capacity in different ways (reading, observation and experiential learning). Text-based multiple-choice questions stimulate reflection on descriptions and operational definitions of the concepts learned. The multiple-choice questions implemented through the NPC stimulate the interactive dimension of knowledge and its retrieval. Game-based training and evaluation activities stimulate the ability to learn and recall knowledge in non-formal and playful contexts and lighten the cognitive load of the subject matter.

The contextualised learning experience within each individual scenario closely links the core components of the process: teaching tools, learning materials, 3D activities.

#### 4.1.1 *Didactic tools*

PIM's World offers various tools designed to support educational activities within the virtual environment. These tools could include interactive assessments, virtual experiments, problem-solving tools, and more. These tools aim to enhance the learning experience and facilitate understanding of concepts in Physics, Informatics, and Mathematics.

#### 4.1.2 *Learning materials*

The virtual world provides access to a range of learning materials that are specific to each subject area (Physics, Informatics, and Mathematics). These materials include digital textbooks, multimedia resources, presentations, and other educational content. They are designed to provide students with comprehensive resources for learning and exploring the subjects within the virtual environment.

#### 4.1.3 *3D activities*

PIM's World incorporates interactive 3D activities that allow users to engage with the virtual environment and interact with objects and elements in a three-dimensional space. These activities include interaction with NPCs, engaging in designed learning activities using their avatar, simulations of real-world scenarios, and other





immersive learning experiences. By engaging in 3D activities, students can develop a deeper understanding of the subject matter and apply their knowledge in practical contexts.

## 4.2 How to use PIM's World as a learning game within school educational paths

By integrating game elements within the virtual world, it is possible to propose engaging and entertaining learning paths to students. This involves integrating elements of the game-based learning methodology within the paths implemented through the virtual world. This integration, for example, allows teachers to propose stimulating objectives to students in terms of missions and challenges. On the other hand, such a structured learning pathway allows students to perceive a sense of progression as they gain game elements at the end of completed tasks. This condition motivates students in terms of intrinsic motivation.

The integration of game elements within the virtual world also allows for the development of an engaging narrative of the learning journey. Thanks to this, a teacher can follow different lines of learning by adopting, for example, strategies that bring students together (collaborative learning) or strategies that make competition the driving force of the learning path. Competition and collaboration between individuals and/or groups, in fact, can both be implemented within a learning path experienced through a virtual world integrated with game elements.

Teachers can identify the specific learning objectives and content areas that align with the school curriculum. Determine how the virtual world can support and enhance the learning experience. Design interactive and engaging activities within the virtual world that allow students to explore and apply their knowledge.

It is also possible to develop immersive learning scenarios within the virtual world that present real-world challenges or situations. These scenarios should require students to use their critical thinking and problem-solving skills to navigate and succeed. Incorporate elements of gamification, such as quests, missions, puzzles, or competitions, to make the learning experience more game-like and enjoyable.

Teachers should offer clear instructions and guidelines for students on how to navigate and interact within the virtual world. Provide support materials, tutorials, or introductory sessions to familiarize students with the virtual world's interface and controls. Offer ongoing support to ensure students can fully engage with the learning game and overcome any technical or conceptual challenges they may encounter.

Teachers would ideally monitor students' engagement and progress within the virtual world. Analyze data and feedback to assess the effectiveness of the learning game and make necessary adjustments. Gather insights on

student performance, preferences, and areas of improvement to enhance future iterations of the virtual world and its educational activities.

### 4.3 Strategies for designing learning paths that take full advantage of 3D virtual world mediated learning

Thanks to the numerous educational activities that can be implemented in the virtual world of the DigiCAMP project, it is possible, within the context of the classroom lesson plan, to design and implement numerous learning paths that integrate theoretical and practical activities contained in the platform. Different educational paths can be designed. Here are some examples, starting from specific topics or activities.

#### 4.3.1 Example of Integrated educational path #1

<b>Subject</b>	Informatics
<b>Topic</b>	Boolean Algebra
<b>Type of virtual world activity</b>	Practical activity
<b>Task to be completed in the virtual world</b>	Practicing boolean algebra by building an electrical circuit

*Table 1 – The key features of the “Integrated educational path #1”*

Designing an educational plan that integrates a practical task on Boolean algebra to construct electrical circuits in the virtual world may involve the following steps:

1. Definition of Learning Objectives
2. Preparation of Students for the Virtual Activity
3. Guided and Supervised Execution of the Virtual Activity
4. In-Class Discussion
5. Practical Exercise in and Reinforcement of Theoretical Concepts
6. Evaluation Phase
7. Final Discussion and Reflection
8. Homework Assignments
9. Further Exploration and Projects

### *Definition of Learning Objectives*

The first step in planning the integrated teaching unit is to clearly define the learning objectives. It is essential to establish what students should learn and how to help them achieve these objectives by the end of the lesson. For an activity like this, the main objectives should include understanding Boolean algebra concepts and applying these concepts to build digital circuits.

### *Preparation of Students for the Virtual Activity*

Before allowing students to access the virtual activity, you can introduce them to the general context of Boolean Algebra and the specific concepts that will be recalled during the practical activity on digital circuits in the virtual world. Specifically, it is useful to provide students with a brief overview of the history of Boolean algebra and its connection to digital circuit design. It is also important to ensure that students have a basic understanding of logic gates (AND, OR, NOT).

### *Guided and Supervised Execution of the Virtual Activity*

For proper and fruitful conduct of the teaching activity, it is advisable to ensure that students have the necessary equipment and accounts to access the virtual world, and that student access is synchronous. Once in the virtual world, guide students to the section of the virtual world dedicated to the activity with circuits. Building on the theoretical insights discussed earlier, you can present the NPC at the entrance of the module where the activity is hosted. The NPC represents George Boole and can be a didactic tool to reinforce what was discussed theoretically in the preliminary phase. Once directed to the specific activity scenario, it can be broken down into sub-activities related to different circuits organized by increasing difficulty. For each circuit, the teacher can provide a brief explanation of the task to be completed. This explanation can be provided either before entering the virtual world or directly in front of each sub-activity. If provided before entering the virtual world, the teacher can also use presentations or other similar educational tools.

### *In-Class Discussion*

After each circuit is completed in the virtual world, students can be invited to "return" to the classroom to participate in a shared discussion related to the concepts applied in the work on electrical circuits, the logic gates used, and the results obtained. In this sharing phase, it is important to invite students to share their experiences, their perceptions of it, and the difficulties they encountered.

### *Practical Exercise in Class and Reinforcement of Theoretical Concepts*

Based on the insights that emerged during the discussion, the teacher can decide to provide students with additional physical materials or digital tools to allow them to practice building real circuits following the example

of the circuits they worked on in the virtual world. In this context, a very useful educational practice is the further integration of theory on Boolean algebra concepts, logic gates, and circuit design principles.

#### *Evaluation Phase*

At the end of the lesson, you can assess students' understanding by assigning specific problems or multiple-choice quizzes. This verification phase may also include an autonomous design phase of circuits based on Boolean expressions.

#### *Final Discussion and Reflection*

Based on the experiences conducted, you can ask students to return to the virtual world and try to consciously summarize the experience.

#### *Homework Assignments*

After the in-class lesson is concluded, you can assign students homework or practice exercises to make the newly acquired learning independent. Students can be encouraged to explore the virtual world and related activities on the studied topic independently, as well as explore, now more expertly, online resources and virtual simulations related to electrical circuits available on the internet.

#### *Further Exploration and Projects*

Additionally, teachers can propose long-term challenges or project work to students on the topic.

### *4.3.2 Example of Integrated educational path #2*

<b>Subject</b>	Informatics
<b>Topic</b>	Virtual Reality
<b>Type of virtual world activity</b>	Theoretical activity
<b>Task to be completed in the virtual world</b>	Basic Conceptual Apparatus in the Field of Virtual Reality

*Table 2 - The key features of the “Integrated educational path #2”*

In the previous example, the virtual world was integrated into a classroom path, focusing on a practical activity contained within it. In the current example of the educational path, we show how to take a different approach by entrusting the explanation of theoretical concepts of a given topic to the virtual world and its NPC inhabitants, while practical activities are conducted and completed during the classroom lesson.

Using the topic *'Basic Conceptual Apparatus in the Field of Virtual Reality'* addressed in the virtual world, it is possible to develop and implement a series of practical activities to be carried out in the classroom. The implementation of these activities can be done sequentially or as dictated by specific educational needs:

1. Free Exploration of a Virtual World
2. Definition of Key Concepts
3. Discussion on Different Types of Virtual Reality
4. Critical Analysis of the Limits and Criticisms of Virtual Reality
5. Brainstorming on Possible Applications of Virtual Reality
6. Practical Creation Activity

#### *Free Exploration of a Virtual World*

Create a virtual environment or use virtual reality tools to allow students to explore a virtual world, similar to what is described in the text. Students can wear VR devices (if available) or use 3D simulators to experience immersion in a virtual environment.

#### *Definition of Key Concepts*

After exploring the virtual world, lead a classroom discussion to define and explain the key concepts mentioned in the theoretical presentation provided by the 'PIM's World' learning content. Concepts like "immersion," "presence," and "interaction" explained within the virtual world can be used as a stimulus for students to share their experiences of immersion in one or more virtual worlds.

#### *Discussion on Different Types of Virtual Reality*

Based on the theoretical content presented in the virtual world, introduce students to different types of virtual reality (Full Immersive VR, Half Immersive VR, Augmented Reality, Mixed Reality). In the classroom, the teacher can show various examples and discuss the different practical applications of each type of Virtual Reality.

#### *Critical Analysis of the Limits and Criticisms of Virtual Reality*

In reference to the learning content of the lesson, the teacher can provide additional information about critical points and limitations of virtual reality. Students can be invited to discuss how these issues may affect the use of virtual reality in specific contexts. For this purpose, the teacher can divide the class into groups and assign each group a specific critical point related to virtual reality. Each group should develop a pro or con argument for virtual reality and present it to the class.

### *Brainstorming on Possible Applications of Virtual Reality*

The teacher can ask students to share their ideas and reasoning on possible applications of virtual reality in various fields of knowledge: art, medicine, education, industry, etc.

### *Practical Creation Activity*

In classroom and school contexts that allow it, the teacher, in order to allow students to apply the concepts learned, can engage them in a practical activity of creating content or simulations in a VR environment. Such activities can be adapted to the resources and tools available in the classroom and have a very important metacognitive function. They help students take control of their own learning by allowing them to handle and explore in concrete experiences the concepts they have worked with.

### *4.3.3 Example of Integrated educational path #3*

<b>Subject</b>	Informatics
<b>Topic</b>	Algorithms And Control Structures
<b>Type of virtual world activity</b>	Theoretical activity
<b>Task to be completed in the virtual world</b>	Algorithm and Properties of Algorithms

*Table 3 - The key features of the "Integrated educational path #3"*

This proposal for a learning path is built upon the learning content from the virtual world of PIM's World related to algorithms. Specifically, the resource from which the following classroom activities are developed, following the learning of theoretical concepts in the virtual world, is titled "Algorithm and Properties of Algorithms" Below is a group of classroom activities that can be implemented, not necessarily in the order in which they are listed:

1. Algorithm in Action
2. Simulating Ambiguity
3. Comparisons
4. Algorithm Investigators
5. Introduction to Algorithm Writing
6. Error Hunt
7. Computational Visionaries
8. Role-Playing Game
9. The Human Algorithm

## 10. The Algorithm Theater

### *Algorithm in Action*

The teacher divides the class into groups and distributes a copy of a local dish recipe. Afterwards, students are asked to execute the recipe in groups, following the step-by-step instructions. This demonstrates the concept of an algorithm in action.

### *Simulating Ambiguity*

The teacher can propose an activity in which students must follow a series of ambiguous instructions, such as "draw a large circle." Then, they are asked to discuss how the instructions could be improved to make them unambiguous and subsequently transformed into an algorithm.

### *Comparisons*

The teacher asks students to compare the instructions of two different recipes for the same dish. Differences are pointed out, and a discussion is stimulated on how these differences influence the execution of the algorithm and the final result.

### *Algorithm Investigators*

The teacher shows real-life examples of algorithms to the students, such as sorting, or search algorithms used in everyday life and explains their applications.

### *Introduction to Algorithm Writing*

The teacher provides students with a set of everyday tasks, such as making a sandwich, brushing teeth, or drawing, and then asks them to write a detailed algorithm that adheres to the properties of algorithms and is capable of performing these tasks.

### *Error Hunt*

The teacher creates some examples of incorrect algorithms by deliberately introducing errors into the instructions. Students are divided into groups and asked to identify and correct the errors in these algorithms. After the error identification process, the teacher can lead a discussion on the importance of unambiguity and atomicity in algorithms.

### *Computational Visionaries*

The teacher, using an online tool or coloured paper and pencils, asks students to create visual algorithms for simple and everyday tasks, such as making a cup of tea or solving a puzzle. This visual approach can help students better understand the structure of algorithms.

### *Role-Playing Game*

The teacher organizes a role-playing game in which students play the role of "human algorithms." For example, they may follow an "algorithm" to prepare a drink and serve it to a "customer." This demonstrates how algorithms can be executed by different people to achieve consistent results.

### *The Human Algorithm*

In this role-playing game, students act as "human algorithms" to complete a specific task. The teacher selects a simple task involving a series of actions, such as making a cup of tea, folding a piece of paper, or preparing a fruit salad. The class is divided into groups, each assigned a different task. Each group designates a "human algorithm" responsible for task execution, while the rest of the group acts as "programmers" who write detailed instructions (the algorithm) that the "human algorithm" must follow to complete the task. During the activity, programmers can only communicate with the human algorithm using written instructions. The human algorithm must strictly follow the provided instructions and cannot deviate from what is written in the algorithm. After completing the task, the teacher can invite students to compare the results obtained by various groups and discuss how the effectiveness and adherence to algorithm properties influenced the outcome.

### *The Algorithm Theater*

In this activity, the teacher encourages students to step into the roles of algorithms and instructions. The process involves creating short theatrical performances based on common algorithms. The teacher selects common algorithms that involve everyday actions, such as making a bed, tying shoelaces, getting dressed, or washing dishes. The class is divided into groups, with each group assigned one of the previously chosen algorithms. Each group is tasked with "translating" the algorithm into a short theatrical performance. Students must creatively "act out" the algorithm's instructions, while the rest of the class observes. At the end of each performance, the teacher leads a discussion with the class about whether the algorithm was followed correctly, whether it was clear and effective, and how it could be improved.

#### *4.3.4 Example of Integrated educational path #4*

<b>Subject</b>	Physics
<b>Topic</b>	Optics
<b>Type of virtual world activity</b>	Practical activity
<b>Task to be completed in the virtual world</b>	Mirrors





*Table 4 - The key features of the “Integrated educational path #4”*

A proposal of a curriculum that integrates a practical task in optics and deals with mirrors:

1. Definition of learning objectives
2. Preparing students for the virtual activity
3. Guided and supervised performance of the virtual activity
4. Classroom discussion
5. Practical practice and reinforcement of theoretical concepts
6. Assessment phase
7. Final discussion and reflection
8. Homework
9. Further research and projects

*Definition of learning objectives*

The aim of this integrated unit is to learn about the types of mirrors and understand their function.

Keywords:

- Mirror
- Focus
- Beam
- Plane mirror
- Convex mirror
- Hollow mirror

The student is familiar with the basic concepts of ray optics, understands the concept of a mirror, knows the different types of mirrors, and can construct an image and describe its properties.

*Preparing students for virtual activity*

Before the activity, it is useful to review the basic concepts of ray optics with the students. It is also a good idea to introduce students to the concept of a mirror and use examples from everyday life to look for practical applications together.

Exposure methods (especially interactive interpretation with discussion and demonstration) as well as activating methods (e.g. competition, quiz, etc.) can be used.



### *Guided and controlled execution of virtual activity*

For the successful conduct of the virtual activity, it is advisable to provide students with the necessary computer equipment (one computer per student, alternatively two students can be seated at one PC to collaborate), provide accounts and train students in the basic operation of the environment.

Once students have logged in and entered the virtual world, students need to be guided to the correct entrance in the virtual world. Students then independently navigate through the different stations, again independently completing tasks and collecting badges.

Students need to be motivated in an appropriate way to collect all the badges. The role of the educator at this point is reduced to that of a guide and technical support who assists in solving non-standard situations (operator problems, technical difficulties, ...).

### *Classroom discussion*

Once a student has completed all stations and tasks, it is a good idea to return students to the physical classroom. A form of guided discussion is appropriate to share insights and impressions with each other. Students can share what surprised them, what was new to them. At this stage of sharing, it is important to invite students to share their experience, their perception and the difficulties they encountered.

### *Practical exercises in class and consolidation of theoretical concepts*

Subsequently, it is advisable to use fixation methods. The teacher responds to the information he/she has gained from the class discussion. If possible, a physics experiment should be carried out to allow students to verify their knowledge. It is particularly appropriate to involve the mathematical apparatus and to verify the calculated results experimentally. Students can then look for other practical uses of mirrors (mirrors at a junction, a test booth, rear-view mirrors in a car and discuss their shape and function).

### *Stages of evaluation*

At the end of the lesson, it is possible to assess the knowledge and skills of each student.

The assessment criteria can be:

- Number of badges earned
- Knowledge of terminology and orientation to terminology
- Ability to construct an image
- Correctly describe and identify the image of each mirror.

The assessment phase may also include conducting an independent experiment.

### *Final discussion and reflection*

Based on the experience, you can ask students to return to the virtual world and try to consciously summarize the experience.

### *Homework*

After the lesson, the teacher can assign homework and students can be encouraged to independently explore the virtual world and related activities on the topic studied.

### *Further research and projects*

In addition, teachers can suggest long-term challenges or project assignments on a given topic.

### *4.3.5 Example of Integrated educational path #5*

<b>Subject</b>	Mathematics
<b>Topic</b>	Geometric Shapes
<b>Type of virtual world activity</b>	Theoretical and assessment activities
<b>Task to be completed in the virtual world</b>	Review the theory through presentations and verify this knowledge using quiz examples

*Table 5 - The key features of the “Integrated educational path #5”*

The design of an educational plan that uses a virtual reality to consolidate the curriculum on basic geometric shapes. The steps of the activity are:

1. Definition of learning objectives
2. Theoretical preparation of students for virtual activity
3. Inducing situations and conditions that the student will encounter in the virtual environment
4. Implementation of virtual reality
5. Evaluation of the success of the virtual activity
6. Final discussion and reflection

### *Definition of learning objectives*

The first step in planning an integrated learning unit is to clearly define learning objectives and outcomes. We determine what students should learn and which concepts they should know and be able to use. It is mainly a reminder of the theory and its application in concrete examples.

*Theoretical preparation of students for virtual activity*

In order for students to be able to use the prepared environment, knowledge of basic geometric shapes is needed. Even these theoretical findings are recalled in the virtual environment.

*Inducing situations and conditions that the student will encounter in the virtual environment*

Students are prepared in advance for the sequence of tasks they will encounter in the virtual environment. They are prepared for the given environment and the possibilities that the environment will offer them. Thus, they will first review the theory through presentations in a virtual environment, and then they can verify this knowledge using quiz examples.

*Implementation of virtual reality*

Students must have proper equipment to access the virtual world. Movement in the virtual world is individual, independent of each other. Every single student completes the assigned tasks in the virtual world.

*Evaluation of the success of the virtual activity*

After completing the tasks assigned in the virtual world, students have the opportunity to self-assess their success in completing these tasks. In addition, in the case of errors in the virtual environment, they return to the interpretation of the theory, where they can reconfirm the given matters and retest their understanding and ability to use them in practical tasks.

*Final discussion and reflection*

All students who have gone through the virtual world with the same activity will evaluate their success and use other concrete examples to prove the depth of their understanding of the theory. They will share their findings with each other and the procedure for eliminating errors in understanding the topic.

*4.3.6 Example of Integrated educational path #6*

<b>Subject</b>	Mathematics
<b>Topic</b>	Fractions
<b>Type of virtual world activity</b>	Theoretical and assessment activities
<b>Task to be completed in the virtual world</b>	Review the theory through presentations and verify this knowledge using quiz examples

*Table 6 - The key features of the "Integrated educational path #6"*

In this section we propose the design of an educational unit that uses a virtual reality environment to familiarize with the subject of fractions. The learning unit will be formed by using a virtual activity to learn basic information about fractions and work with these mathematical units. The steps of the activity are:

1. Definition of learning objectives
2. Preparing students for a virtual activity
3. Implementation of a virtual activity by students
4. Practical training and consolidation of theoretical knowledge acquired in the virtual world
5. Class discussion and reflection

#### *Definition of learning objectives*

The basic learning goal is to acquire knowledge from the curriculum about fractions, understanding the concept and its use in individual cases. Students will master the simplest work with fractions, their expansion and contraction, and the most common mathematical operations with fractions. They can use theoretical knowledge to solve basic tasks.

#### *Preparing students for a virtual activity*

The only prerequisite for using a virtual activity in this case is to enable the use of the right equipment for virtual reality. Theoretical preparation consists only in knowledge of the most basic mathematical operations.

#### *Implementation of a virtual activity by students*

Students enter a virtual world where they turn to the topic of fractions using an avatar. They are then guided through the individual parts of the program, from the theoretical presentations they will study to the quiz questions that will allow them to anchor the knowledge they have acquired. In case of incorrect elaboration of assigned tasks, they are returned to the theoretical panel for reconfirmation of theoretical knowledge.

#### *Practical training and consolidation of theoretical knowledge acquired in the virtual world*

After the end of the virtual activity, the pupils are faced with a practical problem consisting of fractions and working with them. Here they have the opportunity to use the knowledge gained, or to share it together and enable a deeper understanding by correcting each other's solutions to assigned tasks.

#### *Class discussion and reflection*

Individual students should communicate together about their successes and failures in solving tasks in the virtual world. If there is a misunderstanding somewhere, they should explain these problems to each other, during a moderated discussion, so that everyone is able to solve examples of the given type without major difficulties.

The teacher should only be the moderator of the discussion and should leave the opportunity for the students to express themselves.

#### 4.3.7 Example of Integrated educational path #7

<b>Subject</b>	Mathematics
<b>Topic</b>	Symmetries
<b>Type of virtual world activity</b>	Theoretical and assessment activities
<b>Task to be completed in the virtual world</b>	Review the theory through presentations and verify this knowledge using quiz examples

*Table 7 - The key features of the "Integrated educational path #7"*

In this section we propose the design of an educational unit that uses a virtual reality environment to reinforce the subject of symmetries. In the educational unit dedicated to symmetries, it is appropriate to use a virtual reality environment for a much simpler idea of these concepts. In a virtual environment, the spatial representation of symmetrical objects and symmetry in general is significantly easier for most students. The steps of the activity are:

1. Definition of learning objectives
2. Preparing students for a virtual activity
3. Implementation of a virtual activity under the supervision of the teacher
4. Practicing and consolidating acquired theoretical knowledge
5. Final discussion
6. Homework
7. Definition of learning objectives

#### *Definition of learning objectives*

The first step in planning a given teaching unit is to define learning objectives. There is a need to determine what students are expected to learn and how the virtual environment can help them achieve these goals. The basic goal is to understand axial and central symmetry, to be able to recognize symmetrical shapes and to understand the difference between displacement and rotation of objects.



### *Preparing students for a virtual activity*

Before involving the students in the virtual activity, it is advisable to outline the issue of symmetries and repeat the thematic units related to perpendiculars, axes or the distance of individual objects. In the same way, students need to have the necessary technical equipment available to connect to the world of virtual reality.

### *Implementation of a virtual activity under the supervision of the teacher*

After entering the virtual environment, the student uses his avatar to get to the environment, where he chooses a set of symmetry. In individual parts of the environment, theoretical presentations are made, where the basic properties of individual symmetries and the possibilities of their use are given. In other tasks, he then looks for and assigns objects symmetrical to the axis or center and has the opportunity to understand these differences in a three-dimensional environment. The part related to displacement or rotation is intended only as a theoretical introduction to the given concepts (within the required knowledge of elementary school students).

### *Practicing and consolidating acquired theoretical knowledge*

After finishing the virtual activity, the acquired knowledge needs to be anchored in the real world. Preferably by going for a walk in the immediate surroundings, where individual students can then, with the help of the teacher, evaluate the symmetry of common subjects in the real world.

### *Final discussion*

Students share their findings from virtual tasks with each other and explain to each other why and how symmetrical objects can be distinguished.

### *Homework*

At the end of the lesson, it is advisable to assign homework to the students to assimilate the newly acquired knowledge. They should be encouraged to independently explore the virtual world and, related to the topic being studied, online resources or other virtual simulations available on the Internet. They can then individually present the results of this investigation to their classmates. Group work is suitable for this topic.

## **4.4 Making use of the learning activities to perform knowledge assessment**

The virtual 3D environment brings a completely new way of education and knowledge assessment, which can be not only educational but also fun for children. This text will focus on the use of learning activities to perform knowledge assessment in a virtual game environment that contains three worlds: mathematics, physics and informatics, each divided into several sub-domains.

#### *4.4.1 Virtual worlds and subtopics*

The virtual environment of the game offers children three main worlds - mathematics, physics and informatics. Each of these worlds contains different sub-areas that allow children to explore specific topics. For example, the mathematical world may include subfields such as symmetries, fractions, and geometric shapes. This structure allows children to focus on specific areas and gradually develop their skills.

#### *4.4.2 Theoretical information and quizzes*

In each sub-area of the virtual world, children have the opportunity to explore theoretical information that will provide them with basic knowledge about the given topic. For example, in the mathematical world, they can get comprehensive information about shortening and expanding fractions, about axial or central symmetry, etc. This theoretical basis becomes an important tool for further education.

#### *4.4.3 Evaluation through quizzes*

Knowledge assessment is implemented through quizzes that are adapted to each sub-area. After reading the theoretical information, the children have the opportunity to complete a short quiz that tests their ability to understand and apply to the curriculum. Correct answers are rewarded with a badge that becomes part of the child's collection.

#### *4.4.4 Motivation and involvement*

The virtual 3D environment and the game bring entertainment elements that motivate children to learn. Badges and collecting rewards provide feedback and increase engagement. Children are motivated to explore different worlds and sub-areas, which leads to a gradual expansion of their knowledge.

#### *4.4.5 Learning through experience*

The virtual 3D environment allows children to learn through experience and interactivity. This form of education helps children better understand and apply the curriculum, which increases the effectiveness of learning. Using educational activities in a virtual 3D environment to conduct knowledge assessments is an innovative way to make education accessible while ensuring that children gain deep and practical knowledge. This methodology can be an effective tool for educating and developing children's skills in the worlds of mathematics, physics and informatics.



## 5 DigiCAMP 3D Virtual World as a virtual learning platform and its installation

The DigiCAMP 3D World is the main output of the DigiCAMP project, hosting all learning material developed along with learning scenarios. The platform is freely available for students to use for self-learning purposes. This section will provide all the information you need to connect to the Virtual World and take part in the learning activities.

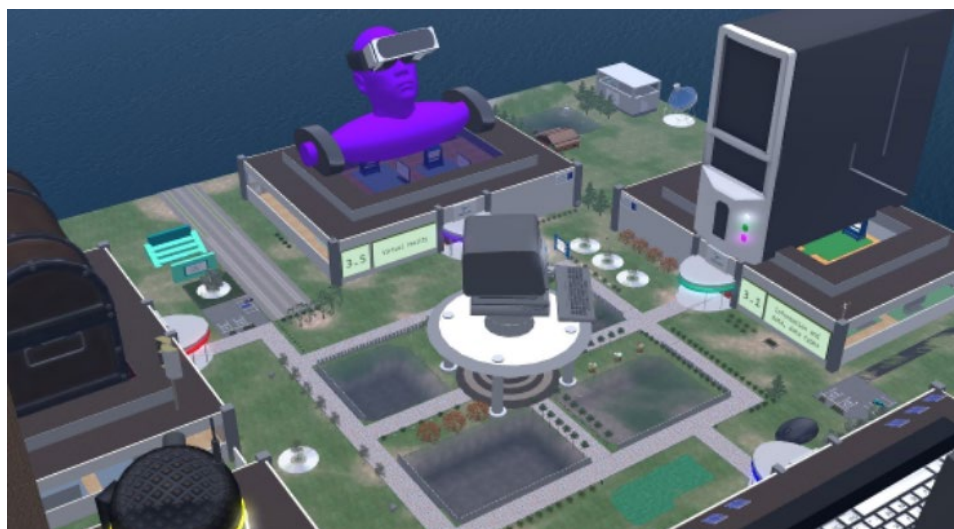
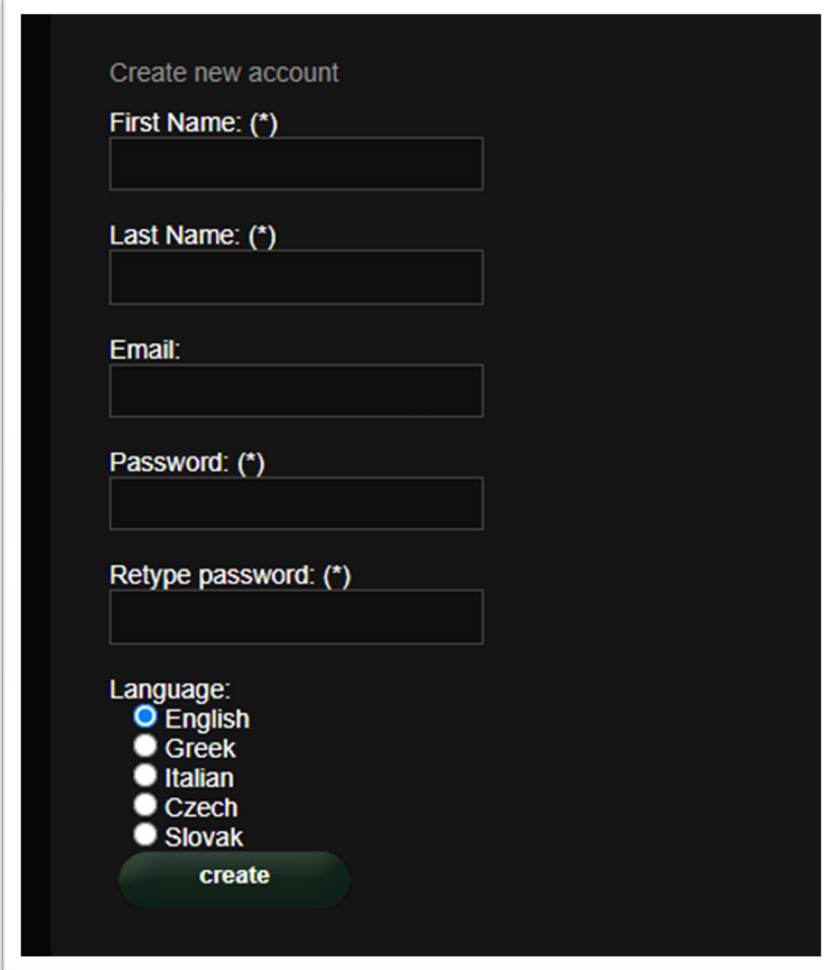


Figure 4 – The 3D world whole structure

### 5.1 Connection instruction

#### 5.1.1 Account Creation

You can create an avatar account (Firstname, Lastname, Password) here: <http://virtualworld.sch.gr:9046/wifi/user/account/>. The Email field is optional. You will need to remember your First Name, Last Name and Password to be able to connect, so make sure you write them down.



Create new account

First Name: (\*)

Last Name: (\*)

Email:

Password: (\*)

Retype password: (\*)

Language:

- English
- Greek
- Italian
- Czech
- Slovak

create

Figure 5 - The info required for account creation

### 5.1.2 Installation and Initial Configuration

To connect to the 3D World with that avatar you need 3D viewer Software such as Firestorm or Kokua. We recommend using Firestorm. You can download the version for OpenSim here: <https://www.firestormviewer.org/os-operating-system/> Scroll down to the “**Choose your Operating System**” section, select your Operating System from the available icons and download the suitable version.

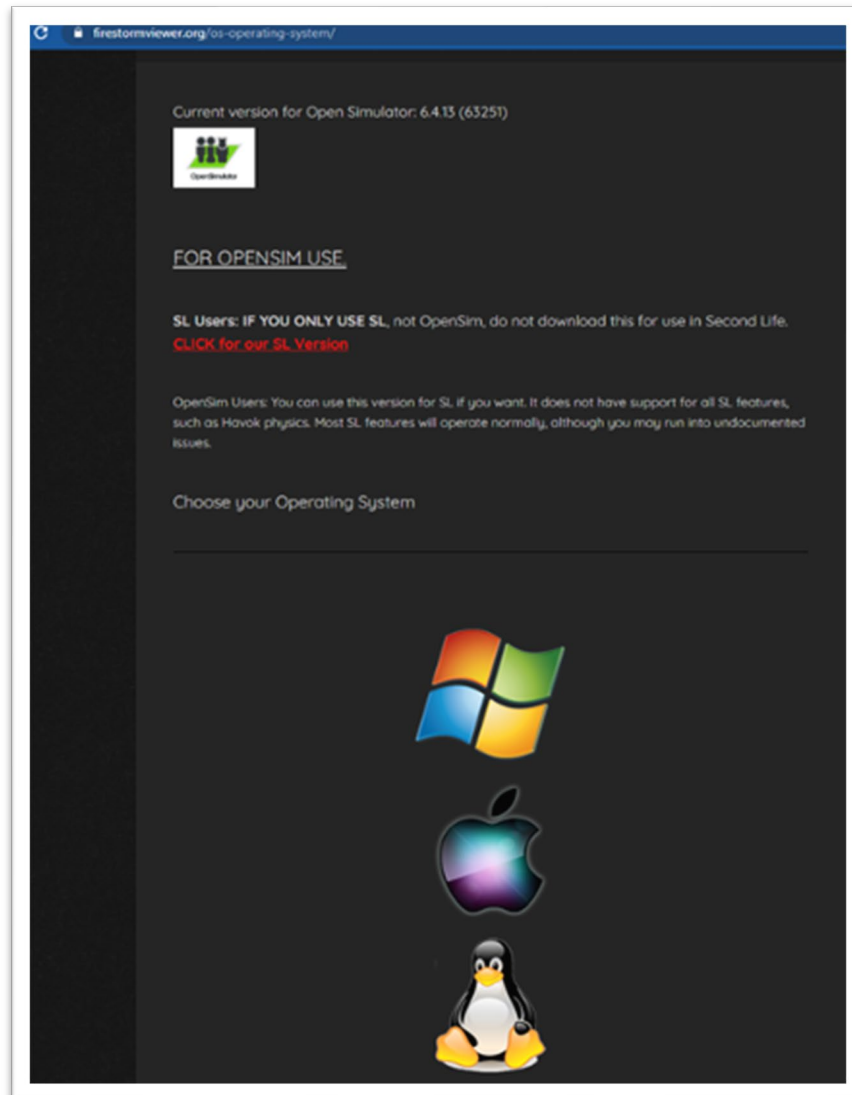


Figure 6 - Some instructions for using OpenSim

Once you have downloaded, installed, and opened Firestorm, you need to add the **DigiCAMP D World** in the list of available destinations (you only do this before connecting for the first time):

1. Viewer -> Preferences -> OpenSim
2. Add new grid: <http://virtualworld.sch.gr:9046/>
3. then click 'Apply' and 'OK'.

The grid should be now added to the **Manage Grids Table**.

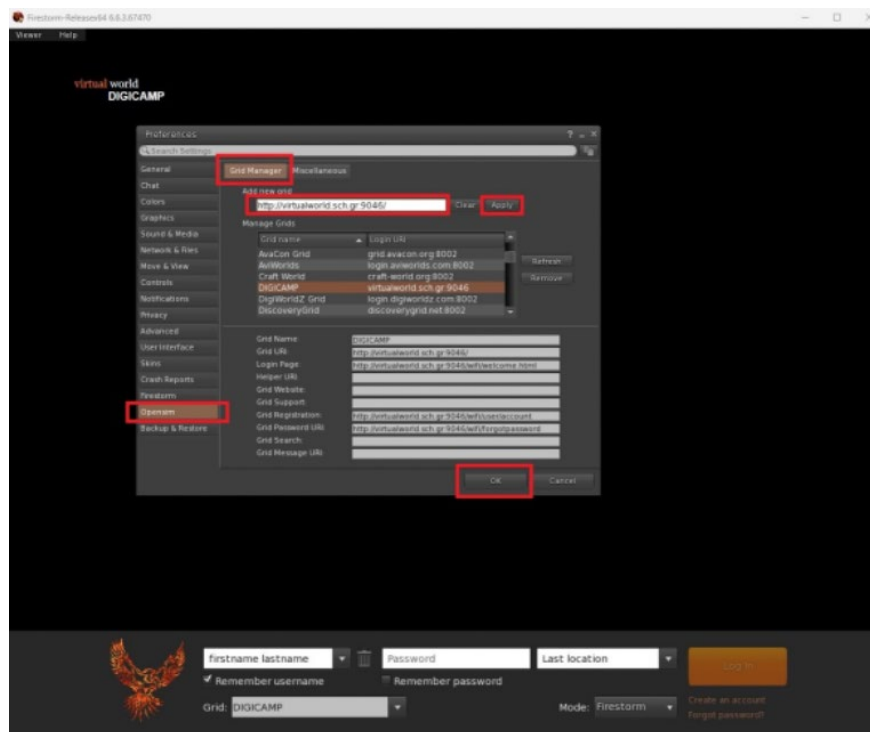


Figure 7 – The Manage Grids Table

### 5.1.3 Connecting to the 3D World

Use your username "**Firstname Lastname**" and **password** and select the "DIGICAMP" grid from the drop-down menu. Click 'Log In' to enter.

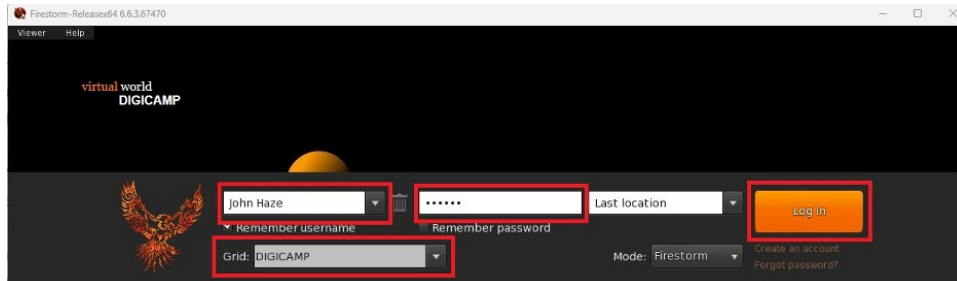


Figure 8 – The “Log In” interface

If the “Grid” dropdown list does not appear in the form, then you have probably downloaded the wrong Firestorm option (return to the installation instructions and make sure you have selected the Opensim version of Firestorm). After a connection is made you will be inside the virtual world with your avatar.



Figure 9 - A portion of the 3D world of DigiCAMP

## 6 Instructions for connecting and controlling the avatar and for using all functionality in the 3D Virtual World

### 6.1 Basic Controls

#### *Moving Around*

A presentation near the landing point, covers all the basic controls for moving around and controlling the camera. Follow the instructions and try to get accustomed with controlling your character.

If you like, you can choose to customize your character following the instructions.

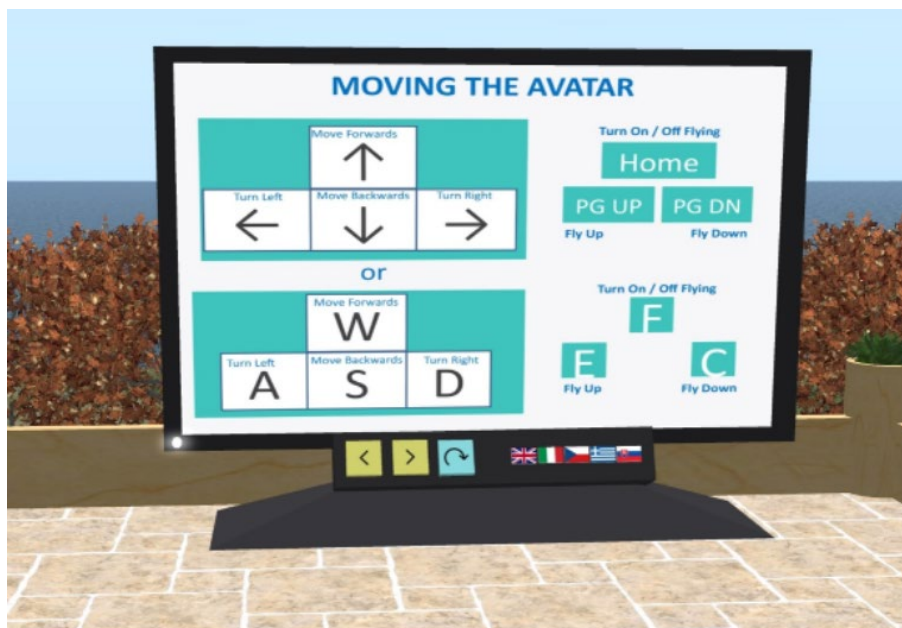


Figure 10 – The instruction for moving the avatar within the 3D world

#### *Navigation*

There are two kind of maps you can use for navigation:

##### **World > Minimap**

- It shows a small map where you can Identify your location and it updates according to Avatar movement
- It acts as a compass
- You can use this map to teleport to another point by Double Clicking required location

## World > World Map

- Larger overview of the region with filtering feature
- You can zoom in/out to find more regions nearby

## *Inventory*

Each avatar has an inventory of files organized by file type:

## Avatar > Inventory (Ctrl + I)

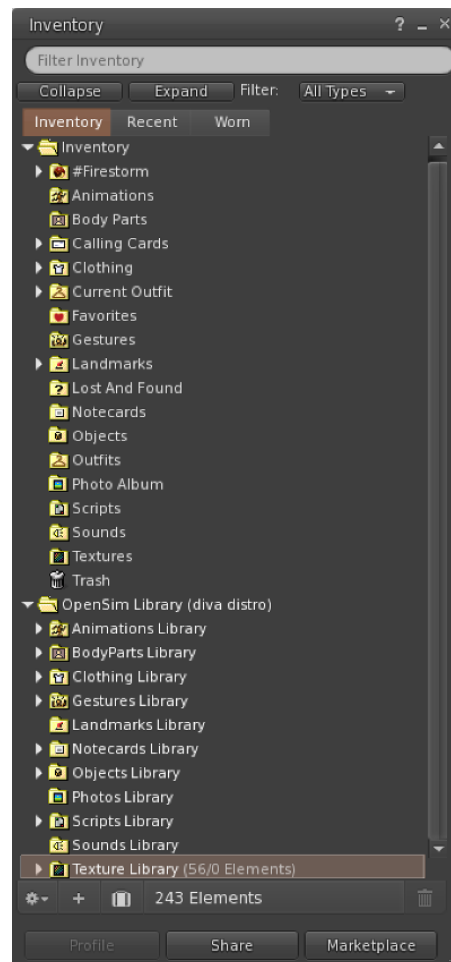


Figure 11 – The inventory of the avatar

You can create files for your avatar's appearance (BodyParts and Clothing folders), you can find or create text files with notes (Notecards folder) or find Objects that you have received from the activities (Objects folder).

### *Communication*

You can add other user avatars as friends to easily find them and be able to teleport to them. From the viewer's navigation bar, select **Comm -> People**, to open a window that display a list with all nearby users. Right click on one of the users and you get the option to view their Profile, add them as a friend, send a private instant message (IM), request that you teleport to them (**Request Teleport**) or that they teleport to you (**Offer Teleport**), and to create a distinct marker on his place to easily find him (**Track**).

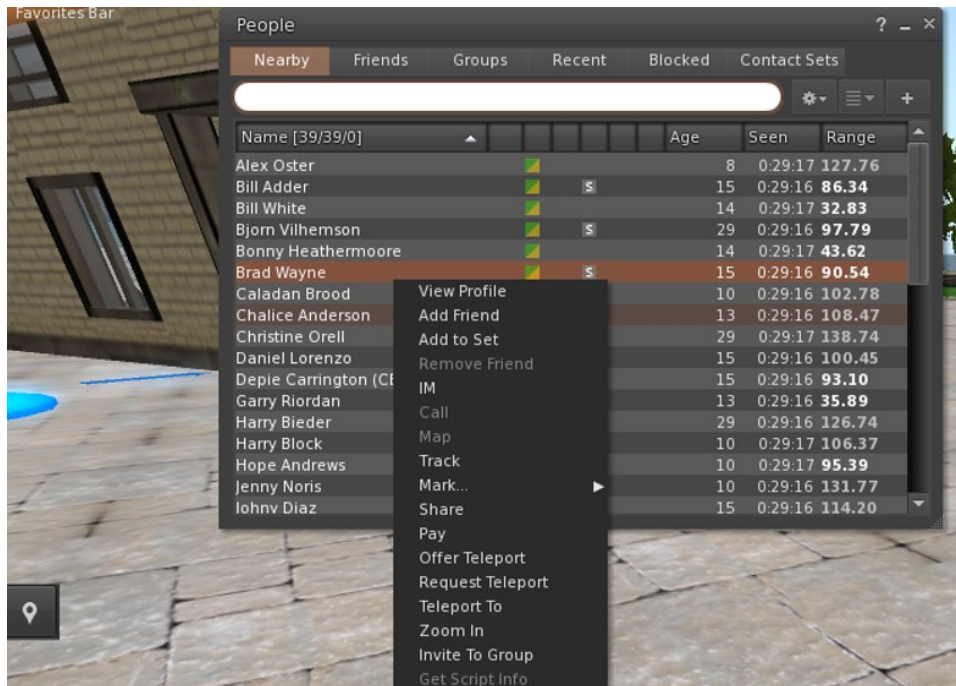


Figure 12 – The Communication interface

If you have already added some user as a friend, you can find them in the 'Friends' tab, even if they are not online at the moment. You can send them a private message and they will be able to see it as soon as they log in the virtual world.

You can open the chat window (**Comm -> Chat**) to view and participate in conversations. The default '**Nearby Chat**' displays all discussions that happen near your avatar. There is also a shortcut for righting quick messages that nearby avatars will receive by using the chat bar on the bottom left of your screen.



You can configure **Gestures** to be used with chat. Gestures are animations performed by your avatar to indicate or emphasize your attitude or your emotions. You can associate specific Gestures with specific words, so when you include them in your chat messages, your Avatar will perform the animations.

First, open your Inventory (**Avatar -> Inventory**) and locate the “**Gestures Library**” folder, under “**OpenSim Library**”. There are several gesture files in that folder, and you can right click and select “**Activate**” the ones you want your avatar to be able to perform.

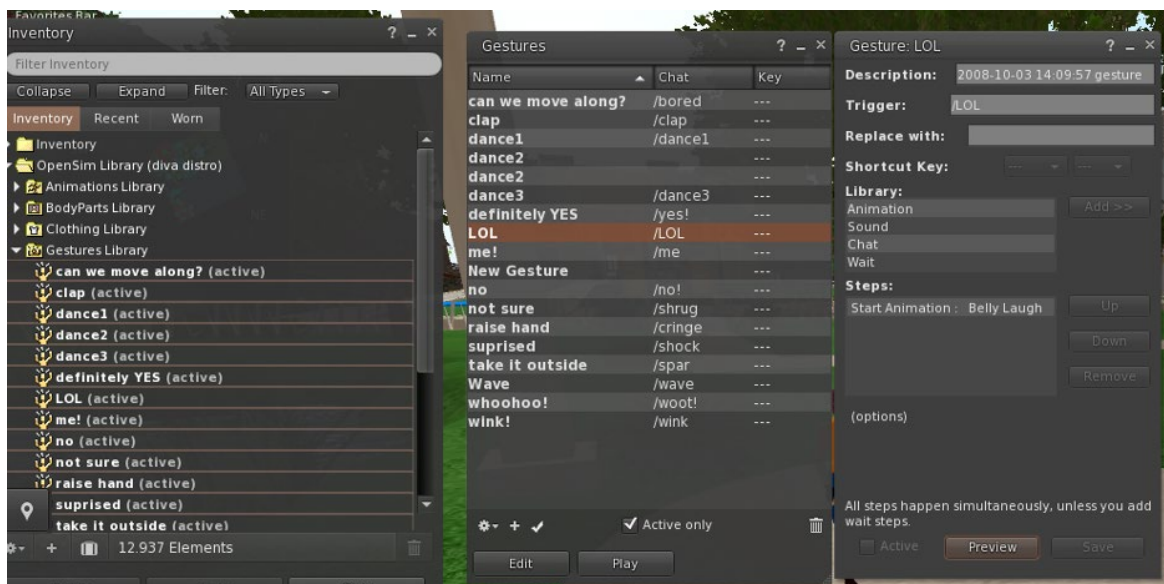


Figure 13 – The gesture library

Then open the Gestures Window (**Comm -> Gestures**) and you will see the Gestures you have activated. Double click on one of the Gestures and you will see your avatar performing the animation. Select a Gesture and click the “**Edit**” button to view the details. There is a **Trigger** field that shows the command to use in chat to perform the Gesture. For example, you can write **/LOL** in the chat menu to make your avatar perform a laughing animation.

You can use the groups window (**Comm -> Groups**) to join or create a Group with other users to communicate with.

Communication with voice with other users in the virtual world is not possible directly from the 3D Viewer. However, we have prepared a voice channel in a Discord server where users can join and participate in conversations while they are connected to the 3D World. Give the following link to your students and they can follow the instructions to create an account and join the Virtual Worlds Discord Server:

<https://discord.gg/xRmkaywtNF>

You can then direct your students to enter the “**digicamp-voice**” voice channel.

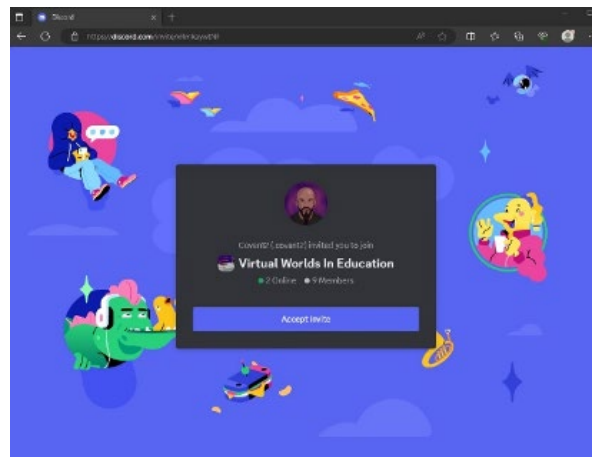


Figure 14 – The page where you can create an account and join the Virtual Worlds Discord Server

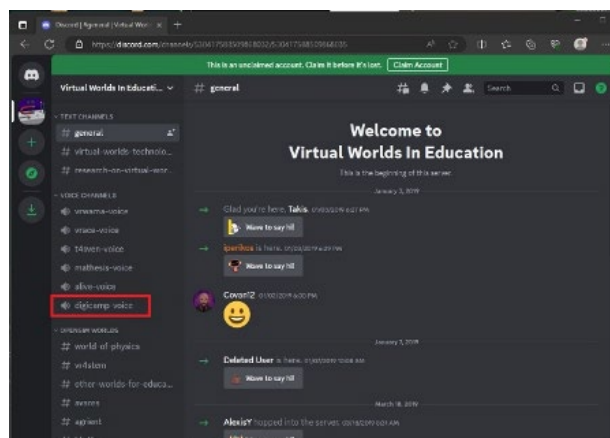


Figure 15 – Inside the Virtual Worlds in Education of Discord

## 6.2 The DigiCAMP Virtual World

### *The HUD Object*

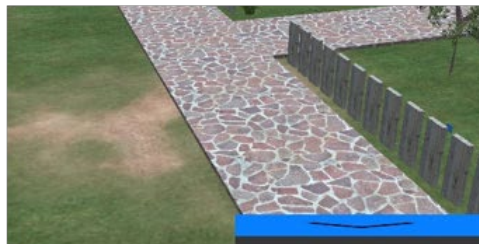
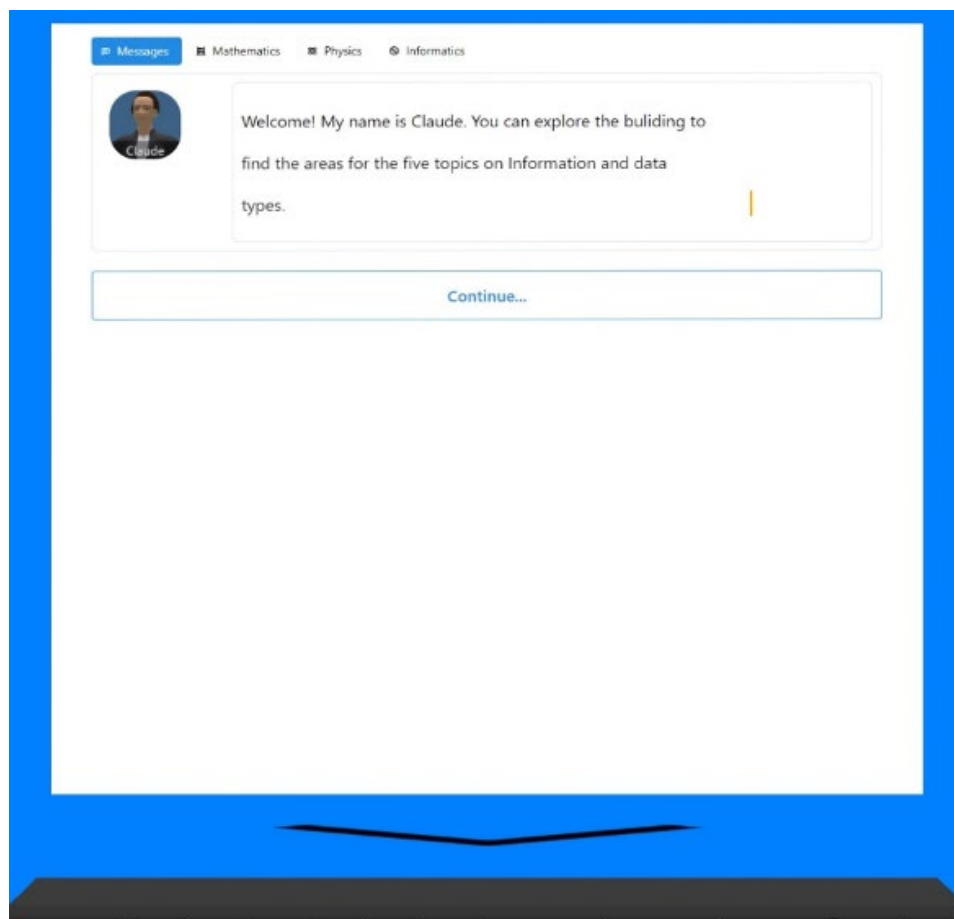


Figure 16 – The HUD Object

The HUD Object is a panel that will appear on the right part of the screen and will display messages from the characters or the game. You can click on the bottom part of the HUD to make it collapse (hide) and expand (appear). The HUD will automatically expand when there is a new message to show.

Messages from NPC characters and the game will appear on the “Messages” tab. Below the text displayed on the HUD, you may find a list of available options to reply or continue the conversation.



*Figure 17 – NPC messages in the HUD*

The HUD object also gives access to the collectables page, by clicking one of the three other tabs (Mathematics, Physics, Informatics). When you complete activities in one of the 3D Worlds, you are awarded a symbol in the corresponding course tab. Click on any of the collected symbols and you can view a description.

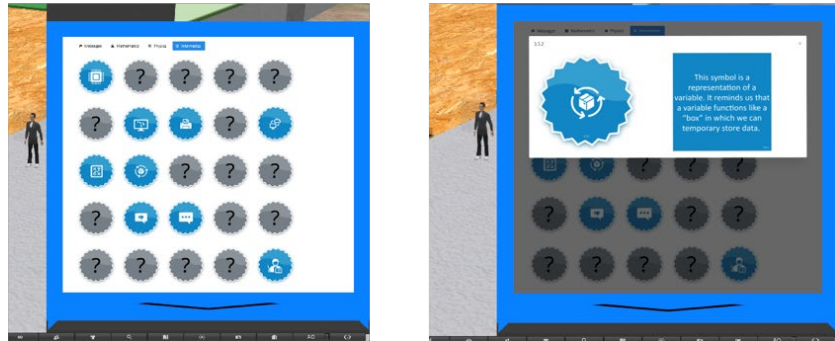


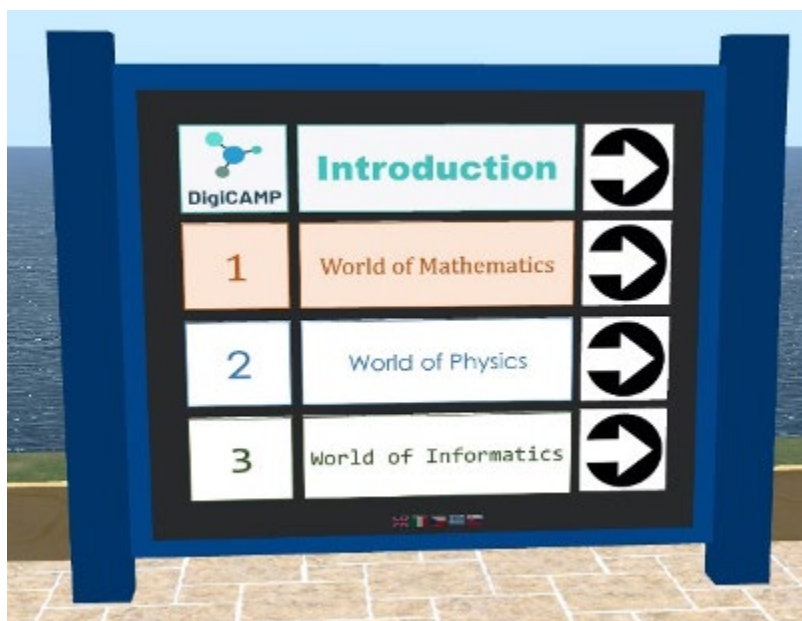
Figure 18 – Rewards/Symbols and descriptions in the HUD object

### *Navigation*

The three **DigiCAMP** courses are in different islands:

1. *WORLD OF MATHEMATICS*
2. *WORLD OF PHYSICS*
3. *WORLD OF INFORMATICS*

You can reach each one of the islands through the Teleportation Panels. Click on the arrow button next to the island you want to visit, and you will be teleported there!



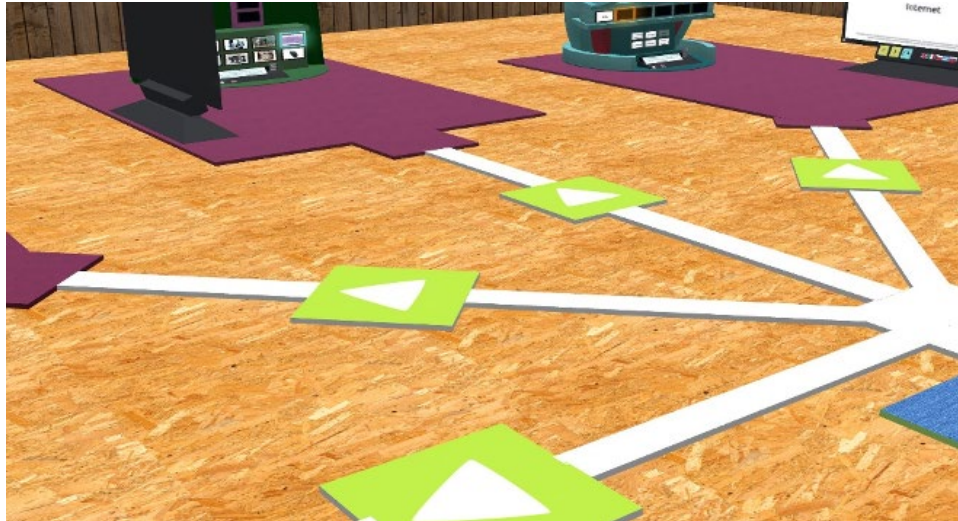
*Figure 19 – The DigiCAMP courses*

Each course has a number of topics, and each topic is located in a separate building.



*Figure 20 – The “geography” of a topic*

Inside each building, there are 5 distinct areas for the 5 subtopics. In these areas you should find a presentation panel and an assessment activity.



*Figure 21 – Subtopics paths*

### *NPC Characters*

At various locations, you will find NPC characters. In most cases you can click on the characters to engage them in conversation using the HUD.

### *Theory*

The presentation panel covers the theory of a subtopic. You can use the arrow buttons to navigate through the slides.



Figure 22 – Theoretical presentations

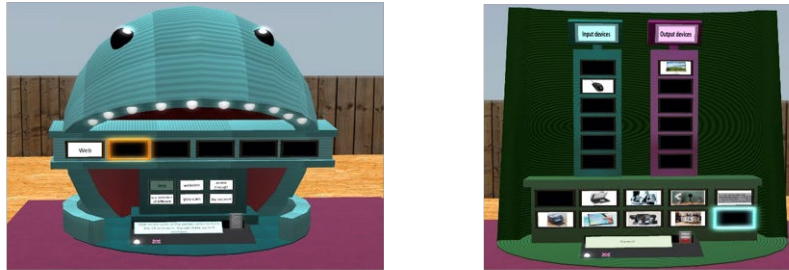
### Assessment Activities

For each subtopic you will also find at least one assessment activity (e.g. quizzes, matching, sorting, classifying). Assessment activities usually include instructions about what you need to do.



Figure 23 – Assessment activities 1/2





*Figure 24 -Assessment activities 2/2*

Completing the assessment activities of a topic will award you a SYMBOL in the corresponding HUD tab.