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Cooperative learning in virtual worlds: An innovative teaching and learning experience for STEAM education

Apprendimento cooperativo in mondi virtuali: un'esperienza innovativa di insegnamento e apprendimento per la didattica delle STEAM

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Abstract

This paper describes a cooperative learning experience conducted within virtual worlds, an innovative approach of the teaching-learning process in the metaverse, achieved thanks to the synergistic action of the University and the School.
It is part of a broader research path aimed at innovating the teaching of the STEAM disciplines (Science, Technology, Engineering, Arts and Mathematics) and it is the result of a project proposals born within a training itinerary specialist developed within the Italian national network "Innova a 360° (AR, VR, AI)".
The exploratory research, based on a case study, aims to actively evaluate the possibility of learning cooperatively within virtual environments, making the delicate teaching-learning process possible in this context, enhancing immersive teaching experiences, of co-construction of knowledge, with a view to enhancing talents through the improvement of technological, digital, multimedia skills and promoting the inclusion process.
This contribution offers food for thought on the advantages of using virtual reality, augmented reality and artificial intelligence in the teaching of STEAM disciplines and towards pupils with disabilities and special educational needs. It also identifies possible effects on teaching practice and projects itself as an innovative methodology aimed at training citizens capable of dealing with the delicate process of social, historical and cultural changes with specific skills.

Keywords: Metaverse, Virtual Worlds, Steam Teaching, Inclusion, Teaching And Learning Innovation.

Riassunto

Questo articolo descrive un'esperienza di apprendimento cooperativo condotta all'interno di mondi virtuali, un approccio innovativo del processo di insegnamento-apprendimento nel metaverso. L'esperienza, che rientra all'interno di un più ampio percorso di ricerca finalizzato all'innovazione della didattica delle discipline STEAM (Science, Technology, Engineering, Arts and Mathematics), realizzata grazie all'azione sinergica di Università e Scuola, è stata una delle proposte progettuali nate in seno ad un itinerario formativo specialistico sviluppatosi all'interno della rete nazionale italiana "Innova a 360° (AR, VR, AI)".
La ricerca esplorativa, basata su un caso studio, si pone come obiettivo quello di valutare fattivamente la possibilità di apprendere in modo cooperativo all'interno di ambienti virtuali, rendendo possibile in questo contesto il delicato processo di insegnamento-apprendimento, valorizzando esperienze di didattica immersiva, di co-costruzione del sapere, nell'ottica della valorizzazione dei talenti attraverso il potenziamento di competenze tecnologiche, digitali, multimediali e favorendo il processo di inclusione.
Questo contributo offre spunti di riflessioni sui vantaggi dell'utilizzo della realtà virtuale, la realtà aumentata e l'intelligenza artificiale nella didattica delle discipline STEAM e nei confronti di alunni con disabilità e bisogni educativi speciali. Individua, inoltre, possibili ricadute nella pratica didattica e si proietta come metodologia innovativa finalizzata alla formazione di cittadini in grado di fronteggiare con specifiche competenze il delicato processo di cambiamento sociale, storico e culturale che interessa il nostro secolo.

Parole chiave: Metaverso, Mondi Virtuali, Didattica delle Steam, Inclusione, Innovazione dell'Insegnamento e dell'Apprendimento.

1. Introduction

The continuous evolution of environmental and social needs that characterize the 21st century highlight the urgency to improve education in science, technology, engineering and mathematics (STEM). The school, in the immediate present, has the delicate task of remodulating the teaching methods of the STEM disciplines by researching and structuring innovative approaches capable of perfecting the students' scientific skills in order to reduce the global factors that characterize today's society.

Such complex challenges require a didactic intervention able to favor the process of integration between science, technology, engineering and mathematics in authentic contexts; thus, innovative didactic approaches can be the turning point to excite and fascinate students and teachers in transversal concepts and applications of the real world (Kelley and Knowles, 2016).

The new teaching approaches must, therefore, be based on experience to offer students concrete opportunities for growth in the skills that characterize our century: critical thinking, creativity, collaboration, interpersonal and communication skills (Buck Institute, 2018). Among these, in particular, creativity constitutes an important way to increase engagement and understanding in these scientific fields, implementing the cross-curricular knowledge system and broadening critical perspectives (Marone and Buccini, 2023). In this perspective, the science-art-creativity triangulation, on the basis of the STEAM teaching (Science, Technology, Engineering, Arts and Mathematics), is an ideal mix that, transformed into pedagogical approaches, allows scientific embodied experience within a physical and digital space (Varela et al., 1992).

It is important to underline how thinking and re-thinking the planning of educational interventions must also take place in the perspective of inclusion because the historical, social and cultural changes of recent years have had a strong impact on students with disabilities and with Special Educational Needs (Italian acronym, BES).In recent years, as a consequence of the pandemic period, a strong interest in new technologies to support teaching has been observed in this sense (Rossi et al., 2023).In particular, the adoption of technology to structure immersive learning settings could act as a tool for enhancing the skills and abilities acquired and also constitutes a valuable resource for enhancing the more critical ones. This leads us to think that an immersive reality system, if placed at the service of teaching, can represent an opportunity to learn, experiment and develop one's potential in a situated learning environment (Finestrone et al., 2023).

On the basis of these reflections, this article presents a didactic experience of cooperative learning in virtual worlds of Science topics. This experience is part of the planning activity envisaged by the national school network, "Innova a 360° (VR, AR, IR)", created to promote innovative teaching methods in the STEAM field.

This article therefore intends to reflect on the possible didactic interventions linked to the development of an innovative methodology through the analysis of a case study.

2. The Italian network "Innova a 360° (AR, VR, AI)": an innovation project in STEAM education

The Ministry of Education and Merit, through the funds of the National Recovery and Resilience Plan (Italian acronym, PNRR), has allowed the creation of a network of 32 Italian schools, called "Innova a 360° (AR, VR, AI)", an experimental project aimed at creating educational paths through the use of technological tools for augmented reality, virtual reality and artificial intelligence.

The project carried out by the network also had the task of promoting the adoption of innovative teaching methodologies by schools, with particular reference to digital teaching and the STEAM disciplines, inspired to the student centrality, to active and cooperative learning, to relational well-being, in line with the «Skills and Contents» area of the National Digital School Plan (Italian acronym, PNSD).

In particular, the project has fully fulfilled the objectives of action #25 of the PNSD bearing in mind what was found by the OCSE (Sparking Innovation in STEAM Education with Technology and Collaboration, 2013), i.e. that the new STEAM teaching models require the professional development and peer-to-peer practice exchange by teachers, two key factors for the successful implementation of effective curricula.

For this reason, the entire project was divided into two distinct and preparatory phases: a first phase of specific training of teachers, and a second one of implementation of training for students with the creation of a digital learning object.

The first phase involved a training period, for a total of 114 hours, organized into two teaching modules (50 and 64 hours respectively). The entire training was conducted by teachers specialized in the field of experimental and special teaching, and delivered online synchronously on the online S.O.F.I.A. platform.

The initial training had the global objective of enhancing and enriching the technological and digital skills of teachers belonging to the network, so as to make them able to effectively manage teaching planning with students in the second operational phase.

The topics addressed by the training course concerned the following specific sectors: computational thinking, programming and educational robotics, mathematics and data science with digital technologies, teaching science with digital teaching and augmented reality, designing and producing objects with digital, art and creativity, teaching STEAM in an interdisciplinary key, inclusion and personalization in STEAM teaching.

The specific objectives of the first didactic module, called "Rete Innova a 360°: Steam e futuro (VR, AR, AI) (Training initiative I.D. 77023)" were: i) to enhance STEAM teaching skills in a dimension of constant evolution, to strengthen the ability to use technological tools, including advanced ones, which make it possible to give greater effectiveness to STEAM learning processes; ii) to promote the creation of national pilot projects with the implementation of educational and training actions on STEAM disciplines, of a disciplinary and interdisciplinary nature, carried out with the use of innovative teaching methodologies; iii) to develop innovative teaching methodologies for learning STEAM with the educational use of technologies, capable of developing creative, cognitive and metacognitive skills, and, at the same time, social, relational, emotional, in a dimension of collaboration, inclusion and connection with the world and with people, essential prerogatives of effective learning. The first module, lasting 50 hours, was carried out over a period of 8 months from 4/10/2022 to 24/05/2023.

The specific objective of the second didactic module, called "Innova a 360°: VR, AR, AI (Training initiative I.D. 77919)", instead, was to create learning objects by promoting the knowledge of Virtual Reality and Artificial Intelligence and its uses in teaching.

The module was divided into two sub-modules, each lasting 32 hours. The first one was entirely dedicated to the knowledge of virtual reality through a training in the use of viewers, 360° cameras, oculus and knowledge of specific platforms for the creation of school games in VR and AR. The second one was mainly aimed at artificial intelligence and therefore at the study of machine learning and the design of an activity with machine learning, also realizing digital storytelling. All aimed at being able to build a learning object with the students in the second phase of the project. The entire second module was carried out over a period of 2 months from 7/12/2022 to 9/02/2023.

The second phase of the project was fully operational. Each teacher belonging to the network has received an official assignment as tutor teacher to work with students for a practical and laboratory path lasting 35 hours. One teacher from each school belonging to the network was appointed as teacher assessor.

Each tutor teacher created with pilot classes, within their own school, an innovative STEAM learning experience by exploiting the skills acquired within the training path illustrated in the first phase, making use of the tested digital tools and methodologies.

Furthermore, all tutor teachers had the important task of preparing the material necessary to carry out the activities in consultation with the teacher assessor, administering the documentation aimed at monitoring and evaluating the activity, collecting the digital material created together with the students and sharing it with the schools belonging to the network also through publication on the pages of dedicated websites.

3. The teaching and learning experience: a case study for an innovative STEAM education

3.1 The didactic experience

The didactic experience was conducted by the DADA «Foscolo» Middle School, belonging to the «Foscolo-Gabelli» Comprehensive Institute of Foggia, Italy, which from 1 September 2019 is officially a school that operates according to the methodology of Didactics for Learning Environments (Italian acronym, DADA), the first school in the Puglia Region and belonging to the network of DADA schools.

A school that adopts this type of methodology discovers in the learning environment the central place of the delicate teaching-learning process, aimed primarily at exploiting the environment as a tool for learning on the one hand disciplinary skills, on the other hand transversal and interdisciplinary ones. The learning environment, thus, turns out to be the place of meeting, discussion and relationship, a place in which to discover one's talents, recognize them and enhance them in order to make concrete choices for one's personal and professional future. Exploring and being a builder of didactic learning environments allows each individual student to be in the front line co-builder of his own knowledge. All this, therefore, favors effective guidance teaching based on the concept of well-being and happiness at school.

The I.C. «Foscolo-Gabelli», for about two years, has been a signatory to a memorandum of understanding with the University of Foggia. In particular, with the supervision of DAFNE Department (Department of the Science of Agriculture, Food, Natural Resources and Engineering), it is conducting research aimed at studying new methodologies for teaching STEAM. Among these, the challenge of trying to test the teaching-learning process of Science within virtual worlds. This is the reason why, within the "Innova a 360°" network, the I.C. «Foscolo-Gabelli» has chosen to present a study on how to be able to teach and learn at the same time within virtual environments managed in a synergistic way by teachers and students, where students can be given the opportunity to concretely build their knowledge, relating and expressing themselves to virtual and immersive context: the metaverse.

The teaching experience was aimed at three second classes and supervised by their Science and Technology teachers who have previously completed the training period.

The tutor teachers, three in total, conducted all the 35 hours of lessons in the form of digital laboratory activities for each class involved. The lessons were held both in curricular hours, as an enhancement of ordinary teaching, and in extra-curricular hours with a view to expanding the training offer.

The heterogeneous classes, for a total of 65 students were presented as follows in table n.1.

	Class 2A	Class 2L	Class 2N
Total number of students	22	22	21
Males	11	13	12
Females	11	9	9
Total number of students with special needs	4	4	3
Students with disabilities	1	2	1
Students with Specific Learning Disorders (SLD)	3	2	2

Table 1: Configuration of the students participating in the experience

For each class, a subject of the Science curriculum, relating to the human body, was identified: cardio-circulatory system, digestive system and assessment of nutritional status and nutritional principles. This last topic was developed through the CLIL methodology (Content and Language Integrated Learning).

Each class lived the teaching-learning experience within a virtual world that was built and created by the students themselves using FRAME platform[1].

FRAME is a multimedia platform that makes it easy to communicate, collaborate, and create in 3D environments, right from the web browser. It can be used for multiple purposes: for immersive team collaboration, events, education, virtual offices, digital twins and more.

In this case study, in particular, it was used to create an innovative teaching experience in 3D learning environments as real virtual worlds within which to carry out teaching activities and co-construct knowledge in a cooperative learning approach.

In fact, each class worked individually in their own virtual world followed by their tutor teacher.

The experience was divided into four phases (see table n. 2).

Phase 1	Presentation of FRAME platform and creation of virtual worlds.
Phase 2	Study on the use of digital educational tools and creation of multimedia digital products.
Phase 3	Enrichment of the virtual worlds with digital and multimedia materials produced and creation of an educational escape room within the virtual worlds.
Phase 4	Immersive activity in virtual worlds.

Table 2: Phases of the experiences

The realization of this didactic experience is structured as planning, conducting and evaluating a practical activity that can be reproduced as best practice in the curricular teaching activities.

From a methodological point of view, the research was configured as a case study, an empirical research of the exploratory type, given its novelty.

The research object, in our case cooperative learning in virtual worlds, was investigated through a plurality of both qualitative and quantitative tools and procedures. The evaluation activity of this case study proceeds in parallel along all the training and practical experimentation processes, providing pre and post data and information regarding the development of skills and liking, with the aim of detecting the results and supporting reflection for the progressive improvement of the practice of this didactic model.

Regarding the innovative experience, and therefore the use of virtual worlds as environments for learning and the co-construction of knowledge, initial and final self-reflection tools were provided for the students, consisting of questionnaires made up of structured questions about the satisfaction of the experience in terms of expectations (pre) and final satisfaction (post).

These tools were accompanied by questionnaires related to the knowledge of the educational tools proposed in the experience for the production of digital and multimedia products (qualitative analysis) and to the degree of ability on their use by the students through a 5-point scale (quantitative analysis). This assessment was conducted at the beginning and at the end of the experience.

The tutor teachers, afterwards, observed the performance of the activities in terms of attention, proactiveness, involvement, effectiveness of the relationship between peers, problem solving skills, compliance with instructions and degree of inclusion (observational and qualitative analysis).

Finally, a questionnaire was submitted to tutor teachers to elaborate a pedagogical point of view and own reflections on the innovative didactic action.

The whole assessment process was supervised by the evaluation teacher.

3.2 Phase 1: FRAME platform and virtual worlds creation

In the first phase, lasting 4 hours, the FRAME platform was presented to all students of each class participating in the experimentation.

1 FRAME platform can be reached and explored at the link https://learn.framevr.io [last viewed on 15/11/2023].

FRAME can be considered the easiest way to create your own corner of the metaverse. It works on desktop, mobile and VR because it runs directly from a web browser. Frame was created mainly with the aim of holding meetings, events and seminars in the corporate environment as it allows you to easily create spatial and multi-user sites.

The use of FRAME assumes that the web browser is the metaverse, considering that suddenly we are entering a new era of spatial computing which will result in many traditional websites, apps and services existing on the spatial web along with the 2D interfaces that we are used to today.

In the proposed didactic activity, FRAME was tested as a didactic tool for the creation of virtual environments aimed at carrying out innovative lessons based on group work, cooperative learning, and on a new way of transmitting and, above all, sharing knowledge.

Furthermore, using FRAME for educational activities carried out directly in a virtual environment is greatly facilitated by the fact that FRAME is built precisely so that non-technical users can use it to create compelling and useful immersive experiences with just a few clicks. So it turns out to be an extremely accessible tool for everyone, and totally inclusive. Its easy use allows it to reach all age groups and especially students with special educational needs.

First of all, each student activated their personal account using their Google Workspace for Education school account. Activation was free as the use of FRAME for free was chosen.

Secondly, the tutor teacher presented to the students the different virtual environments which are in FRAME database and, after having viewed all the available environments, the different characteristics, the loading spaces and the dimensions of each environment, the students chose the virtual environment that best reflects the design idea for the construction of one's own virtual world. The virtual environments chosen were: Zen Office 2.0 (class 2A), School (class 2L) and Support Center (class 2N).

In FRAME setting section, the spectator mode has been activated, so as to allow more users to enter the virtual world, and the permissions and roles have been established. Editing was allowed only to administrators, while interacting, viewing, speaking and using the video camera was granted to all users present within the virtual world. In order, the items photosphere, emoji, zone lock and streaming, within the permissions section, has been set by default. Each virtual world thus created was protected by a password.

All students have been made administrators of the virtual world by the tutor teacher, in order to make each student completely protagonist of the course, to the advantage of a real co-construction of knowledge, so as to develop autonomy, responsibility, the relationship between peers, cooperative work and peer-tutoring.

In order to enter the virtual world, each student had to create his own personal avatar activating the full body avatar setting. Some researchers of experiential pedagogy associate the avatar with the character of a videogame, who interacts without limitations, in a common and hybrid frame, with digital artifacts and physical objects, integrating multisensory information (Riva and Wiederhold, 2022; VanFossen & Gibson-Hylands, 2023).

The moment of creating the avatar was certainly the funniest moment, because thanks to the functions available in the menu, more specifically in the profile section, it was possible to customize one's avatar and entrust him with the projection of his own identity (Oprean and Balakrishnan, 2020). Each student has therefore created his own avatar to the extent that he sees himself. He felt free to express himself, not necessarily creating an avatar that recalled real features or characteristics, but redesigned his virtual self, according to his deepest vision of himself. Surely this phase is very important for each student, but mainly for students with special educational needs, who through this virtual vision of themselves break down differences, feeling completely equal to others. This brings out one's own uniqueness, the deepest and truest one.

Finally, the tutor showed the students how to manage the functions related to the platform's assets for inserting digital and multimedia material into the virtual world. In particular the students have learned to insert images, multimedia presentations, text labels and text areas, audio, 3D texts, shapes, 3D models, whiteboards, streaming screens, effects, web browsers, objects from inventory, web links and spawn spots, these the latter are very important for creating links between different places in the same virtual world so as to facilitate movement within the different environments of the virtual world.

3.3 Phase 2: Educational tools and digital and multimedia products

In the second phase, lasting about 15 hours, the students followed the theoretical lessons proposed by the tutor within the virtual world. The lessons were held online and in asynchronous mode in a specific area characterized by the presence of a multimedia panel with the Google Chrome browser and the Google Meet application. The students took part in the lessons with their avatar, connecting from the notebooks set up in the various computer labs of the school. During the lessons, in addition to having presented the contents of the three macro topics relating to the study of the human body, the main educational tools were introduced for creating digital and multimedia products to be inserted into virtual worlds.

Specifically, the software CANVA, Thinglink, Genially, Learning Apps, Wordwall, Kahoot, Google forms and the main Google apps (sheets, docs, slides) were proposed.

Digital education games, in particular are useful for knowledge acquisition, because produce positive behavioural changes, and they are highly engaging and improve students' cognition and perception (central and peripheral visual acuity, selective attention and memory) (Lamb et al., 2018).

The students have internalized the contents of the topics and the various themes through the creation of multimedia presentations with CANVA, in-depth videos, interactive games aimed above all at self-learning and a metacognitive evaluation, learning verification modules to be evaluated and self-evaluated in the learning, skills and competences learned.

The creation of digital and multimedia products took place through the inclusive methodology of co-operative learning.

The tutor teacher divided the students into heterogeneous groups, chosen on the basis of each one's characteristics, so as to favor a relational exchange, positive interdependence, and the ability to independently create a peer to peer and effective peer tutoring to achieve an efficient meaningful learning (Hertz-Lazarowitz & Miller, 1995; André et al., 2013).

At the beginning of the course, all students were given a questionnaire to evaluate their personal knowledge of the proposed educational tools. This qualitative analysis, together with the data obtained from the quantitative assessment by the tutor teachers regarding the degree of ability to use these digital tools and the digital skills of the pupils, has made it possible to obtain an initial general picture of the specific technological and multimedia skills.

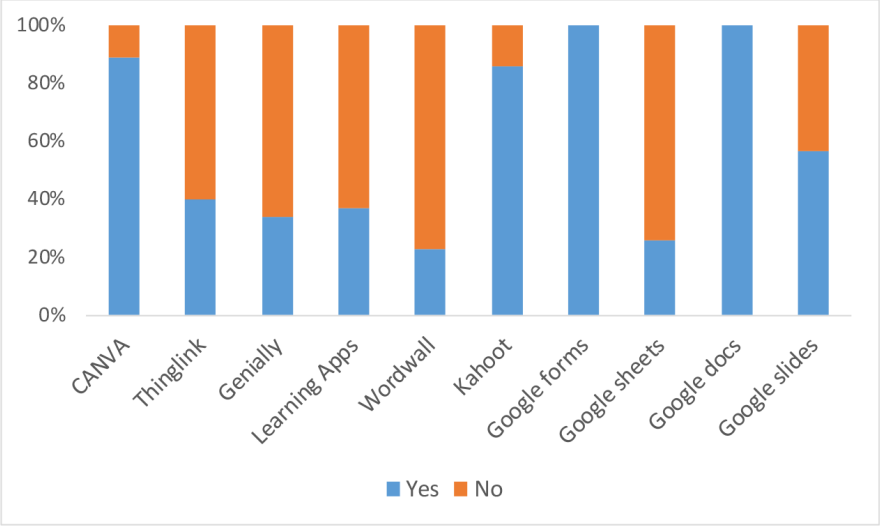

Figure 1: Qualitative assessment about the knowledge of the educational tools proposed in the teaching and learning experience. Data are expressed as percentage values

From the qualitative analysis of the data obtained (figure 1) it emerged that Google apps were the best known with a weighted percentage of 71% compared to 52% of the other digital educational tools.

This result may be attributable to the fact that students are used to using Google Workspace for Education in ordinary school and teaching activities.

Following this, CANVA and Kahoot turned out to be the best known by students, probably because after the pandemic period they found wide use in educational activities, respectively for the creation of captivating multimedia texts in graphics and for gamification and game-based learning (Siahaan and Nasution, 2022).

Less known, however, are the other tools proposed, a result which has confirmed the importance of the general objective of this experimentation, i.e. to provide specific tools for enhancing digital skills and the use of digital and multimedia tools in the teaching-learning process of the STEAM disciplines.

3.4 Phase 3: Virtual worlds and educational escape rooms

In the phase 1, the students of each class, guided by the tutor teacher, chose a learning environment among those proposed by FRAME platform. The learning environment, however, appeared as a mere scenario, devoid of any type of didactic material, except for the area dedicated to synchronous online lessons, thanks to the presence of a multimedia panel equipped with a Google browser.

Phase 3, therefore, turned out to be the crucial phase of cooperative learning, as the concrete construction of the virtual world took place, which was equipped with all the multimedia and digital material created within phase 2.

In this phase, the tutor teacher was a simple supervisor, while the students were the real conductors of the process.

Using the «edit mode» and «add asset» functions of the toolbar present in the foreground of the main screen of the platform, the students have enriched the virtual world, structuring it according to their own tastes.

Therefore, different virtual spaces for learning were identified. Multimedia presentations were placed in these environments, so students can discover all the disciplinary topics through their use (figure 2).

Figure 2: Virtual spaces for learning and examples of multimedia presentations are shown

In addition, the virtual educational games created were inserted in special virtual areas for gamification and the several verification tools developed were inserted in specific virtual spaces for self-assessment and metacognitive assessment.

Also, in this phase the students worked in cooperative groups and the peer to peer methodology was favoured.

The contents were built in a cooperative way, the knowledge was shared and taken shape through the various educational activities with which the virtual world has been enriched.

After structuring the virtual world, according to their personal taste, thus becoming an expression of the class group itself, the students created an escape room within the virtual world, which was important for the final phase of the entire teaching experience.

Several images depicting the letters of the alphabet were inserted within the virtual world, which, collected and arranged in the correct order, are able to compose a hidden sentence within a virtual game present among the various activities offered in the world.

Some letters were arranged randomly in the various spaces of the virtual environment, while others are the result of solving the various educational tests.

Thanks to the study that can be carried out in the virtual world through the contents relating to the macro-topic chosen for each world, conveyed by multimedia presentations, it is therefore possible to obtain the letters hidden within these didactic tests.

Figure 3 shows the environment chosen for the escape room.

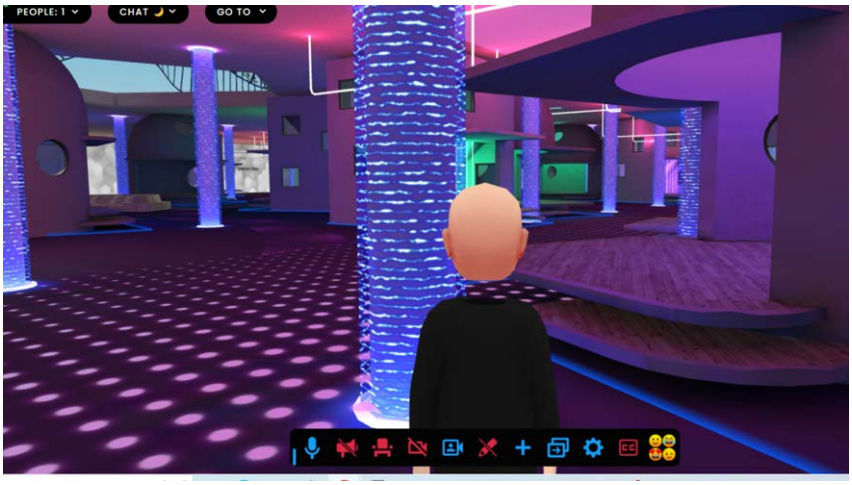

Figure 3: Environment chosen for the escape room

The three class groups did not interact with each other, for this reason the students of one class were not made aware of how the virtual world had been structured and the work carried out within it by the other classes, including the creation of the escape room.

This allowed phase 4 to be conducted as effectively as possible.

3.5 Phase 4: Immersive activity in virtual worlds

In phase 4 the virtual worlds appear to be fully structured and completed. Therefore, the students of each class had the task of exploring the virtual world built by one of the other classes. Through the study of the materials and the carrying out of the didactic tests prepared, the students were able to solve the amusing puzzles present inside, find the hidden letters, compose the sentence and «escape» from the virtual world.

This phase was conducted in a ICT laboratory using laptops, tablets and personal computers, in fact FRAME platform works highly effectively through the browser. The immersion in virtual and augmented reality was also conducted thanks to viewers in a multimedia lab.

Pico G2 4K VR viewers were used to carry out a totally immersive experience; they are able to effectively support the FRAME platform.

The virtual worlds created by the students can be explored by scanning the QR code in figure 4, which redirects to an interactive box.

Figure 5 shows the interactive box. By clicking on the links available in the box it will be possible to immerse yourself in the virtual learning environments.

Each link takes you to the virtual world created by each class.

Figure 4: Virtual World QR code: scan to access an interactive box where there are links to explore virtual worlds

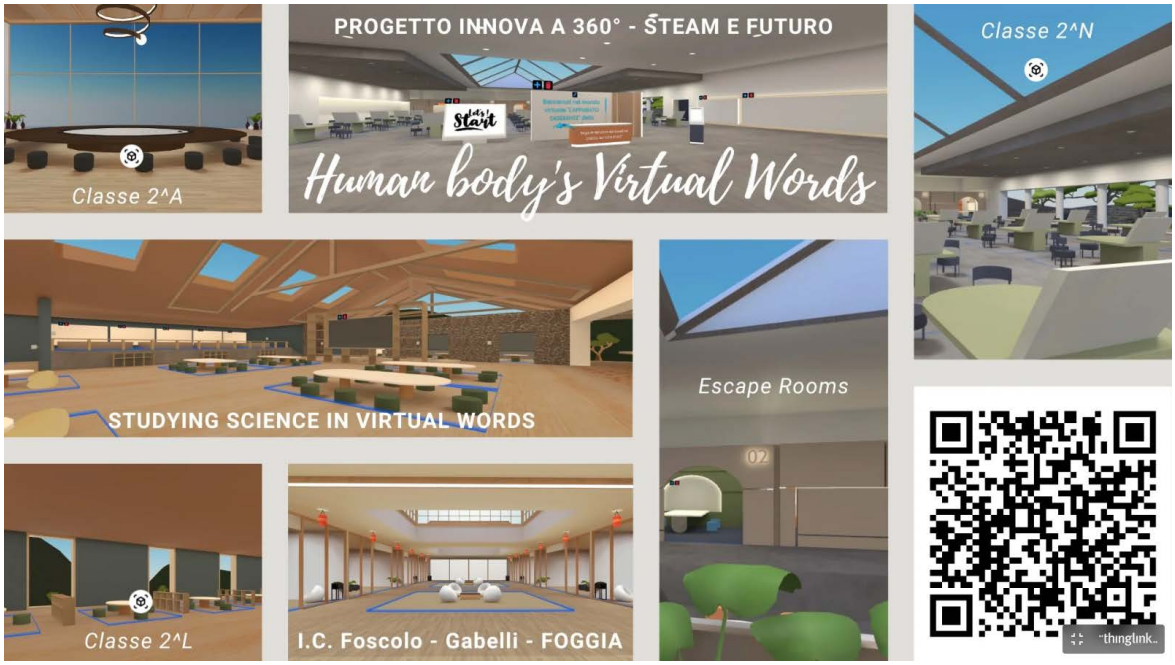

Figure 5: Interactive box "Human body's Virtual Worlds"

It is possible, however, to explore the three virtual worlds individually also through the use of the URLs[2], specific to each virtual world.

4. Discussion of the results and concluding remarks

The proposed teaching experience immediately aroused the interest of all the students involved.

As can be seen from the graph in figure 6, after getting to know the FRAME platform and understanding the objectives of the experience, the students showed a high degree of initial curiosity towards the educational path proposed to them, and a high degree of expectations in the comparisons of using virtual worlds in teaching subjects at school and for self-study at home with classmates.

2 The three URLs, specific for the three classes are respectively: https://framevr.io/innova360classe2a - https://framevr.io/innova360classe2l - https://framevr.io/innova360classe2n [last viewed on 15/11/2023].

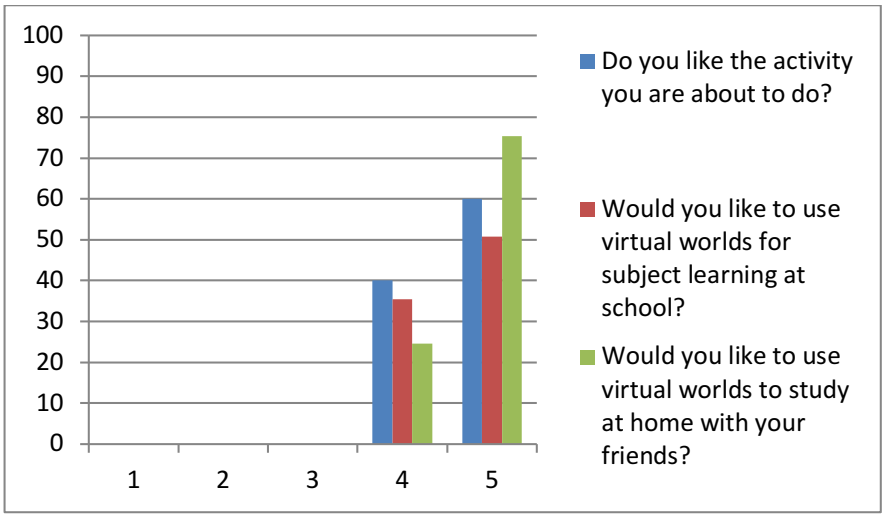

Figure 6: Satisfaction of the experience in terms of expectations (pre). Data are expressed through a 5 point-scale as percentage values

This result was confirmed at the end of the experiment.

In fact, a high degree of satisfaction was recorded and a concrete possible impact on teaching practice was positively assessed by the students, especially in the use of virtual worlds as a learning environment for personal and cooperative study, configuring a possible future projection of the teaching method (figure 7).

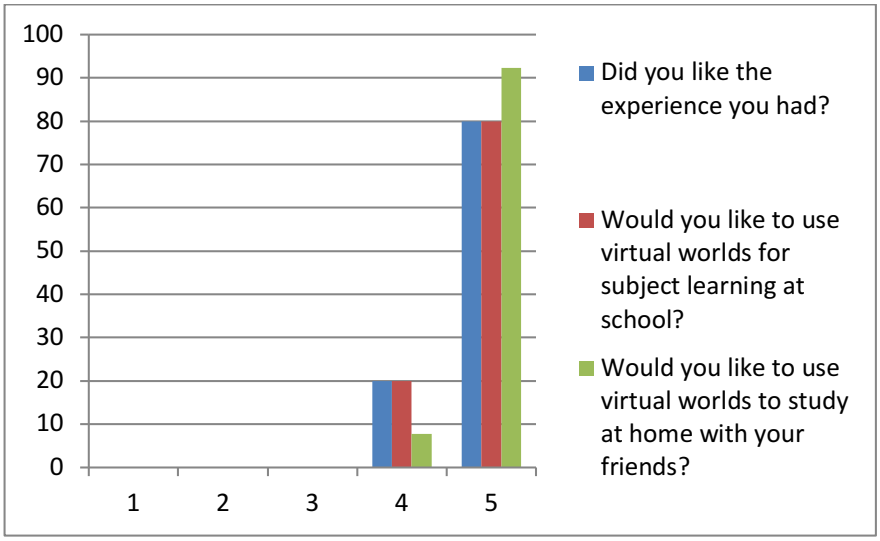

Figure 7: Satisfaction of the experience in terms of expectations (pre). Data are expressed through a 5 point-scale as percentage values

During the entire period of the experience, the teachers noted a high degree of interest on the part of all the students which translated into a high level of attention, both qualitative and quantitative.

A good level of productivity and effective time management were also observed.

In particular, a positive and proactive ability to approach the problem was recorded, associated with a good problem solving ability, above all thanks to the methodological action of peer to peer and peer tutoring, confirming how the use of technology has fully placed itself as a scaffolding to learning (Wood et al., 1976).

Inside the virtual world, the students recognized in their classmates the value and importance of mutual help and in the teacher the figure of an attentive and necessary guide for understanding the methods to be adopted in order to carry out the assignments correctly.

All the groups worked in harmony, each according to their own characteristics and the difficulties that arose were resolved easily, differently from what the teachers often found in the ordinary face-to-face work.

In fact, Cicconi and Marchese (2019), demonstrated that environments that allow Augmented Learning experiences could concretely contribute to changing, enriching and improving the learning experience since they favor collaboration and social interaction, focal points for the promotion of inclusive teaching (Mesa-Gresa et al., 2018; Howard & Gutworth, 2020; Sharma et al., 2020; Ke et al., 2022).

It has also been observed that students with special educational needs have been fully included in the entire virtual learning environment, and have been able to work autonomously within the group, requesting help from their peers where necessary and showing an almost constant degree of attention and participation and lasting.

Among the students with disabilities, one had autism spectrum syndrome; specifically, he was able to relate positively with his classmates while maintaining a higher degree of attention, in terms of duration and quality of time, than generally observed in the non-virtual environment.

What has been observed is in line with what has been indicated by some scholars on the perceptive aspect and the cognitive load used in learning environments (Sweller et al., 2011). In fact, it emerged that one of the components most involved is the construct of perception: when one is immersed in a virtual environment, the visual stimuli are amplified and, in this way, the use of working memory increases (Han, 2020).

Lombardi and Traetta (2023) hypothesize the metaverse and virtual spaces, as places without spatio-temporal and physical barriers, possible laboratories of inclusion, open to all students, especially those experiencing situations of social marginalisation and with cognitive and physical disabilities.

Digital Educational tools (5-point scale)	t	1	2	3	4	5	Average	Mode
CANVA	t_0	7.7%	10.8%	12.3%	15.4%	53.8%	4	5
	t_1	0%	0%	6.2%	24.6%	69.2%	4.6	5
Thinglink	t_0	20%	32.3%	16.9%	23.1%	7.7%	2.7	2
	t_1	0%	0%	20%	32.3%	47.7%	4.3	5
Genially	t_0	21.5%	29.2%	21.5%	20%	7.7%	2.6	2
	t_1	0%	0%	21.5%	40%	38.5%	4.2	4
Learning Apps	t_0	10.8%	32.3%	18.5%	27.7%	10.8%	3	2
	t_1	0%	0%	10.8%	13.8%	75.4%	4.5	5
Wordwall	t_0	27.7%	27.7%	21.5%	16.9%	6.2%	2.5	1
	t_1	0%	0%	15.4%	40%	44.6%	4.3	5
Kahoot	t_0	13.8%	7.7%	18.5%	13.8%	46.2%	3.7	5
	t_1	0%	0%	10.8%	13.8%	75.4%	4.7	5
Google Forms	t_0	3.1%	4.6%	23.1%	10.8%	58.5%	4.2	5
	t_1	0%	0%	23.1%	18.5%	58.5%	4.4	5
Google Sheets	t_0	30.8%	18.5%	24.6%	13.8%	12.3%	2.6	1
	t_1	10.8%	15.4%	24.6%	21.5%	27.7%	3.4	5
Google Docs	t_0	0%	0%	3.1%	12.3%	84.6%	4.8	5
	t_1	0%	0%	0%	3.1%	96.9%	5	5
Google Slides	t_0	6.2%	15.4%	21.5%	38.5%	18.5%	3.5	4
	t_1	0%	0%	10.8%	27.7%	61.5%	4.5	5

Table 3: Percentage distribution of pre- (t0) and post- (t1) experience evaluations relating to the degree of use of the proposed educational digital tools, media and mode (N=65)

The analysis of the results reported in table 3 is interesting, because it clearly emerges that in the conditions created for this didactic experience, the students have developed a high degree of mastery of technological and digital skills in reference to the ability to use digital educational tools proposed. Werang and Leba (2022), in fact, underline how the virtual environment increases student engagement, considered one of the most important factors influencing the learning process.

This confirms that working in a positive environment, full of interest and motivation, generates a state of well-being such as to put students in a position to be able to achieve the pre-established objectives more easily and more effectively. Facing school life with positivity and in a state of global well-being facilitates the learning process also with a view to enhancing one's personal talents (Dato et al., 2021).

In conclusion, although it is a case study, the didactic experience presented leads us to hypothesize in a more concrete way that the eduverse can be implemented practically and that, therefore, learning within virtual worlds can be a possible challenge for pedagogy experimental and special education.

Surely, this didactic experience takes the form of a small parenthesis of a much broader scenario to be characterized, explored and opened up to all disciplines, not just STEAM.

Structuring the teaching-learning process within virtual worlds can be an added value capable of giving effectiveness to an innovative didactic action and to a new way of conceiving educational action.

Certainly, the path of teacher training and awareness of the use of educational technologies as scaffolding to learning becomes fundamental, in particular of support teachers, who can use the high inclusive value of virtual and augmented reality as an active strategy in the various contexts of disability.

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Conflict of interests

The authors declare no conflict of interest.

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