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Virtual worlds in distance learning

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ABSTRACT

Virtual worlds are considered an additional proposal within the e-learning model. Online platforms have not been enough resources to be successful in the teaching and learning processes, therefore, it is necessary to search more options that contribute to their improvement. Virtual worlds, through inverse and visual experiences for the student, offer new panoramas that allow living situations and solving problems in different areas, such as mathematics. This article analyzes the opinion of higher-level students regarding the use of virtual worlds in their distance classes. Likewise, the virtual worlds provide help in improving teacher-student and student-student relationships. Some cases of educational institutions that integrated the use of virtual worlds into their classes are shown. A Likert-type scale questionnaire has been applied to a sample of 65 higher-level students. Its reliability was validated by means of Cronbach's alpha coefficients and Pearson's. It was found that students consider that the use of virtual worlds would improve class work and relationships between their peers and their teachers. It is remarkably undoubted that virtual worlds within education path are considered an excellent tool for e-learning. However, although the interest on the part of students is high, it is necessary to carry out more researching and developing procedures on the virtual worlds as an alternative to support learning.

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1. INTRODUCTION

A virtual world is an environment inspired or not by reality. Within this world, users are allowed to interact through avatars with objects or with the virtual world itself. These virtual worlds are applied in different areas such as: entertainment, education, 3D design, social applications. There are three characteristics that frame virtual worlds. The first is interactivity, which refers to the fact that the user is able to communicate with other users and with the world itself. The second is corporeality, that is related to the physical laws to which the virtual world is subjected. Finally, persistence since although no active user is found within the virtual world, the world is still active. So when users close their session in the virtual world, their positions in the world are saved in order to when at the beginning of their next session, they could continue from the same point they were when they left the world [1].

Virtual worlds were created primarily to be used in virtual reality, which tried to emulate feelings of a real world in a virtual environment. Currently, the uses of virtual worlds have extended beyond virtual reality and the field of entertainment. One of those uses is in the field of education. However, as far as we know, the problem is that the use of virtual worlds for teaching mathematics has not been sufficiently explored. It is a fact that in this period of contingency caused by the COVID-19 pandemic, teachers must be more creative and use all the resources they have to teach students. Due to this, in this work a quantitative,

descriptive and correlational study, applied to engineering students in computer systems, is presented to know: i) The acceptance that virtual worlds would have among students to improve the teaching/learning process; and ii) The benefits that could be gained from virtual worlds to teach mathematical topics, such as applied calculus, probability and statistics, differential equations, and linear algebra, which are fundamental to the training of a computer systems engineer. The results obtained are encouraging since they showed that the students, having had good experiences in their interaction with virtual worlds, such as video games, are willing to transfer them to the educational field and thus obtain better results in terms of their learning.

Some pedagogical principles that are considered valid for face-to-face and distance education have been analyzed [2]. It was found that the explored pedagogical principles such as individualization, socialization and interaction, activity, autonomy and independence, creativity, intuition and games are a fundamental part of quality education for students. Therefore, the principles are present in both modes of education. When opting for a change in the pedagogical model, it does not lie in the use of technologies, but depends on the training, intention and decision of the educator. That is, the internet and the technologies that are available are also able to enhance learning in order to obtain a higher quality and content, however, the use of technology does not guarantee better learning.

Within face-to-face education, several pedagogical principles have been applied. They have been retaken for years and that have also been used as a basis for distance education. What differentiates face-to-face education from distance education is the way in which information is transmitted and the way in which communication between teachers and students occurs.

In another study [3], an overview of the quality status of virtual educational environments was provided. Likewise, the dimensions and sub-dimensions of an empirical instrument were examined in order to improve and evaluate the quality of online education. There is an enormous untapped potential for improvement in the use of technology for distance education. However, there is no total security in regards of the terms of the quality that is offered [3].

Previous researchers [4] conducted a literature review in order to identify current applications, the benefits to be gained, and the problems faced. From this review, the capacities, experiences and factors of the virtual world associated with educational opportunities are presented, as well as the gaps in the fulfillment of pedagogical objectives. Institutions, like other fields, are in search of improvements. Education has been involved in the use of new technologies and in its distance modality. It goes beyond the simple knowledge located within the network, making use of virtual realities where a better interaction between students and teachers is promoted. This is promoting as well collaborative and cooperative learning through a community. Although virtual worlds provide students with visual knowledge and allow them to dive deeper into an activity, there is no evidence that students are becoming more capable, or have developed strategies that indicate successful learning. It is possible that gaps persist in students' abilities when learning [4].

Previous research explored different studies focused on the analysis of users of virtual worlds and users who are inclined towards self-learning. Several application areas of 3DVW in higher education were found and classified into 13 main categories. The categories are: field trips, virtual reading, virtual labs, meetings and discussions, simulations, creation in worlds, activities of students, socialization, miscellaneous activities, curricular services, course material, games and assignments [5].

Hew and Cheung [6] reviewed empirical research studies on the use of three-dimensional immersive virtual worlds in educational settings such as K-12 and higher education in 2010. The research provided information on three points: i) The different ways teachers and students use virtual worlds; ii) The types of research methods used in previous studies; and iii) The types of research topics conducted in virtual worlds and their findings. Different uses were also found that have been given to virtual worlds: as spaces for communication, simulation and experience. Through the literature reviewed, it was noted that the experiments took place in university settings and took place in subjects such as media arts, health, and the environment.

The results of the surveys carried out showed data on the acceptance of the students for the use of virtual worlds. They were also denoting free mobility in three-dimensional space, meeting new people and experiencing virtual excursions. In the same way, the students complained of the inability to access the virtual world through old computers, with low capacity or the same limitation of software in computers on school property [6].

A virtual world that has been very successful due to its use by both professors and researchers is called Second Life. According to Kristianti, Purnawati, and Suyoto [7], the design and application of an online educational strategy, at university level, carried out in a 3D virtual world (Second Life) was presented with two essential objectives: i) To explore whether a learning activity immersive is effective in improving student-teacher and student-student communication; and ii) Establishing the possible effectiveness of this type of e-activities as an element of improving the educational experience of the online student.

The results obtained from this experiment were positive when reaching the proposed objectives. Primarily the objective that was expected to be achieved was the improvement of communication between student and teacher. Thus, it is achieving a greater number of messages between student and teacher and in the same way between students sharing notes of the received topics, discussions about work and exchange of information on bibliographies. As in addition to the mentioned, it is included the interaction obtained through avatars, giving the student a feeling of freedom to express themselves more freely [8]. Other researchers emphasized that virtual worlds like Second Life allow simulating various situations and being able to experience them, resulting in an excellent means of learning [9], [10].

2. LITERATURE REVIEW

In the 1950s one of the first artifacts to be considered the first sensory immersion or virtual reality machine was the Sensorama, invented in 1957 by Morton Heilig, a philosopher, inventor, and filmmaker. This machine offered a multisensory immersive cinematic experience in which the sensation of riding a motorcycle was experienced. In addition to the images, the wind was felt on the user's face, as well as the smell of the environment [11]. Another invention was created later by Ivan Sutherland and his student Bob Sproull in 1968, who developed a helmet known as the Head-Mounted-Display (HMD). It consisted of a viewer, usually stereoscopic to create depth and displayed images in three dimensions [12].

Once the development of virtual reality began to consolidate in what it is today, in 1974 the first online multi-user 3D video game was born. The first game that would usher in virtual worlds was provided by Maze War with the concept of online players as avatars chasing each other in a maze. Players assumed the role of a flying eyeball and navigated a maze, moving forward, backward, or turning 90 degrees to the left or right [13].

In late 1978, Roy Trubshaw, a British ESSEX university student, created a role-playing game called Multi-User Duagenon (MUD), a text-based adventure in which players move through a series of locations and perform actions by typing words or phrases [14]. The important thing in this game was the multiplayer section. A group of users could participate in a fantasy wrapped world and interact with each other.

In 1987 the first virtual world developed by LucasFilm Games for the commodore 64 was created, which worked with the Quantum Link service [15]. The world of habitat was made up of a large number of discrete locations called regions. Each region can be linked up to four other regions, which can be reached simply by walking your Avatar to one edge or to the other edge of the screen. Each region contains a set of objects that define the things that an Avatar is able to do in this location and the scene that the players watch on the computer screen. Many items are portable and can be carried in an Avatar's hands or pockets.

Between April and May 1995, the 3D virtual chat platform known as Worlds Chat was launched, pioneering this particular genre of virtual spaces. Worlds Chat originally had 15 avatars to choose from, 20 rooms available to explore, and two worlds, Sadness and Glee. Along the way, Worlds Inc. experienced the sale of the gamma Active Worlds development kit to users or organizations for the development of their own virtual spaces. In this way, AlphaWorld and Starbright World became their own separate Worlds Chat platforms, in years after World Chat's inaugural launch as the first multi-user 3D virtual space.

Active Worlds is the oldest profit-oriented 3D technology. It was established in 1995 and, like Lego, uses bricks as unit construction. Its easy-to-use graphical user interface allows users to create either real or fantasy objects. After the user makes a composition, e.g., a building, he/she can do actions like dispatch its location to other persons, choose a suitable avatar, meet in real time or send messages, known as telegrams. These are similar to SMS that appear in a special area of the screen, each time a participant logs into AW.

One of the world's largest social networks for youth and teens entertainment is Habbo, run by a Finnish company called Sulake Corporation Oy. The world of Habbo is based on a hotel, where each of its rooms acts as chat rooms [16], [17]. The Sims is the first life simulator created, where the use of personalities in non-playable characters (NPJ) stands out, interacting with the user's avatar directly [18], [19].

Second Life, an online virtual world, was delivered on June 23, 2003. It was developed by Linden Lab, a San Francisco-located company. Second Life is much the same to massive multiplayer online role-playing games although its creator has remarked that it is not a game. In this virtual world, which can be reached through either a software client provided by Linden Lab or third-party viewers, users are known as residents and their virtual representations as avatars. Using avatars, users can connect with other avatars, objects or places. Second Life is the first virtual world in which residents build their content from scratch.

World of Warcraft or commonly called WoW is an online role-playing video game or Massive Multiplayer Online Role-Playing Game (MMORPG). Developed by Blizzard Entertainment, it is the most popular MMORPG of the last decades with a Guinness record for the largest subscriber base, which continues to grow to this day [20], [21]. In 2006, Rockstar Games, produced the video game "Bully", which was developed within a school. The game could not continue if classes were not passed with passing grades. Some preview of the game is shown in Figure 1 and Figure 2.

Figure 1. Videogame environment Bully [22]

Figure 2. Bully video game math class [22]

As is usual in all games, players use an avatar with which they interact within the virtual world. They are either exploring the vast world created, having battles between users or against monsters, completing game missions or interacting with players from all over the world and also with non-playable characters (NPC). The goal of the game is to complete story missions and level up which will help them to complete increasingly difficult missions, as well as get better equipment [22].

Currently, there are many types of virtual worlds using the bases that have settled over the years. Virtual worlds have been developed to reach gigantic and immersive worlds, with a better interaction of the same world and the user's avatar. As well as the undoubted improvement in the connection of massive users from all over the world, which has been reached due to the improvement in communication networks (internet).

In the evolution of virtual worlds, the predominant interest has been to entertain people so that they can do things that in real life is very difficult. The virtual worlds have been aimed at entertainment and recreation for users. However, the particularity of simulating situations, as well as being in contact with other people, has allowed them to enter the field of distance education.

Within the educational field, particularly in face-to-face education, technology has been present for more than two decades. Unfortunately, in general, its use has been limited to information searching on the internet and using of projectors and electronic whiteboards, preserving the traditional teaching style. It means that instead of dictating concepts or writing lesson on the blackboard, the information appears on slides that are shown by teachers through a projector. At best, teachers make use of specific software or videos that allows them to show situations related to the subject that needs to be addressed [23], [24].

Currently in the confinement stage that we are experiencing, as a result of the COVID-19 virus pandemic, all sectors have been forced to change their practices and ways of proceeding [25], [26]. In the educational field, classes are conducted remotely at a distance. Teachers make use of platforms that allow them to manage their content (notes, activities, assignments, tasks, presentations), as well as to teach their classes remotely [27], [28]. Consequently, computers and the internet have become the main protagonists at a technological level in the teaching and learning processes, as well as the platforms and tools that teachers use.

There are other technological resources that have had less use by teachers as support in their distance classes, these are virtual worlds. They allow students, through avatars, to interact with three-dimensional objects in the classroom environment. In this way, the emulation of situations allows the student to build concepts in all areas of science that could be difficult to understand and that are approached in the remote mode. Thus, virtual worlds are providing new opportunities by developing attractive and interactive experiences in education [29], [30]. However, as far as we know, the problem is that the use of virtual worlds for teaching mathematics, which is one of the fundamental areas of science, has not been sufficiently explored. In particular, in the context of mathematics, the acceptance of virtual world by students and how they could benefit the teaching/learning process of topics such as applied calculus, probability and statistics, differential equations, and linear algebra have not been completely addressed.

In the literature, several cases have been reported on the use of virtual worlds applied to education [4]–[8]. They highlight the importance of innovating in the ways of transmitting knowledge and all in those times of confinement caused by the COVID-19 pandemic, where one of the greatest challenges for teachers is to maintain the motivation of students to learn. However, to try to ensure that a tool, in this case virtual worlds, will be useful for a specific purpose. In this sense, for education, it is necessary to carry out a study to analyze the acceptance that it will have among the community of students.

The problem raised in this work points in that direction, that is, as far as we know, the use of virtual worlds for teaching mathematics has not been widely explored. Therefore, in this work a questionnaire was designed to perform the acceptance analysis of virtual worlds in the area of mathematics among students. In addition, if positive results were obtained, the possibility of describing the characteristics that a virtual world would have for its use in teaching subjects in the areas of differential calculus, applied calculus, probability and statistics, and linear algebra was raised.

3. RESEARCH METHOD

This was quantitative research employed correlational design. The instrument was a questionnaire delivered to the respondents who are chosen with random sampling technique. They were consisted of 65 engineering students from Computer Systems Department, National Polytechnic Institute, Mexico. The ages of the students range from 19 to 31 years old.

The questionnaire was made up of 10 questions presented through Google Form. Nine questions were multiple-choice Likert scale questions and one question was open, in which a proposal was requested that included a mathematics topic to be worked on in a virtual world. The questionnaire was intended to investigate the acceptance and use that virtual world have had by higher-level students, as well as the importance of using them in distance education. Both were to strengthen learning and the teacher-student relationship. In particular it was of interest to review its use in the development of mathematics topics.

The data was collected during the period of the COVID-19 pandemic (December, 2020), when the students were taking distance classes. The math subjects they were taking were Applied Calculus, Probability and Statistics, Differential Equations, and Linear Algebra. All students participated voluntarily. For statistical work, Excel was used as a data processor.

The questionnaire was validated through Cronbach's alpha coefficient since it allowed the measurement of the homogeneity of the questions, averaging all the correlations between all the items. Its interpretation is that the closer the index is to the extreme 1, the better the reliability, considering an acceptable reliability from 0.70. Its statistical formula is given in (1)

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum S_i^2}{S_t^2}\right] \quad (1)$$

Where: K=The number of items; Si^2=Sum of Item Variances; S_t^2=Variance of items sum; α=Cronbach's Alpha Coefficient.

An analysis was carried out using Pearson's correlation to determine the relationship between the knowledge that students have of virtual worlds with the use that it can be given within distance education. It also sought to find a relationship between the use of virtual worlds in distance education. It helps to solve problems in the mathematical field, as well as improving the teacher-student relationship. Question 10 of the questionnaire allowed to know the way in which the students wanted various math topics to be presented using virtual worlds.

4. RESULTS AND DISCUSSION

Regarding the age of the students, the results of the sample obtained are observed in Table 1. There were 73% of the sample made up of students whose ages range between 17 and 22 years old, which places them in the early youth stage. Being young they have a greater technological attachment than other generations. Therefore, they have probably had contact with some type of virtual world or relationship with the term virtual worlds. The instrument's reliability result was verified by means of Cronbach's Alpha, which showed a result of 0.720, valid for research in social sciences. Table 2 shows the values obtained for each of the variables involved in the formula.

Table 1. Ages of the respondent

Age	Percentage
17 to 19 years	38%
20 to 22 years	35%
23 to 25 years	13%
26 to 28 years	7%
29 to 31 years	2%
More than 31 years	5%

Table 2. Values obtained in the excel processor

Variable	Value
K	65
K-1	64
$\sum S_i^2$	7.083173077
S_t^2	24.33653846
k/k-1	1.015625
$[1-\frac{\sum S_i^2}{S_t^2}]$	0.708949032
α	0.720026361

The descriptive results are presented in Table 3, as well as in the graphs generated by the Google Form. It is indicated that 76.9% of the students participating in the study know the meaning of virtual worlds, with a score of 4.09 on a scale of 1 to 5, of which 67.7% have participated in a video game that occupies virtual worlds. Despite the fact that in general they have not had training for the use of virtual worlds, since on average they scored this aspect with 1.98 on a scale of 1 to 5, and that until now 87% have not had classes in which their teachers have occupied the virtual world. Using virtual worlds as entertainment through videogames has allowed them to consider virtual worlds as a resource that can be used by the teacher in distance education.

There are 80% of the students in the sample consider that in the field of mathematics at the higher level and in the distance education model, working with virtual worlds will help solve problems, and on average they rated this aspect 4.6 in on a scale of 1 to 5. They also identify virtual worlds as useful for improving the teacher-student relationship, with an average score of 3.86. These results in line with Hew and Cheung [6], who point out that virtual worlds are spaces of communication, simulation and experience.

Regarding the use of videoconferencing or virtual worlds in distance education, an average of 3.8 was obtained on a scale of 1 to 5. It indicates that more students prefer to take classes making use of virtual worlds, which confirm the approaches presented in [4], [5]. They affirm that virtual worlds can provide the student with visual knowledge and can immerse themselves in an activity that makes sense to them.

Table 3. Student opinion regarding the uses of virtual worlds

Question	Average	Variance
1. You know what a virtual world is?	4.09	0.678
2. Have you participated in a video game that uses virtual worlds?	3.9	1.116
3. Video games that use virtual worlds are better than those that don't	3.38	0.927
4. Now that you are working remotely, has the teacher used virtual worlds for the class in any Learning Unit at your school?	2.2	1.256
5. Have you received any training to work with virtual worlds?	1.98	0.921
6. You consider that, in the distance model, working with virtual worlds allows students to achieve meaningful learning.	3.98	0.515
7. In the field of mathematics at the higher level and in the distance education model, working with virtual worlds will help solve problems.	4.03	0.499
8. The teacher-student relationship in the distance education model is strengthened if the work is carried out with virtual worlds.	3.86	0.464
9. Interaction between students and teachers is better through virtual worlds than videoconferences.	3.78	0.702

Table 4 reveals the results of the Pearson correlation. It shows the question that is most related to question 6 (Do you consider that, in the distance model, working with virtual worlds allows for significant student learning?). As can be seen in the information pointed in Table 4, there is a directly proportional relationship between question 6 with questions 3, 7, and 8.

Table 4. Pearson correlation values

Questions	Correlation values	Question
P6, P3	0.5605	3. Video games that use virtual worlds are better than those that don't
P6, P7	0.7479	7. In the field of mathematics at the higher level and in the distance education model, working with virtual worlds will help solve problems.
P6, P8	0.6424	8. The teacher-student relationship in the distance education model is strengthened if the work is carried out with virtual worlds.

The greater the use of virtual worlds in video games, the greater is considered to be useful in learning subjects such as mathematics. Being able to overcome challenges by being in an inverse world and communicating with other people, moving around, working with 3D objects, allows addressing problems-which in video games require decision-making, show critical thinking, be analytical, follow a series of steps according to what is indicated in previous study [29]. They are also required for the student to solve math problems. That is why the students assume that in the video games that they carry out through virtual worlds, an option is presented to achieve an understanding of the problems in the area of mathematics. Virtual worlds are also useful to have better communication with the teacher in the distance education model as a result of the interaction they reached through the development of video games [28].

On the development of mathematics topics using virtual worlds, the information obtained was organized considering the identified characteristics. They are presented in Table 5 and Figure 3. Students are interested in the space in which they study. This is an immersive space that is pleasant. It is not strictly attached to environments to which they are accustomed in their academic work at a distance that they are now taking in this confinement due to the pandemic.

Table 5. Analysis of the proposals for virtual worlds for the development of mathematics topics using virtual worlds

Virtual world feature	Percentage
3D object simulations	21%
Avatar customization	8%
Different environments	26%
Scoring or reward system	11%
Study rooms for students	7%
Interactive exercises	21%
Taking and storing notes	6%

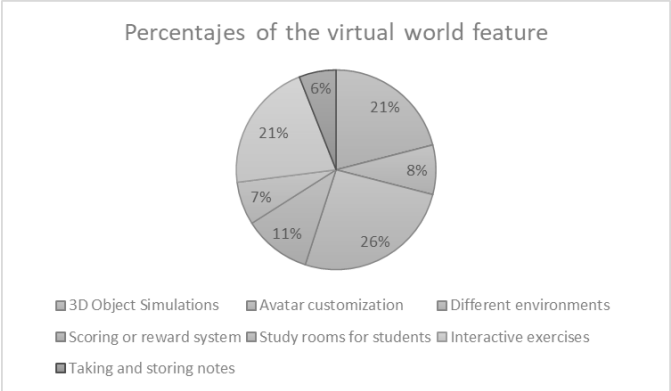

Figure 3. The percentages on the characteristics that virtual worlds must have in order to be useful in education

Another outstanding feature was the simulation of 3D objects together with interactive exercises, being able to visualize applications using 3D objects and being able to interact with them, would help to understand more easily the subject that is being taught. Regarding the exercises, the students ask for interactivity in the form of games that avoid the monotony of texts and flat exercises where no real application is shown. The other proposals include features such as a reward system for performing exercises or tasks, which encourage the student to perform these tasks, as well as provide interest in the topics, also the customization or personalization of avatars where they can express individuality and functional characteristics based on the taking of notes and their storage. Based on the student descriptions, this article makes a proposal:

To create an environment of a Virtual World, it was found feasible that each student can create their own character similar to themselves, so that in this way they feel identified and can generate better interactions. It is proposed to use tools similar to those of Adobe Fuse, which allows a realistic 3D modeling of physical persons as shown in Figure 4. The second part of the modeling would be the place or environment where it is desired to develop the world, due to its simplicity Unity modeling allows landscapes to be created relatively quickly as shown in Figure 5.

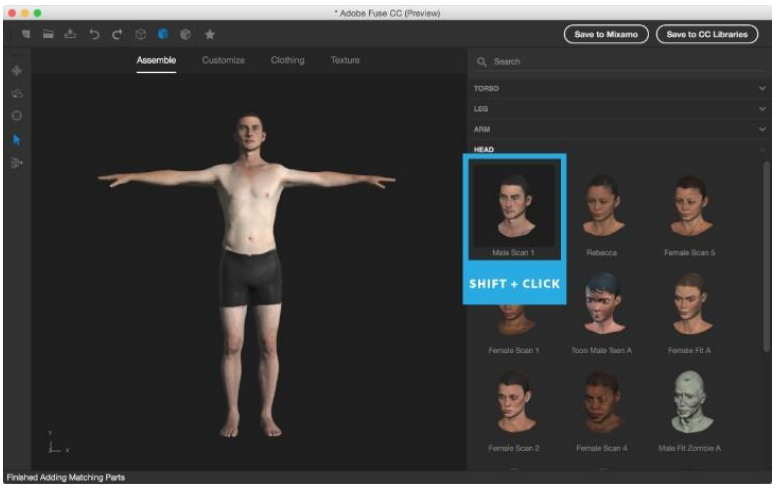

Figure 4. Character modeling in Adobe Fuse

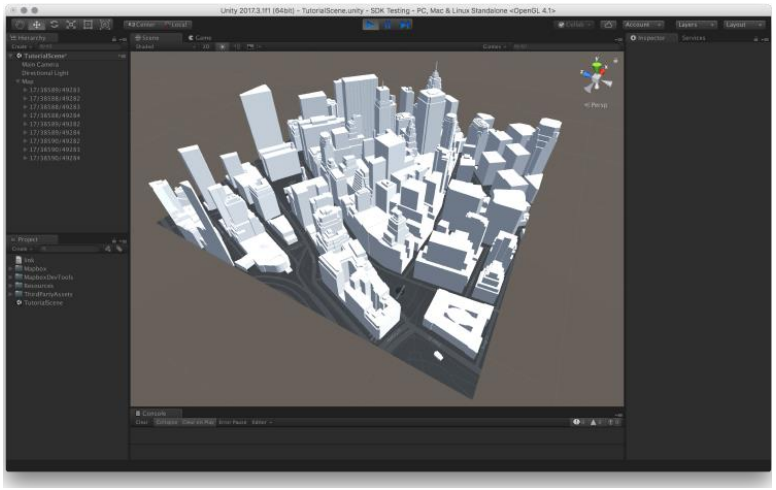

Figure 5. City modeling in unity

Once the two sections have been built, aspects would raise such as the target audience and other technical aspects. It can be an online game, regardless of the prices to maintain the database and the creation of all the resources. The open world option may be of interest, include a greater number of audiovisual elements such as classes in any subject to complement the missions and learn at the same time. It is allowing the option of an open world, but with the certainty that the player will continue with their learning to unlock new objects. Also propose the online option where the interaction between game characters is allowed, creating an online community, but the initial requirement would be progress in the game's progress.

5. CONCLUSION

Virtual worlds have many benefits in areas of education. They also have a good opportunity of being widely accepted to learn math concepts. The study found that the students know the virtual worlds. They are willing to work with them on math topics either inside or outside the classroom (through the distance education scheme). In addition, they consider that some aspects of the interaction with their teachers can be strengthened.

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