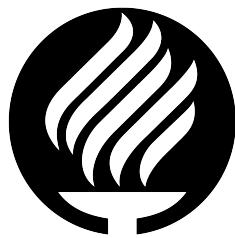


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Serious Games Teach Physics: How effective are they?

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“The study of physics is also an adventure. You will find it challenging, sometimes frustrating, occasionally painful, and often richly rewarding.”

- Hugh D. Young

Abstract

Technology is increasingly important in today's classrooms. Simulations and digital videos are the most used for educational purposes. While the simulations focus on educating, they tend to be boring and the engagement of the users cannot be the same. So designing a fun simulation and The purpose of this study is to examine, develop and test a serious game to teach physics in video games regarding the user experience and thus be able to measure the effectiveness after playing.

Keywords: serious games, education, physics, kerbal space program

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Chapter 1

Introduction

"If the universe is an artificial simulation then the mathematics is its code and a physicist is a programmer."

- Shubham Sanap

A serious game integrates both the topic to be learned and the game with the aim of creating entertainment from start to finish. With the recent growth of this e-learning model, both companies and schools have begun to create personalized environments in order to motivate people to learn new things in an effective way, offering a space in which to practice without stress.

This study stems from the previous results of “Can Students Learn Physics by Playing Video Games? Effectiveness of a Serious Mod” in which Alonso Oropeza studies the possibility of improvement in physics issues through a questionnaire before and after using the mod carried out in that study. The test carried out had an effectiveness in men of 1 percent and in women of 11 percent, so based on the work carried out, it is expected to improve the learning percentages in this study.

This study will clarify the concepts of the video games, physics, mods, e-learning, gamification and serious games. Subsequently, previous studies and the state of the art. After introduce the problem, the solution and the research methodology will be presented. Finally, the results will be analyzed and it will be concluded whether the study carried out meets the general objective.

Chapter 2

Literature Review

"If you only read the books that everyone else is reading, you can only think what everyone else is thinking"

- Haruki Murakami

This chapter is segmented into five main components:

1. Prior Knowledge

Serious Games, e-learning, gamification, classification, mods.

2. Current Industry

Trends, SGS, IJSG, popularity of Serious Games and successful use cases.

3. Relevant Work

Featured works in the field of Serious Games and their relationship.

4. State of the Art

The latest level of development regarding Serious Games for science education.

5. Conclusions

2.1 Prior Knowledge

Serious games are games that are designed to encourage learning or training on any topic that can be considered useful or educational. It can be defined as a video game that seeks to teach

rather than entertain the user. Similarly, there are several concepts that are often confused or misunderstood, such as e-learning and gamification.

As mentioned by Clark C. Abt, an American researcher (Viking Press, 1970) Serious games can be defined as a set of games that are included in the teaching and learning process without eliminating fun and pleasure [1].

On the other hand, e-learning is digitizing anything and mounting it on a digital platform.[2] In the same way we have gamification which consists of using game environments and rules and using it in real life with a training purpose.[1] This distinction is shown in Figure 2.1.

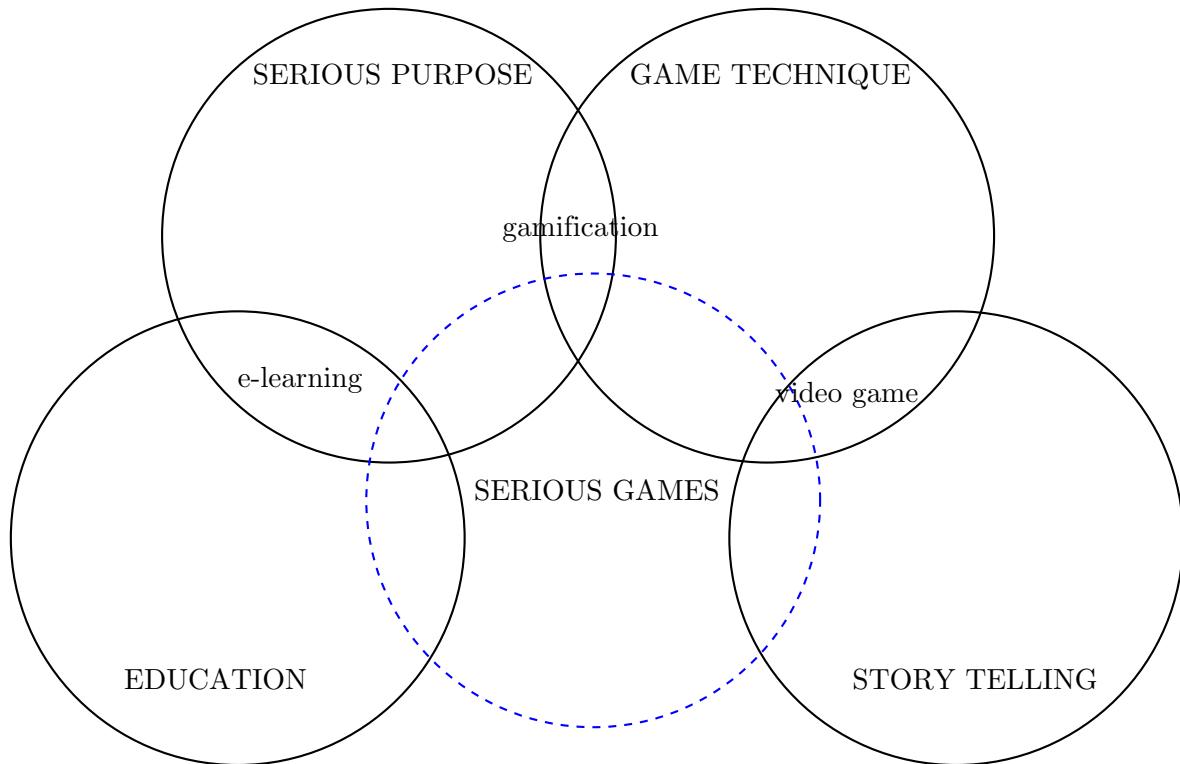


FIGURE 2.1: E-learning, Gamification and Serious Games.

There are several classifications for serious games. The classification by market which are designed for a specific public. Although very useful, these market-based classifications suffer from two limitations.[3] First, due to the discovery of new markets for Serious Games, its limits continue to expand. Second, these ratings are based solely on the Serious Games apps and not the games themselves.

In other words, market-based ratings can only report on the uses of Serious Games, not its content.

The classification by purpose is based on the need to be satisfied in the game, that is, to teach, to send a message. These are linked to specific games so they are more difficult to generalize, that is, medicine games, business games, physics games.[3]

If we focus on obtaining the skills and purpose of teaching and the type of game to be implemented, the G/P/S classification model can be used. The G/P/S model is intended to provide a common ground with which to explore the entire field of serious gaming.[\[3\]](#) The classification model can be shown as in Figure 2.2

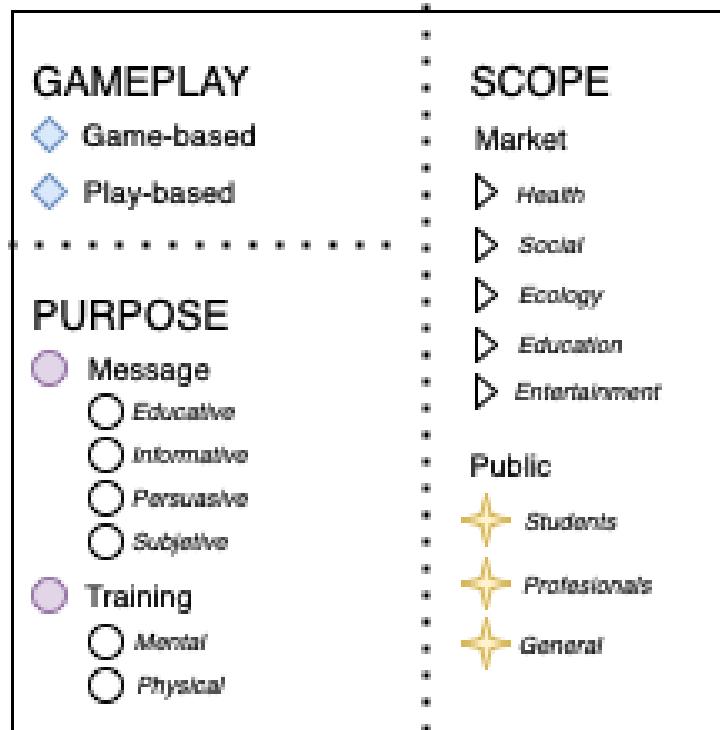


FIGURE 2.2: Representation of the GPS classification model.

Therefore there are video games that are created from start to finish to be a serious video game but on the other hand time is a decisive factor when it comes to implementation. Taking into account an existing video game with functional characteristics to be able to implement or adapt. This is known as "mods" which is simply an alteration of software to adapt it to other needs.

In this case we will focus on video game mods, as we have already seen before, a serious game is made up of entertaining, teaching and being serious. So a video game on the contrary focuses on having fun rather than teaching, therefore a serious video game can be created from an existing video game and it is not necessary to start something from scratch to be able to teach.

2.2 Current Industry

In the last 10 years, serious games have appreciated to a (compound annual growth rate) CAGR of 18.5% Companies use the video game environment and techniques to educate or train users or employees, including to promote products or services in an engaging and fun way.[\[4\]](#) Some of the

fields in which they have developed are: education, defense, healthcare, emergency management, city planning, scientific exploration, and others. [3].

Likewise, the segment of mobile devices dominated this last period in terms of the market for serious games. The study tells us that the topics that were dominant or had the greatest boom were those of simulation and training within the industries.[3]. This began to be done since the Covid 19, in which companies looked for different ways to train their staff to achieve better performance.[5] At the end of the analysis several significant trends were revealed, such as:

- This study includes the serious games market analysis, trends, and future estimations to determine the imminent investment pockets
- The report presents information related to key drivers, restraints, and serious games market opportunity.
- The serious games size is quantitatively analyzed from 2020 to 2030 to highlight the financial competency of the industry

The Serious Games Market is segregated by Application (Advertising Marketing, Simulation Training, Learning & Education), End-user Industry (Healthcare, Education, Retail, Media Entertainment, Automotive, Government), and Geography.[?].

By Application	<ul style="list-style-type: none">● Advertising and Marketing● Simulation Training● Learning and Education● Other
By End-User	<ul style="list-style-type: none">● Healthcare● Education● Culture● Automotive● Government● Other

The growing popularity of Serious Games has gone so far that the reports generated by searching for "Serious Games" on the Web of Science yield the following information:

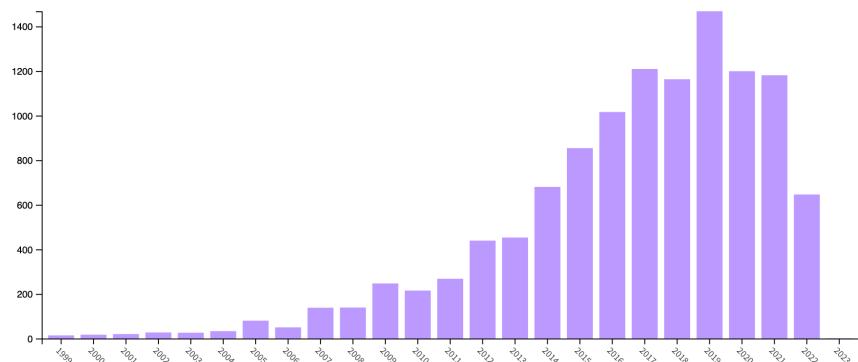


FIGURE 2.3: Publications about "Serious Games" over the years



FIGURE 2.4: Web of Science categories for "Serious Games"



FIGURE 2.5: Web of Science authors for "Serious Games"

Although the main objective of this research is to focus on how serious games help us to teach physics. This is not the only goal of serious games so we can take those success stories which have been used to solve real life problems. As has been mentioned in the area of physics, it is not yet widely explored, so there is not a wide variety which serves to compare this research.

(Hamari, 2015) developed a Serious Game to educate children about mechanics. Research corroborates this theoretical position, showing that students are significantly more engaged and concentrate much more when they are required to do so in the classroom. The challenge-skill dynamic has also been found to increase motivation and broaden the capabilities of players. [2].

(Djouti, 2009) made a study about a serious game about politics in America that is presented on the book of “The Simulation of New Alexandria: A Serious Game of State and Local Politics” by (Jansiewicz, 1973) in which he determine that is not necessary to be in digital because the humans interactions can be more use full for politics. [6].

Finally, (Donald, 2015) develop a serious game that help the undergraduate students in St Andrews to make diagnosis and treatment for tuberculosis. With the help of Microsoft and DeltaDNA produce a prototype in which this paper discusses the main project and how this simulation provides a workplace. [7].

2.3 Relevant Work

(Jannicke 2012) discuss how should serious games focus to be more attractive for students and professionals. He mentions that the main challenges are that Learning by gaming is often seen as not serious enough within higher education and vocational training. So, the game needs to be attractive and interesting for the audience and must achieve the serious purpose. [8] This work reveals the one big challenge that all serious games developers have during the design and implementation.

How relevant is the obstacle, which led several authors such as Zilio [9], Drummond [10], Arias [11] and Oropeza [12] to make proposals that try to solve the problem.

TABLE 2.1: Previous work timeline

2017	D. Drummond proposees a cheaper and safer simulation for new health instruments
2021	D. Zilio proposes a method that interaction of user changes the decisions taken by the game.
2021	M. Arias demonstrate the dialog-based narrative to encourage students to participate actively.
2022	A. Oropeza create a mix form dialog based and effects to ensure engagement.

Drummond He tells us how to develop serious motivating games by finding a point where the intrinsic and extrinsic motivations of end users can converge. proposes to identify the characteristics of serious games that improve their learning effectiveness based on a framework derived from cognitive science and called "the four pillars of learning". All this based on the professionals and patients in health education [10].

Zilio They discover how to use serious games as a new teaching strategy. This study presents a method developed in this regard, that is, serious games were used as a complement to synchronous online classes to ensure the continuity of pedagogical activities in a physiology course. A narrative simulation model was used in which the results obtained in terms of motivation and commitment were efficient to implement a new online plan. [9].

Oropeza presents a model in which he take the attention of young students by a narrative story of aliens, also some explosions are included so the users can enjoy learning physics and destroying things.[12].

These works help to develop an effective serious game that help people to learn easily. Zilio and Oropeza used a narrative method to involve the people playing their games. They used an innovative design which attract people to play it. Drummond says how to make a "serious" game by knowing the exact point that converge into knowledge. Using the best practices that have been usefully for those authors will help to develop a serious game.

2.4 State of the Art

According to a study by (Cheng, 2015), it seems that the number of science educators involved in using Serious Games for science learning is still relatively low. [13]. In the study of (Oropeza, 2022) the development of a serious game dedicated to teaching physics is proposed.[12] Therefore the number of studies that teach science through serious games is limited.

(C. Girard, 2013) The study is based on the way of using this e - learning such as a educational tool and how we can create engagement with the user. The objective was to review the results of experimental studies designed to examine the effectiveness of VGs and SGs on players' learning and engagement.[14]

So we have a different approach to the main objective. So developing a Serious Game is not an easy task. Therefore taking into consideration the state of art (SOTA) relative to education is discuss below.

Rosyid proposes a novel in which develops a procedural content generation game called Chem Dungeon. The game consists of escaping from a maze by forming a compound, for which the

TABLE 2.2: SOTA overview

Author	Intervention	Name	Genre	Subject	Fun strategy	Platform
A. Oropeza	Serious Mod	SeriousPhysX	Class Simulation	Rectilinear Movement	Explosions	Windows / Mac
D. Rawitsch	Serious game	Oregon Trail	Procedural maze	History	Immersive Narrative	Web
H. Rosyid	Serious game	Chem Dungeon	Procedural maze	Science	Immersive Narrative	Web

player must collect the correct atoms and avoid being killed by the enemies that roam inside it. [15].

Lang talk about how was developed Oregon Trail, the creators were Don Rawitsch, Bill Heinemann and Paul Dillenberger, three students in Carleton College in 1970. which simulates how do a pilgrim travel to Oregon to make a community. Its a long travel that have many tramps but is uses a dialog based to story tell. [16].

Oropeza This study is based on how to teach physics on the topics of Uniform Rectilinear Motion (URM), Uniform Accelerated Rectilinear Motion (UARM), Collisions and Explosions. It demonstrates the effectiveness of teaching through a serious physics-oriented game, as well as describing the process and learning curve of generating a KSP mod for education purpose.[12] This study focuses on how to make an effective serious game and how this will help to teach the users and motivate them by playing a mod serious game.

All works presented purpose a serious game for the education. Rosyid has a focus on chemistry while Rawitsch focus on history and Oropeza focus on physics. Everyone wants to motivate the player to deep learn or to teach on a simulated environment that their choices will not affect. Problems within a game usually start with ease and then become progressively more difficult as players skills develop. In addition, the objectives are clear and the information is available to the players to teach them.

There are also limitations to the method itself, but those are discussed in the table below.

TABLE 2.3: SOTA method

Name	Participants	Instruments
SeriousPhysX	20	Demographic, Academic and enjoyment questionnaires, (pre-game and post-game)
Oregon Trail	35	Consent form, academic subject
Chem Dungeon	50	Consent form, Demographic, enjoyment questionnaires, (pre-game and post-game)

In terms of procedures, the SeriousPhysX consisted on asking to students around 14 years old that were interested on physics. For Oregon Trail it is a part of a history class in which students learn from the game and then they have a questionnaire. Finally chem dungeon is similar to SeriousPhysX because both of them are most robust procedures to record and analysis the data obtained by playing those serious games.

2.5 Conclusions

It is important to know that serious games are designed to encourage learning or training on any topic that can be considered useful or educational. It can be defined as a video game that seeks to teach rather than entertain the user.

The current industry is moving to digital world, some of the biggest industries are making serious game as a fundamental lab where they can teach their workers based on simulations that make the people to enjoy and learn faster.

Finally for the creation of a serious game for science, three works were compared. Of the SOTA, only SeriousPhysX is the only one that focus on teaching physics creating a mod, the other ones are good to compare although they focus in other subjects. One of the most effective methods that we analyse is that immersive narrative can keep more the player attention. The best procedural method is Chem Dungeon that is very robust and perform a good analysis of the data.

Chapter 3

Problem

3.1 General

According to the information previously presented, a common point that the authors of similar works have in common regarding the challenges to be faced when making a serious game is to remove the stigma towards serious games.

At the same time, in the previous research elaborated by Alonso Oropeza we can contrast that as other researchers arrived to the same problems, to develop a Serious Game keeping the purpose of teaching and keeping the entertainment, likewise the development of a Serious Game is a challenge, this for derived to the limitations that can be presented when trying to change the objective of a game to an educational approach.

According to SOTA, two main challenges are[12]:

1. The Serious Game must be attractive and appealing to its target audience.
2. The Serious Game must achieve its serious purpose.

Rawitch's research focuses on an analysis of the effectiveness of video game-based learning. of the effectiveness of video game-based learning. It is mainly a focus specifically on empirical evidence of the efficiency of games. However, there is not enough information regarding research that focuses on analyzing teaching patterns within games.

All the works have presented a pattern in which the attention of users who try the various serious games comes to lose interest or focus on the game. Visualization has been a common problem with previous researchers who have attempted to develop a serious game.

On the other hand, the area of opportunity in terms of the methodologies used to perform the corresponding measurements was diminished by the technique used by Oropeza. This is supported in the SOTA, where it is mentioned that Oropeza generated a methodology from Rosyd's more robust methodology. The methodology to carry out the evaluation must be clear in order to demonstrate effectiveness in the learning of high school students. [12]

Finally, in education, new learning alternatives are sought that can positively influence the learning outcomes of users. This derived from external problems (wars, pandemics, disease) adapting educational systems that allow flexibility in student learning in any case.

3.2 Specific

The problem faced in this study is that there is no dynamic serious game focused on the movement of projectiles, as well as one that invites the end user to delve deeper into the subject.

In order to solve the problems, it is necessary to turn to previous research to see how other authors were able to solve the problem. As previously analyzed in SOTA, Dr. Rawitch when teaching history through a serious game faced the same problem of maintaining visualization, concentration, entertainment and the purpose of teaching in his game. This based on a psychological study that aims to solve the enigma of learning. He mentions that the brain produces chemical and electrical processes by which a person retains information, that is to say, learns. Based on that it is mentioned for a better production it is focused on the user's perspective and experience. That is, the ease with which the end user will be able to learn something in a shorter time.

On the other hand Oropeza focused on improving the user experience (UX) A commonly accepted definition of UX is the one offered by the International Standard on Ergonomics of Human Systems Interaction, as "the perceptions and responses of a person resulting from the use or intended use of a product, system or service". In which we detail that the user experience will not help us to know if the game will achieve its purpose of teaching until the time of testing with students.

The purpose of teaching is the biggest challenge when developing a serious game. For this there are previous experiments that assess the factors that influence users at the time of testing to assess learning. [15]

1. Mental state of the user at the time of testing.

2. Concentration and the environment in which the test is taken.
3. Technical experience when solving the test.
4. User's learning experience.

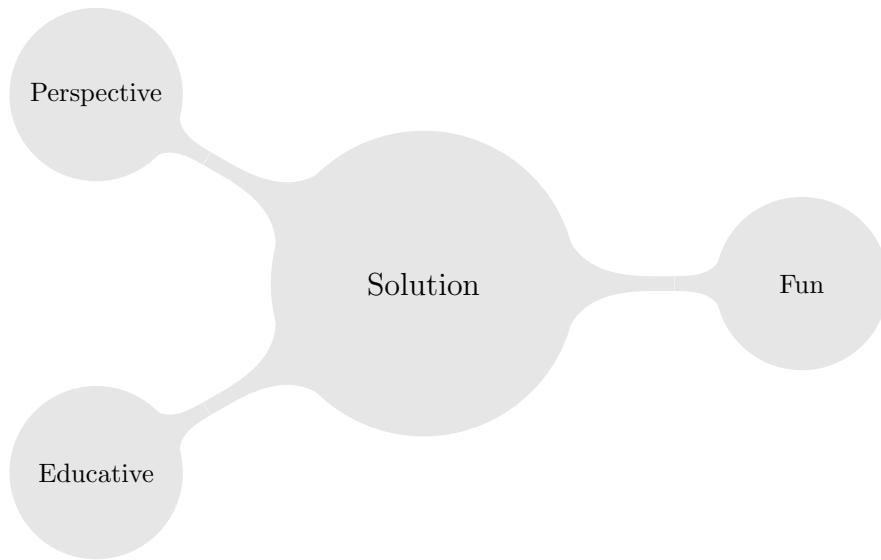


FIGURE 3.1: Specific Problem

Finally, it should not be forgotten that this study aims to create a solution that can be molded by educators to suit different serious purposes, learning strategies and target groups. Fortunately, a tool was found that allows the educator to do this, and without the need to know how to programming. This point is described later in the solution.

Chapter 4

Solution

"We cannot solve problems with the kind of thinking we employed when we came up with them.

- Albert Einstein

The objective of this study is to educate high school students in Physics by means of a dynamic and customize serious game to evaluate its efficiency as a learning tool.

Instead of designing a serious game from scratch, we chose to make a mod (behavior modification) of a video game focused mainly on entertainment. As previously reviewed, the authors create a game and add the educational aspect, however Oropeza was the only one who chose to take an existing old game and make a behavior modification inside the game.

Therefore, the tool used by Oropeza was chosen to develop a new mod in Kerbal Space Program (KSP) a video game that is a simulator of ships, airplanes, where the player has the ability to build and explore the universe. KSP was created with the intention of being a NASA simulator, where the main activity is to create a ship piece by piece and manage a space program.

The scope, theme and learning strategy of the mod was defined in collaboration with high school teacher Octavio Gutierrez, head of the science department at the Tecnológico de Monterrey campus Querétaro.

To facilitate the implementation of the mod, Professor Octavio provided the Physics 1 syllabus. For this second version, the topic of Projectile Motion was chosen, with 3 of the most complex exercises that were shown to the students at the time of learning.

The mod was named as [Space Tec](#). The hypothesis is that space tec solves the specific problem that was mentioned in the previous chapter, and the hypothesis will be evaluated in the chapter [Results](#).

Space Tec includes the following missions:

- Mission 1: Projectile launched at 90° with propulsion failure at a dynamic distance.
- Mission 2: Coin thrown from rest from a bridge, calculate distance.
- Mission 3: Aircraft with engine failure, cabin disengagement for calculation of half parabolic shot.

4.1 Develop of KSP Mod

A part called "spacetec" was added inside the game, this part helps to create an interface during the takeoff of the ship where elements such as:

- Basic information about the planet (gravity)
- Formulas to solve the exercise.
- Exercise focused on the serious game.
- Text field: to customize the exercise within the game.



FIGURE 4.1: Space Tec Mod

In plug-ins are elaborated by a user to change the behavior of some program, in this case we focus on modifying KSP. It consists of .DLL files written in the C programming language. Add-ins allow us to use in-game functions and modify them to create new in-game functions. Information such as:

- Ship Speed.
- Angle of inclination.
- Mission time.
- Ship status.

Research began in the community forums, where the [Plugin Development C](#) was found. The forum is a useful tool, however the post 1.8.0 version of KSP may be outdated and it is preferable to check the documentation directly from Unity.

I also used the documentation from [Unity documentation](#) on which the KSP game is based and the use of its functions and programming style facilitates the implementation of new features.

In particular, it teaches the basics of how to code a plugin for KSP. The forum was used to configure the Visual Studio IDE, understand how to hook the mod to the game, learn the main methods and events, and interact with common objects such as ships, parts and modules.

Initially [this forum](#) was used to configure the Visual Studio IDE and take the first steps to create a mod based on a ship part. In the same way it was also consulted the [following video](#) which explains step by step the initial configuration.

After having the IDE configured, more information was required because the version of KSP 1.8.6 was used and the methodology used in the forum and in the previous video was obsolete for the version of Unity that was used. For this we resorted to [Unity documentation](#) to create the in-game view. Despite the problems that occurred in the deprecation, it is not the purpose of this research to improve the existing API.

Using the various resources mentioned above we developed an interface comprising formulas, exercises that help to learn projectile movement. This embedding code in a part of the ship adds these functionalities.

The KSP pieces are the building blocks of the spacecraft that are assembled like a Lego, while the modules are responsible for adding functionality to the piece. This by means of a co-routine which can be consulted in its implementation.

```

//now this function gets called every frame or something and gives you access to the flight controls
private void fly(FlightCtrlState s)
{
    //s.yaw = -0.2F; //set yaw input to 20% left
    //s.pitch += 0.3F; //set pitch input to whatever the player has input + 30%
    //s.roll = 0F; //set roll to 50% (either clockwise or counterclockwise, try it and find
    if (vessel.altitude >= failProp)
    {
        s.mainThrottle = 0F;

    }
    else
    {
        s.mainThrottle = 0.8F;
    }

    if (vessel.horizontalSrfSpeed > 0)
    {
        s.yaw = -0.01F;
    }
    else if(vessel.horizontalSrfSpeed < 0)
    {
        s.yaw = 0.01F;
    }

    //the range of yaw, pitch, and roll is -1.0F to 1.0F, and the throttle goes from 0.0F to 1.0F
    //if your code might violate that it's probably a good idea to clamp the inputs, e.g.:
    //s.roll = Mathf.Clamp(s.roll, -1.0F, +1.0F);
}

```

LISTING 4.1: spacetecc.cs

4.2 KSP Mission Builder

The missions were created by means of a tool included in the KSP Making History DLC. Mission Builder is the tool that helps users to create and develop missions by drag and drop.

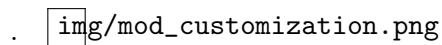


FIGURE 4.2: Breakdown of User Experience Questionnaire

As explained in the beginning of the chapter, the topics chosen were specially chosen to be able to teach them in this video game environment. The missions that were developed were:

1. Mission 01. Projectile Movement (Obtain initial velocity)
2. Mission 02. Projectile Movement (Obtain distance)
3. Mission 03. Projectile Movement (Obtain displacement)

To learn how to use the Mission Builder tool I recommend reviewing the following [playlist](#). Also the DLC includes a pack of tutorials which help to use the tool more quickly and easily. If necessary, please refer to the Mission Builder manual.

There was no difficulty in fitting the mod into the mission created in Mission Builder. The main problem was to develop a mission capable of entertaining and amusing the user. For this purpose the third mission was created in which the total control of the ship to fly is up to the user and his skills in order to accomplish the objectives.



FIGURE 4.3: Mission 03: Projectile Movement.

In order to keep the user's eyes always on the screen and on the events, the view was left with the information at all times. Likewise, the results when solving the exercises are shown in the data provided by the videogame itself.

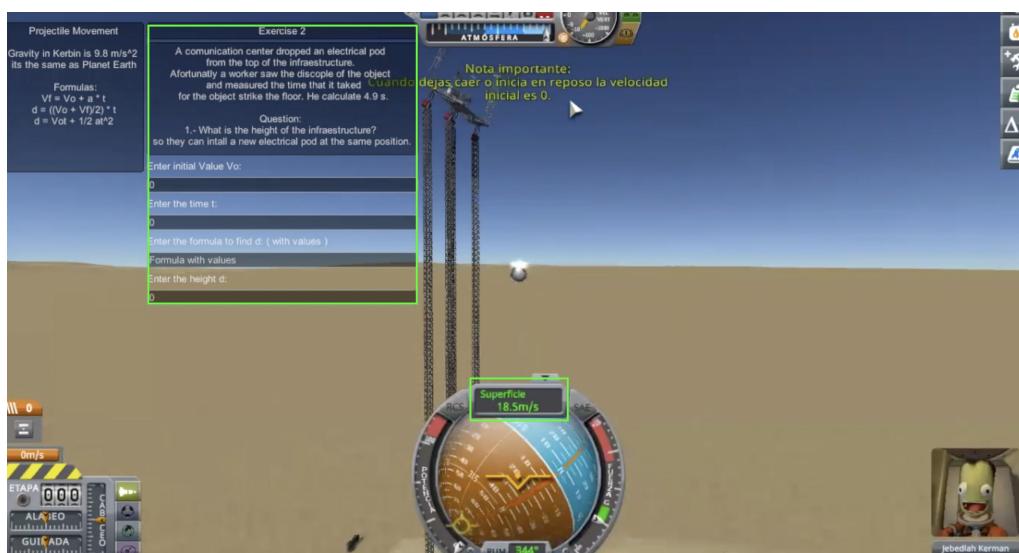


FIGURE 4.4: Mission 02: Result of the height in KSP.

Finally, it was decided to add a final score and achievements in order to encourage and motivate users to challenge themselves and have fun in the process. This was done by pre-designed feats in Mission Builder to add fun. As well as saving the Kerbals from a possible explosion due to ship system failure.



FIGURE 4.5: Space Tec starting summary

Chapter 5

Method

"When you change your thoughts, remember to also change your world."

- Norman Vincent Peale

The method used is based on the methodology used by Alonso Oropeza. Oropeza developed a robust methodology focused on high school students. In which of the research at SOTA is the best evaluation methodology for students.

This method helps us to obtain the following information before using the seriopus game, in order to compare the results:

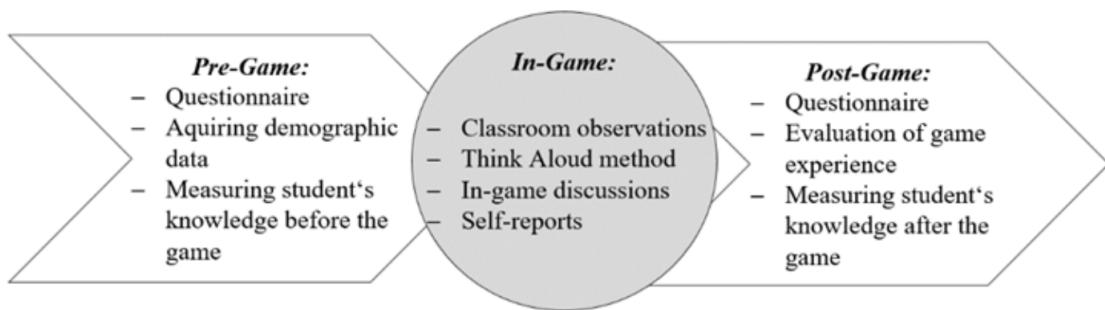


FIGURE 5.1: Serious Games evaluation strategy

Subsequent to the end of the game, other characteristics such as game experience and knowledge acquired are measured. Therefore the game experience can be used as a metric to determine how much fun our game is. [12]

5.1 Materials

In order to obtain the results it would be thought that only the serious mod would be used, however an abbreviated version of the serious game was used, being mission 1, the one necessary to be able to answer the tests.

Likewise, this study aims to test the effectiveness of Space Tec to teach Physics, for them, the hypothesis that there is a difference in knowledge learned between the previous and the subsequent survey was raised.

Therefore, in order to perform a statistical analysis, qualitative indicators were used because the sample of people does not meet the population size to perform a t-test.

5.2 Participants

In order to obtain the target group, it was determined to opt for a strategy in which 2 events were held via FaceBook to schedule with those interested with a pre-registration. Both groups registered an average of 20 people, of which group A was attended by 7 people and group B by 11 people. Therefore, it was decided to expand the target group, giving entry to high school students without registration to the groups.

The invitation to participate through Facebook, which was directed mainly to high school students who decided to participate on a voluntary basis. The applicants were given to know the methodology of the test, as a method to encourage and participate they were rewarded with a surprise gift (candy, potatoes, etc.). The results were kept anonymous. Finally, a total of 23 students were obtained.

5.3 Instruments

In order to obtain data, two questionnaires were created in Excel Forms, [survey](#). These questionnaires are based on Oropeza's methodology.

Information obtained from the previous survey:

1. Demographic
 - What is your gender (Male, Female, ...)?
 - What is your age ? (14, 15, 16, ...)
 - Where are you from ? (Abroad, Queretaro, CDMX, ...)

2. Academic

- Choose your academic program (PBB, PTM, PMI)
- Area of interest (Business, Humanities, Natural and Applied Sciences)
 - Perception
 - * How interesting do you find physics (1 - 10)?
 - * How important are physics (1 - 10)?
 - * Do you think that there is a fun way to learn physics? (yes, no)

3. Knowledge:

- A projectile is thrown vertically upward and returns to its starting position in 5 seconds
- If a rock is thrown at an angle of 65° what would be the final velocity at the highest point of the trajectory. If it is initially launched at 12 m/s.
- 'When an arrow is launched vertically, it is already falling from its highest point. When an arrow is launched vertically, it is already before its highest point;

Information obtained by post-survey:

1. User Experience

- Attractiveness
- Efficiency
- Simulation enditemize
- Knowledge:

.A projectile is thrown vertically upward and returns to its starting position in 5 seconds If a rock is thrown at an angle of 65° what would be the final velocity at the highest point of the trajectory. If it is initially launched at 12 m/s. 'When an arrow is launched vertically, it is already falling from its highest point. When an arrow is launched vertically, it is already before its highest point;

5.4 Procedure

The tests were carried out for 1 week. It consisted of two groups which had the same experience testing the fast version of the mod. The first group consisted of 7 students of which 6 were female and 1 was male, the second group consisted of 13 students of which 5 were female and 8 were male.

The procedure was the same in both groups, first the place where the game would be played was already set up, 3 laptops with KSP licenses were used. Next to them were 2 tablets to be able to answer the surveys in Excel Forms. The step-by-step procedure is described below.

1. First, the purpose of the dynamic was explained to them, in which the objective was to measure their knowledge before and after playing the game.
2. Participants take the pre-survey.
3. Once they start the serious game, they are given instructions.
4. The participant starts the game.
5. At the end of the game, the participant is asked to answer a brief post-survey.
6. At the end, the participant is thanked for participating and chooses his or her gift.

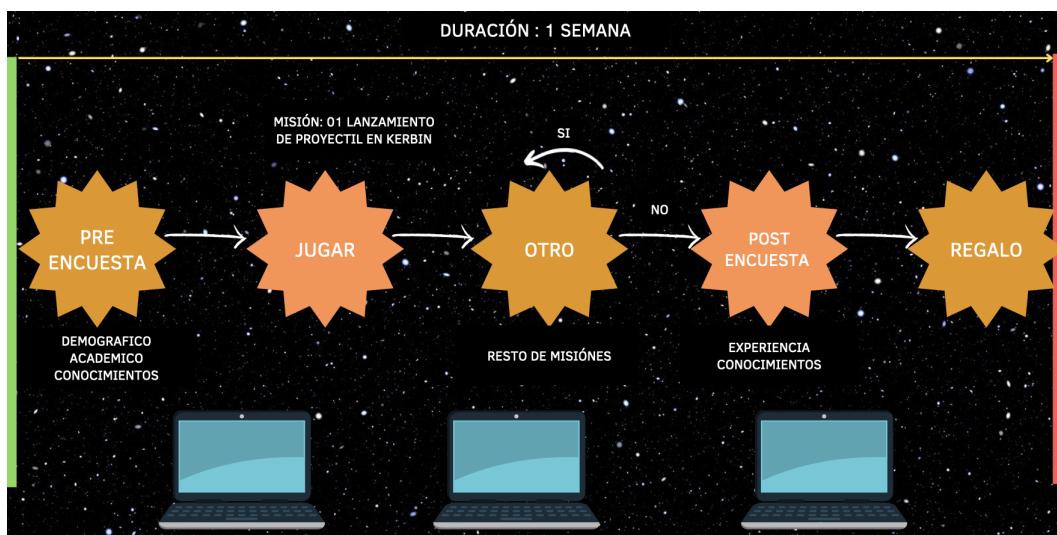


FIGURE 5.2: Space Tec mod evaluation methodology

Chapter 6

Results

“Education is the most powerful weapon which you can use to change the world.”

- Nelson Mandela

The analysis of the results was a multi-stage process. The data obtained from the surveys was collected directly in Excel Online. Once the surveys were completed, the file was downloaded for analysis in Excel, because the online version is not able to analyze the data with the same effectiveness. A demographic, academic, and improvement analysis was performed. The survey results can be downloaded [here](#).

The population consisted of 11 males and 12 females, within 16 to 21 years of age. The figure demonstrates the population described.



FIGURE 6.1: Population (male vs female)

It is noted that there was an increase of 19.57

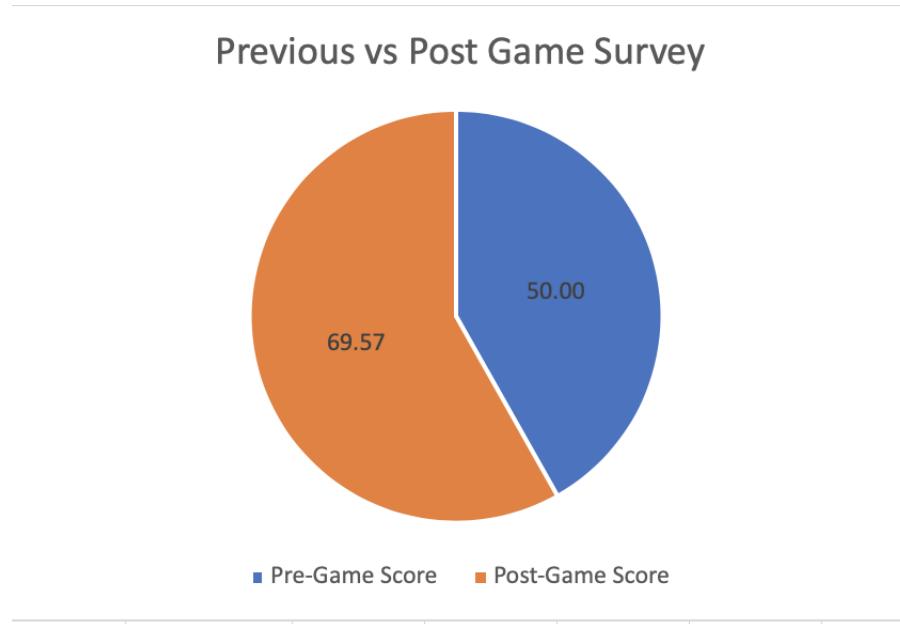


FIGURE 6.2: Augmentation of Knowledge

Analyzing participant by participant we can observe that there is an increase, however due to the sample size of the population we can only infer that it is a trend. As shown in the following figure.



FIGURE 6.3: knowledge of each participant

Taking into account the tastes of the participants in terms of the careers they will choose in the future, it can be analyzed that 45

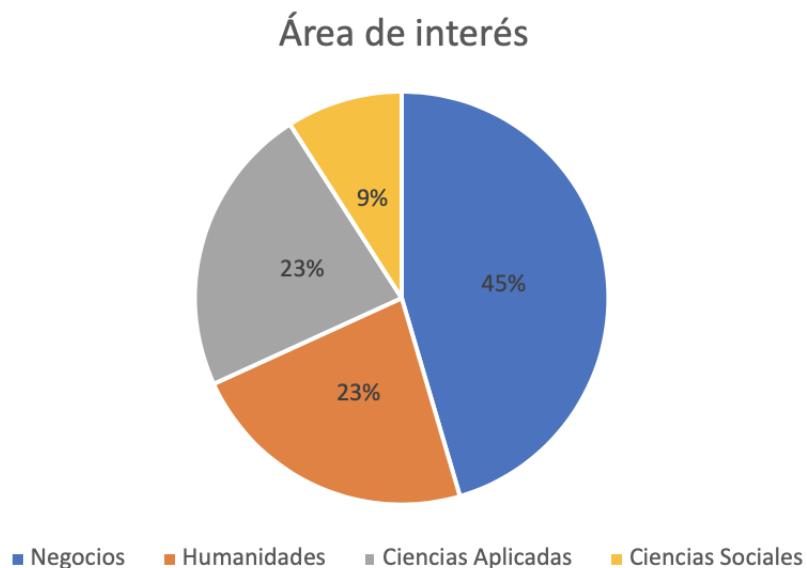


FIGURE 6.4: area of interest

Considering the academic program of the participants, it can be analyzed that 61

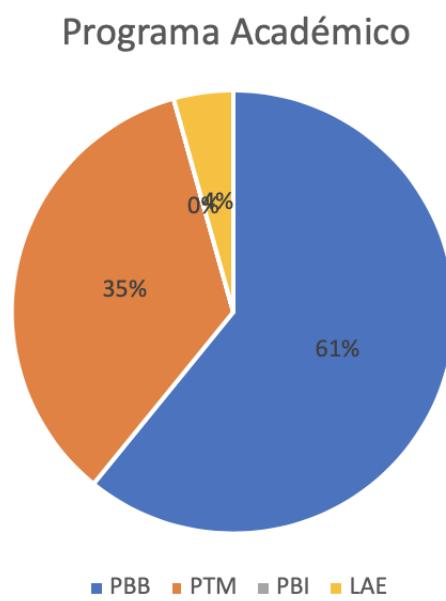


FIGURE 6.5: area of interest

Finally, in order to know if the students enjoyed the dynamics of learning through a serious game, the following questions were analyzed to understand if the participants would like to add this learning methodology in their Physics classes.

1. How easy did you find learning through a game?
2. Do you think this methodology would help facilitate learning?

3. How motivated do you feel to learn applied physics in a voluntary way?
4. Would you like to learn through serious games in your physics classes?

Analyzing the questions that are measured from 1 to 10 with 10 being the most liked, people with less than 6 points and with more than 6 points were distributed in two groups. Having the population distributed, an analysis was made with the following concepts:

1. Average Previous Average of people who have a rank higher than 6 in implementing the learning methodology.
2. Subsequent average number of students that have a rank higher than 6 in implementing the learning methodology
3. Increase of qualification in relation to previous and posterior
4. Percentage of improvement in relation to previous and subsequent

Taking into consideration the survey after playing the serious game, we can conclude that there is an increase in learning even when there are improvements in terms of explanation and dynamics within the game. There is a 25.8 increase in the number of users who have a score of 7 or more in the questions analyzed, on the other hand we have an increase of 14.1 points over the people with a score of less than 7.

Based on the averages obtained within the total population, it is observed that there are areas for improvement in terms of explanation within the serious video game. This is found with an average of 6.2 out of 10 being the best qualification. Similarly, it can be concluded that the motivation generated was only 4.7, this in relation to deepening the topic of parabolic movement on its own.

Chapter 7

Conclusions

”Opportunities don’t happen, you create them.”

- Chris Grosser

Among the results of previous research, a serious mod was developed and tested in Kerbal Space Program, in order to teach projectile motion. It was found that the users rated it as a different experience, however it did not motivate the students to go deeper into the subject by themselves. On the other hand, it was found that in order to entertain and keep the user's attention it is necessary to improve the experience by reducing ambiguities within the exercises and information given within the mod.

For educators who are interested in using Space Tec, it is recommended to use the strategy in such a way that it is used as a tool to teach and not as the methodology to teach the whole subject. Finally, Space Tec is not intended to replace traditional classrooms.

7.1 Future Work

For further work, the user experience could be created and improved in order to attract more participants as this learning modality may have limitations in its implementation but can be a strong complementary tool. Hand in hand with Oropeza research, give a greater applicability to the serious games focused on teaching Physics. Also in the future with the help of technology and new tools the development of a serious game will be more friendly so it can be implemented not only in schools but also in industries as a testing method without spending resources.

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the experience of active knowledge acquisition during lessons and encounter a barrier for successful participation in serious games later. although a variety of games have been developed and proved successful for the mediation of skills in complex systems (windhoff, 2001), this paper discusses why we think that serious games should be considered as a suitable learning method for the mediation of skills needed in the education of engineers and secondly to give some examples of current games and experience of their use.” 02 2012.

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