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Game-Based Learning: Possibilities of an Instrumental Approach to the FEZ Game for the Teaching of the Orthographic Drawings System Concepts

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Abstract

Challenges and rewards are integral to the logic of digital games, and through them, users can learn and develop various skills. When games are employed in educational contexts, they can enhance creativity and contribute to students' development. The Game-Based Learning (GBL) methodology is grounded in the use of games in the educational context, whether they are meant for educational or entertainment purposes. This article aims to investigate whether the digital puzzle game called FEZ - which takes place in a three-dimensional scenario where the player interacts through two-dimensional views - can be used for teaching geometry, specifically from the perspective of Descriptive Geometry for learning concepts about the System of Views. To achieve this goal, we analyzed FEZ from the perspective of the Instrumental Approach as an educational resource for teaching concepts of the Orthographic Drawings System. As a result, we identify similar characteristics between the Orthographic Drawings System and the design aspects of the FEZ game that suggest the possibility of using this game as a didactic resource.

Keywords: *Game-Based Learning, Orthographic Drawings System, Instrumental Approach, FEZ*

1 Introduction

The educational landscape nowadays faces a real challenge when it comes to transforming learning into a more attractive and engaging task, given that conventional teaching approaches are becoming increasingly obsolete. Undoubtedly, the digital era is transforming our way of life, as most people today are in contact with some kind of advanced technology, be it through social networks, online shopping, transportation apps, or even digital games (Gabriel, 2013).

Thus, society has undergone a significant transformation due to the development of digital communication and information technologies in every aspect, including education (Gabriel, 2013). To support these technological specificities of contemporary society through pedagogical practices, it is necessary to modify the learning process. From this perspective, we can highlight that digital games are a valuable educational resource because they are already a part of many people's daily routines.

Games are complex and engaging platforms that transcend gender and age barriers. They are characterized by challenges, objectives, goals, rules, and rewards, which users can learn and develop skills to succeed in (Vaz de Carvalho, 2015). Games offer interaction with a different world through immersive experiences and stimulate experimentation with a variety of sensations (Pimentel, 2021). Users can develop different abilities while entertaining themselves at the same time (Nipo, 2022). This is made possible by the existence of a set of rules inherent to the games, which bring order and guide the flow of the game, allowing users to learn through them (Vaz de Carvalho, 2015).

When discussing games from an education-focused perspective, we enter the field of Serious Games or Educational Games, regardless of the context of their application, be it education, training, or health (Pereira, 2019). Serious Games aim to combine educational objectives with playability to promote learning through immersive and enjoyable environments (Kishimoto, 2017). When used in teaching and learning processes, both digital and analog games can enhance creativity and motivate students (Savi, 2008). Regarding technology, the National Curriculum Parameters (PCN) recognize its potential to significantly increase student interest in pedagogical practices (Brasil, 1997). Therefore, games are considered a promising resource to engage and motivate students in the appropriation and comprehension of school content that would otherwise be deemed uninteresting.

In this regard, the teacher's role in assessing the relevance of a tool as a didactic resource is crucial. It is the teacher's responsibility to analyze a game and determine its potential for use as an educational tool. Thus, the teacher should assess whether a game can help students acquire new knowledge and develop skills that will prepare them for the future (Pimentel, 2021). An ideal game for educational use allows for the practice of personal competencies and existing knowledge, promoting learning and innovation.

The game chosen for the purpose of this research is the FEZ game. Launched in April 2012 by Polytron Corporation and distributed by Trapdoor, FEZ is a puzzle-like digital game that blends two-dimensional elements

with the use of three-dimensional (3D) features, having a theme consisting of exploration and problem solving. The story of the game takes place in a restricted and colorful world in two dimensions, having as a protagonist a small character named Gomez. In the game, it is possible to identify some geometric characteristics present in their aesthetics, playability, and narrative. The main one among them is the system called Orthographic Drawings, which is mostly present in its playability.

The Orthographic Drawings system is the basis of Descriptive Geometry, and its main objective is the capability to represent three-dimensional elements on a two-dimensional surface (Cruz, 2012; Neves Junior, 2018). A graphic representation guarantees the possibility of a detailed perception of an object that is represented through its orthogonal projected views on a projection plane. Properly, the mechanics of the FEZ game orbit around the use of four different views in each scenario (plane) where the main character needs to move.

The analysis of a game as an educational resource can be carried out through the observation of its characteristics and the development of strategies for its use in teaching practices. The processes involved in Instrumental Genesis can provide the theoretical basis for the appropriation of the game FEZ as an educational resource. Instrumental Genesis, which belongs to the theory of Instrumental Approach structured by Rabardel (1995), refers to the processes that involve the relationship between a subject, an artifact, and its transformation into an instrument. The first of these, Instrumentalization, describes the process of designing an instrument, in which the subject appropriates the artifact, getting to know it and transforming it into an instrument; Instrumentation, on the other hand, is the process in which the subject develops new patterns of use for the now-instrument, giving it new potentialities and possibilities.

Given the presented context, this article aimed to investigate whether the digital puzzle game called FEZ - which takes place in a three-dimensional scenario where the player interacts through two-dimensional views - can be used for teaching geometry, from the perspective of Descriptive Geometry, for the learning of concepts about the System of Views. The investigation is based on the processes that constitute the Instrumental Genesis as a theoretical contribution to highlight the possibilities of Instrumentalization and Instrumentation of the FEZ game.

We aimed to analyze the constituent elements of the narrative, aesthetics, and mechanics of the game, highlighting similarities between the characteristics of FEZ and the essential elements for representing a three-dimensional object in a two-dimensional plane, as recommended by the concepts of the System of Views. As a result, we presented some cases present in the game that can be used in teaching System of Views concepts, indicating that FEZ can be used as a didactic resource. We hope that this work will lead educators and researchers to reflect on the importance of integrating digital technological resources into their pedagogical practices, motivating them to specifically consider not only educational digital games but also entertainment games as potential educational resources for contemporary education.

Therefore, we hope that this research might lead educators and researchers to reflect on the importance of rethinking digital technological resources in their pedagogical practices, as well as motivating them to specifically visualize not only digital educational games but also entertainment games as potential educational resources for contemporary education.

2 Theoretical Framework

2.1 Active Methodologies and Game-Based Learning (GBL)

The undertaking to make learning more attractive and captivating is a perpetual challenge for educators around the world. So, it is important that teachers can make use of a plurality of materials and methods since traditional teaching methodologies embrace the figure of the teacher as an authority over the student. In this perspective, the teacher should conduct the lessons employing the use of expositive classes only (Lovato, 2018).

Nowadays, we live in the age of technology in which knowledge is available to everyone at an increasingly rapid speed. Recently, the profile of students has undergone several changes in the light of a socioeconomic context that demands increasingly high-performance expectations (Barbosa, 2013) for it requires autonomy and positioning never required in the past (Lovato, 2018). Thus, social changes have led to new perceptions about teaching and learning processes, pointing to the emergence of the Active Learning Methodologies that are more appropriate to the time in which we live.

Some teachers falsely believe that the active factor is inherent to the entire learning process considering that once the student participates by observing a class, he/she is actively involved. However, cognitive science indicates the need for students to do more than merely observe and listen so that active learning is achieved (Meyers, 1993).

The expression “Active Learning Methodologies” may seem something new but in its essence, it had been inserted in the practice of some teachers for some time. Teaching through projects, solving a problem, or using games and competitions are some examples of teaching strategies analogous to Active Learning Methodologies, even if they are not known as that (Barbosa, 2013).

Teaching through “projects” and “problem solving” are examples of Active Methodologies since they foster situations in which the students are motivated to perform complex mental tasks of analysis, synthesis, and evaluation (Lovato, 2018). Thus, we can understand the learning strategies of Active Methodologies – such as those in which the students develop tasks – while reflecting on what is being done (Lovato, 2018).

In explaining the Active Learning Methodologies, Barbosa quotes a Chinese proverb passed by Confucius that says: "What I hear, I forget; what I see, I remember; what I

do, I understand." The author highlights the direct relationship of the sentence with what advocates active methodologies (Barbosa, 2013). Departing from that, Silberman modified Confucius' proverb to make more sense of understanding Active Methodologies writing it as follows: "What I hear, I forget; what I hear and see, I remember; what I hear, see, and ask, or discuss, I begin to understand; what I hear, see, discuss, and do, I learn by developing knowledge and skill; what I teach someone, I masterfully master" (Silberman, 1996).

That is the way Active Learning is achieved, that is, when students interact with the subject under study through listening, speaking, doing, questioning, discussing, and teaching. They are encouraged to lead the construction of their own knowledge rather than just receiving it passively by the teacher. Hence, the latter acts as mediator and facilitator of the learning process instead of placing themselves as the only source of information and knowledge (Barbosa, 2013).

We can highlight some of the methodologies that foster Active Learning, including Problem-Based Learning (PBL), Project-Based Learning, Team-Based Learning (TBL), Peer-Instruction, and Flipped Classroom (Lovato, 2018).

In this context, it's worth highlighting teaching and learning methodologies that are based on games, which can also contribute to active learning. Games, whether in digital or analog format, have always been a part of human history (Huizinga, 2000). They have great potential to generate engagement and motivation in task completion, as the user is voluntarily immersed in the playful context of the game and is committed to following the instructions provided (Huizinga, 2000).

We can think of a game as a machine composed of a system of gears, which represent the rules. From this perspective, we can differentiate digital games from analog ones by the dynamic nature of the rules in digital games, as opposed to the static nature of the rules in analog games (Munhoz, 2018). In the case of digital games, technology eliminates the need for the player to invest time in understanding the rules, allowing them to dive right into the game and learn the rules as they play. In this way, the rules represent the means by which the player understands the game and its mechanics, thereby comprehending the systems that must be manipulated to achieve the ultimate goal of creating a meaningful interaction for the player (Munhoz, 2018). This characteristic of digital games, to encourage learning of rules as the player progresses through the game, is particularly relevant for the present work.

Accordingly, we can highlight Digital Games as resources capable of contributing to Active Learning, reassembling Game-Based Learning (GBL), which also integrates Active Learning Methodologies. They are granted the ability to promote motivation in teaching and learning processes and increasing students' interest in learning (Falcão, 2015).

Games are complex and attractive platforms where players have fun while developing skills (Nipo, 2022). This process is promoted by the existence of a set of rules in the games, which is an essential characteristic that brings order and directs the user towards learning (Vaz de Carvalho, 2015). Consequently, by understanding the potential of the game as a learning tool we began to consider the possibilities of its use in the context of formal education.

Various researches emphasize the contributions of games to education. There is evidence that games when properly used in teaching and learning processes provide motivation, enhance creativity, and contribute to the intellectual development of students (Savi, 2008). While immersed in the rules of the game the student's concentration is directed to the performance of the activity itself and the act of playing without concern the results or effects of this activity (Kishimoto, 2017). The set of rules of the games is an important element to be understood by developers and researchers because it is those rules that bring order and conduct the players' experience.

The use of games to promote learning is a trend that has been increasingly incorporated into actual education (Sena, 2016). It is a theme of great relevance for educational management and capable of potentializing the relationships between students and teachers as well as the quality of learning. Since ancient Greece there were reflections about the role of games in people's lives. The philosopher Plato disapproved of activities that stirred competition and the result defending that games should aim at meaningful and pleasurable learning. However, according to Brougère (1998), Aristotle considered work the most important activity of the time and, therefore, the game should be used as a means of resuming energies, promoting relaxation, and resting.

The Active Learning process abandons passive learning practices with little interaction to place the student as the protagonist of their education, stimulating autonomy and independence. Active Methodologies should encourage students to do more than simply listen. They should read, write, and discuss with teachers and other students to be committed to problem solving (Vaz de Carvalho, 2015).

Similarly, Game-Based Learning (GBL) is a methodology focused on the development and application of games in the context of education (Vaz de Carvalho, 2015). The use of games can be worked through Serious Games that are designed exclusively for education with rules created to address specific content or through Entertainment Games, which also present potential to work some content in the educational context (Pereira, 2019).

The GBL is also consistent with the learning style of students of today's generations. It provides motivation because it is fun, very versatile, and it can be adapted to almost all disciplines and skills to be learned in a very effective way if they are correctly used (Sena, 2016).

Mediated by properly prepared teachers, the GBL can transform a classroom as it develops teaching and learning strategies that enable students to improve skills that are increasingly placed as fundamental to the 21st century. Among these competencies we can highlight problem solving, interaction and collaboration, communication, digital literacy, and critical thinking (Vaz de Carvalho, 2015).

In the case of Serious Digital Games, the interactive resources are promoted by the technologies associated with the playful strategies of the games. Among the advantages inherent to the use of Digital Games in education we can underline immediate feedback of the player's actions, learning in practice, learning from mistakes, goal-guided learning, discovery-guided learning, training, constructivist learning, and accelerated learning (Sena, 2016). Consequently, games are considered such important artifacts when we think of the educational environment.

While teachers and institutions are increasingly optimistic about the potential of Serious Games, finding games that effectively address desired content and maintain student engagement can be challenging. Developing a new Serious Game can be a complex and expensive task, requiring integration of different areas of knowledge, such as design, programming, script, and sound, with the content to be addressed in the game. This typically requires qualified professionals and specialized tools and processes (Rocha, 2015), which may not always be accessible to educators with limited technical and financial resources. As an alternative, entertainment games can be utilized as didactic instruments, offering a more accessible and flexible way to incorporate gaming in teaching practice. Given the potential benefits of Active Learning and Game-Based Learning methodologies for education, it is worth considering both Serious Games specifically designed for educational purposes and Entertainment Games with potential use in didactic approaches.

2.2 The Orthographic Drawings System

By the end of the 18th century, the French mathematician Gaspar Monge (1746-1818) designed the Orthographic Drawings System, also known as the Orthographic Projection System or the Mongean System. Monge's studies resulted in the emergence of the first techniques of graphic representation that developed the Representation Systems (Cruz, 2012; Neves Junior, 2018). The Orthographic Drawings system, which is one of the studies belonging to the Representation Systems, has as its fundamental purpose the ability to graphically represent objects that have a three-dimensional shape on a plane.

The representations in the Orthographic Drawings system aim to denote in the plane the figures of the space. The system generates a theoretical framework for the discipline Descriptive Geometry, which is considered the branch of mathematics that studies the projection of three-dimensional objects according to the rules of the Orthographic Drawings system (Lopes; Gusmão, 2020).

The representation of an object takes place through its views or its orthogonal projections (Neves Júnior, 2018). To get the views of this object it is necessary to use at least two planes that will maintain a perpendicular relationship to each other: one vertical ($\pi 1$) and the other horizontal ($\pi 2$) (**Figure 1**). These planes will divide the space into four main areas named dihedrals, while the intersection of these planes is called the ground line (Cruz, 2012). When the object is positioned between the planes its information will be projected on them through projecting lines that will always maintain a relationship of orthogonality with each other and in relation to the planes, generating therefore the representation of the object.

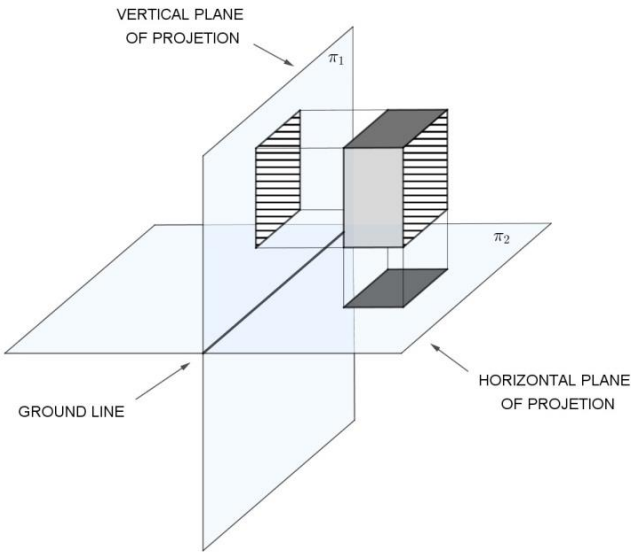

Figure 1. Projection plans.

Afterwards, the planes are flipped to obtain what is called *épura* (in Portuguese), *épure* (in French), or terms such as "skeleton" or "wireframe" in English. In this article, we will use the term skeleton (**Figure 2**). The vertical plane will show the length and height of the object while the horizontal designing plane will show its length and width (Costa, 1996; Neves Júnior, 2018). These are the basic views that enable the representation of a three-dimensional object in a two-dimensional space (Cruz, 2012).

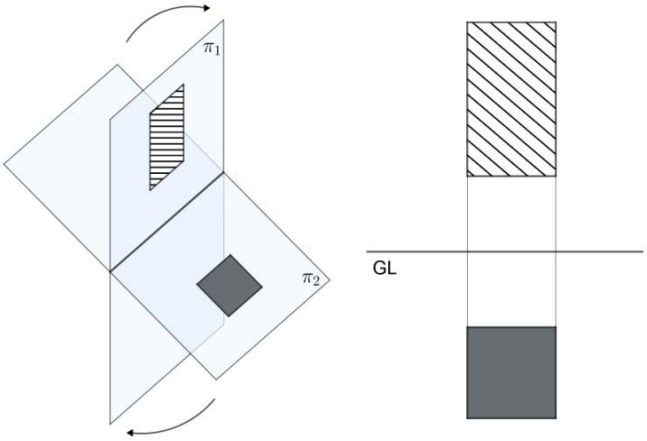

Figure 2. Flipping the projection planes generates the skeleton of the object.

Furthermore, it is possible to use two tools to aid in the understanding of an object: the Projection Box and the Surrounding Orthohedron, both of which are imaginary boxes (**Figure 3**). The Projection Box allows for the

construction and representation of additional projections of an object, in addition to the front and top views created by Monge. With the Projection Box, it is also possible to visualize the side views (left and right), the bottom view, and the rear view, totaling six possible views of an object. On the other hand, the Surrounding Orthohedron has the main function of assisting in the interpretation of an object and aiding in the understanding of the volume that an object occupies in space. It serves as a bounding box for the object, constructed based on the maximum x, y, and z coordinates of all the points that compose the object. Therefore, the Surrounding Orthohedron, as the name suggests, surrounds all the faces of an object without leaving any space between these faces and the Orthohedron itself. The use of both the Surrounding Orthohedron and the Projection Box becomes essential for understanding more complex objects (Lopes; Gusmão, 2023).

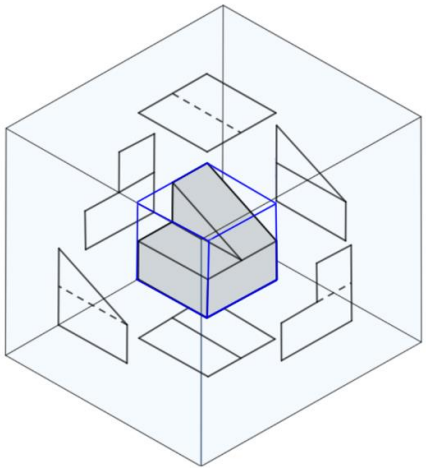

Figure 3. Visualization of the six views of the object through the Projection Box and Surrounding Orthohedron (blue line).

The planes of the projection box are unfolded to obtain the skeleton that will depict all the views of the object in a single plane. It makes an analogy to the movement performed by Monge by matching the horizontal plane with the vertical plane that generates the Mongean skeleton (Lopes; Gusmão, 2023) (**Figure 4**).

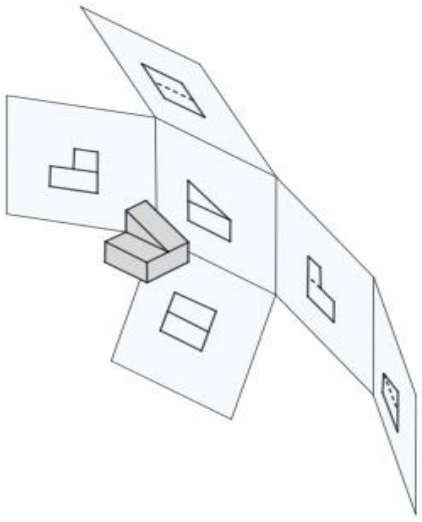

Figure 4. Flipping the planes of the projection box.

The obtained views are called: front view (FV); top view (TV); left-side view (LSV); right-side view (RSV); rear view (RV); and bottom view (BV) (**Figure 5**). It is noteworthy that the views must be organized following a certain order established through the relationship between the dihedrals. This organization makes it possible to correctly understand the object through its dimensions (height, width, and length) along with its characteristics (Lopes; Gusmão, 2020).

The main view, the front, is the one that contains the most important information about the object. It is positioned in the center of the skeleton, disregarding the posterior view, and it is the reference to locate the other views. The top view is located below the front view while the bottom view is above it. The right-side view is located on the left of the front view and the left-side view on the right of the front view. The rear view can occupy different positions. It can be next to the side views, above the bottom view, or even below the top view (Lopes; Gusmão, 2020).

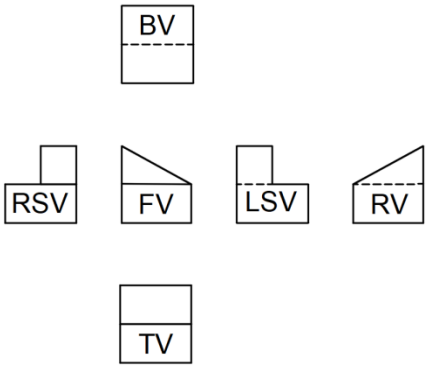

Figure 5. Skeleton of the six views of the object.

The study of the Orthographic Drawings System can be found in several areas of knowledge, such as Engineering, Architecture, and Design. Moreover, the appropriation of its concepts can be perceived elsewhere, for instance, in digital games.

As shown ahead, the FEZ game is constructed narratively, aesthetically, and mechanically following the logic presented in the Orthographic Drawings System. However, a decent performance requires that the player should have the spatial interpretation capacity to comprehend the modifications of the scenario starting from the visualization of their different perspectives.

In the game the player has the possibility to switch between the four views of the scenario that is related to our object of study. Additionally, it is associated with the frontal, posterior, right-side and left-side views of the Orthographic Drawings System. These issues start most of the time intuitively, bearing in mind that it is an entertainment game with non-educational purposes. Yet, what we intend to infer is the possibility of using it precisely as a pedagogical mechanism for teaching/learning the concepts that guide the study of orthogonal projections present in the Orthographic Drawings System.

2.3 The FEZ Game

Launched on April 13, 2012, the FEZ game was conceived and designed by Philippe Poisson (Phil Fish) with the collaboration of a small team that included Renaud Bédard (programmer), Brandon McCartin (sound designer), and Brandon McCartin (composer) (**Figure 6**). Developed by Polytron Corporation, the FEZ game is distributed by Trapdoor and is a puzzle-like video game, which involves a two-dimensional (2D) layout with a three-dimensional (3D) logic mechanics. Its theme consists of exploring and seeking to meet objectives and challenges presented in the game.

The story of the game takes place in a colorful and restricted world in two dimensions, having as a protagonist the small character named Gomez.

Figure 6. FEZ game presentation banner.

Gomez is a two-dimensional creature faced with the mysterious existence of a third dimension and sent on a journey full of challenges and obstacles. From that moment on the character gains powers to transit between the scenarios of the three-dimensional game. The player is then able to rotate the game scenario to obtain four distinct perspectives in two dimensions, enabling the movement of the character through the game domain.

Figure 7. Initial scenario of the FEZ game.

The FEZ game is available on a variety of platforms such as Xbox 360, Microsoft Windows, Linux, OS X, PlayStation 3, and PlayStation Vita. The game is a free-rated video game for all ages, and it was nominated as the best independent game in 2012 and the best downloadable game on VXG at the BAFTA Video Games Award (innovation category) in 2013.

2.4 The Instrumental Approach

Ongoing the theoretical support, the Instrumental Approach is a theory that seeks to study the relations between men and machines as well as the necessary characteristics in the appropriation of artifacts for the development of certain activities. Created by Pierre Rabardel (1995) based on the concepts of Psychology, it seeks to understand how a subject interacts with objects around him/her and modifies them from his/her personal schemes. The aim of this study is to understand how the dialogue between artifact and instrument occurs after the development of usability schemes.

In this regard, we must understand the difference between artifact and instrument. The artifact consists of technical objects, systems, machines, symbolic objects (or materials), or part of a more complex artifact (Rabardel, 1995). On the other hand, the instrument is defined as a mixed entity, which includes the artifact or part of it, or even a set of artifacts added to the usage schemes. It is not restricted to the technical object or to the machine as it is an entity that mixes subject and object (Rabardel and Béguin, 2005).

The relationship between the subject and the object generates the instrument (mixed entity), an individual construction from which it becomes a messenger of varied senses for the subject. For the artifact to be transformed into an instrument the subject must be able to appropriate the artifact by incorporating it into its activities (Rabardel and Béguin, 2005). This development of transformation is called Instrumental Genesis, the central idea of the Instrumental Approach (Rabardel, 1995). It concerns the transformation of the artifact by the subject that acts on it through two processes, namely, Instrumentalization and Instrumentation.

In Instrumentalization, the subject interacts with the artifact identifying its characteristics and functionalities. It refers to the recognition that the subject will make in relation to the evolution and critical moment of the different components of the artifact, in which the potentialities and limitations are progressively recognized. In other words, this process follows an external direction to the subject right in the artifact (Rabardel, 1995).

In Instrumentation, however, the subject must develop patterns of use for the instrument. After understanding and appropriating the artifact and its functionalities it develops usage schemes to achieve its objectives. Instrumentation is related to the internal direction of the own subject (Rabardel, 1995). The more you use the artifact to perform tasks the more the schemes progress (Bittar, 2011). Thus, the subject gives the instrument new standards and functionalities that are generated from his previous knowledge and experiences.

For instance, when a teacher is dedicated to performing an activity, he/she has an action performed on a particular object of work. This action is different for everyone even if it involves the use of the same artifact, which can be a material or technical instrument, applied in the elaboration of the activity. Each unit creates a scheme of use for that artifact in the way that suits it best, building its own knowledge and thus generating new schemes to the instrument (Rabardel and Béguin, 2005). Consequently, the Instrumental Genesis depends on the process of appropriation of the artifact, its use, and the functional value that will be added to it so that the advance in the use of schemes comes from the use of the artifact by the subject in its activities (Bittar, 2011).

The processes of Instrumentalization and Instrumentation compose inseparable parts of the Instrumental Genesis. They go from the subject to the object and from the object to the subject for they do not remain static, and the object and instrument may change functions (Salazar, 2009).

In this research, we observed the possibility of applying these processes to the educational context. Here the teacher is the **subject**, who appropriates the artifact (in this case the FEZ game) to transform it into an **instrument**, distinguishing its properties, functionalities, and interface. Through the instrument in hand and starting from its previous experiences, schemes are thought and developed for its use aiming the development of the **object**, which is the study of the concepts of the Orthographic Drawings System **(Figure 8).**

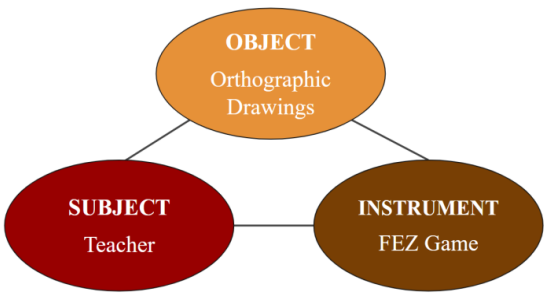

Figure 8. Analogy of the elements of the Instrumental Approach to the educational context within the perspective of this research.

We can perceive that these processes allow teachers to understand the relationships related to the possibilities of using technological tools in the educational environment. This theory equips us with appropriate elements to analyze teaching and learning through the instrumental approach of technological tools, in this case, a digital game.

3 Methodology

This research is the result of a descriptive and qualitative data collection. To achieve our described research objectives, we took as a methodological path the division into two major stages: bibliographic research and analysis of the FEZ game. The bibliographic research involved an investigation on active methodologies, instrumental approach, the Orthographic Drawings System, and games. The analysis of the game was performed from the perspective of the Instrumental Approach through the systematization of the elements of the game followed by the Instrumentation and Instrumentalization of the elements identified as pertinent to teaching.

The systematization of parts of the game was done based on the Elementary Tetrad of Schell (2008) with emphasis on narrative, aesthetics, and mechanics. Subsequently, we conducted an analysis of the relevant game elements built on the theory of the Instrumental Approach (Rabardel, 1995) with the aim to analyze and indicate the characteristics of Instrumentalization of the elements. Finally, we suggest possible schemes of usability of such characteristics in the context of the Orthographic Drawings System through Instrumentation.

Thus, we went through the methodological path where we converted the FEZ game from an artifact to an instrument in the teaching concepts of the Orthographic Drawings System in the light of its potentialities and limitations.

4 Discussion

4.1 Analyzing the FEZ Game to Teach the Orthographic Drawings System

The appropriation of the processes that structure the Instrumental Genesis presents itself as a viable way to use a technological resource, in this case, an entertainment game for teaching a given theme in a didactic and attractive way. In this section, we will analyze how the processes of Instrumentalization and Instrumentation are applied in the appropriation of the FEZ game as a didactic tool to be integrated into the pedagogical practices of teachers, particularly the Orthographic Drawings System.

Since the subject's experiences is a specific process it is important to emphasize that the following analyses and possibilities are grounded on the reflection of the experiences and involvements of the authors, as well as on the scientific foundations of Game-Based Learning, Geometry, the Orthographic Drawings System, and the Instrumental Genesis. The Instrumental Approach is based

on the premise that an artifact is not an effective resource per se. So, it is necessary that the artifact is transformed into an instrument through the processes that integrate the Instrumental Genesis to become meaningful and effective in teaching and learning methods (Neves, 2020).

4.2 Instrumentalization - Game Analysis

As seen before, the first process that integrates Instrumental Genesis is called Instrumentalization. The subject appropriates the artifact knowing it, perceiving its functionalities and properties, and giving it a function, previously unconceived. In this case, FEZ would be an artifact for a teacher who does not know it and the Instrumentalization process would occur at the time when he/she plays the game, perceiving its mechanics, playability, and characteristics. In this process FEZ would no longer be an artifact but an instrument.

To understand the Instrumentalization of the FEZ game it is necessary to give a brief contextualization of the technical characteristics of the game as an artifact. The development of a digital game comes from a multidisciplinary process, which encompasses several areas of knowledge. Hence, we can understand and organize the parts of a game in different ways.

In this research we take as a source the Elemental Tetrad by Jesse Schell that allows us to contemplate the parts of the game artifact through its constituent elements (Schell, 2008). Schell presents a scheme that assists in the description and understanding of the game dividing it into four constituent parts: aesthetics, mechanics, narrative, and technology.

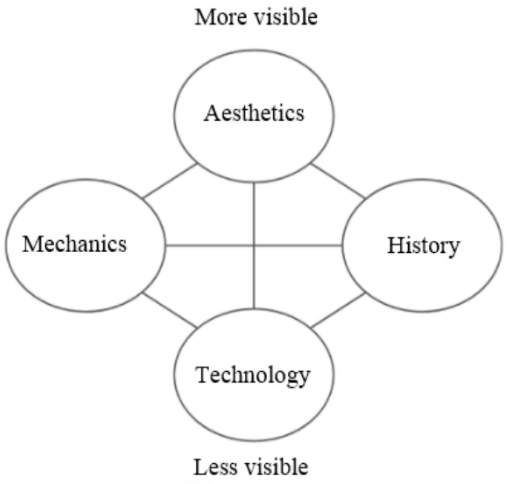

Figure 9. Elementary Tetrad by Jesse Schell (2008).

Aesthetics refers to everything we see in the game: the arts and artifacts used, the colors, and even the sounds are considered as elements (Schell, 2008). The mechanics, on the other hand, are the sets of rules that govern the game, determine the challenges and rewards of the game as well as how the player will be able to follow his/her journey (Schell, 2008). We will explain the elements of the tetrad in more depth below.

The narrative of a game is a sequence of events that unfolds the story we want to tell and will be revealed as we play it (Schell, 2008). In the FEZ game we take control of Gomez, who needs to deal with the discovery that his two-dimensional world is much more complex than he imagined. The game introduces us to our protagonist living quietly in a quiet, wooded, and pixelated vertical village along with other residents and animals. Gomez can walk sideways, jump, climb platforms, descend from one floor to the other, and enter different houses.

However, the protagonist is subjected to an event that leads him to an existential crisis: The appearance of a mysterious cube from another dimension and makes a revelation that completely alters his understanding of reality (**Figure 10**). The two-dimensional world where Gomez has always lived can now be seen from other perspectives, which lead him to new ways of visualizing space and objects. Then, Gomez's new three-dimensional vision expands his possibilities for exploration and displacement around the world.

Figure 10. Appearance of the mysterious cube in the game's story.

Soon after this revelation, Gomez returns to his starting point yet this time he is accompanied by a mysterious being named Dot. While winning a magical Hat in the Moroccan style, named Fez, he comes across the explosion of a giant cube that is fragmented into 32 parts scattered throughout his world. Dot teaches Gomez the main skill to use throughout his mission in the search for cube fragments: the possibility of changing his point of view from 90° to 90°.

Following the contributions of Schell (2008) to systematize the elements of the game, we identified the aesthetics and mechanics of the FEZ game as fundamental characteristics for this work. However, the narrative is also relevant since it helps to contextualize the tasks that will be developed by the player.

When we talk about the mechanics of a game, we are referring to its procedures and functions, that is the rules of the game. It clearly describes the objectives of the game and what means are made available for the player to conquer them (Schell, 2008). It is through the game mechanics that the support for the display of aesthetics is given in addition to the presentation of the narrative.

The mechanics of FEZ are centered on the playability of a 2D platform, in which the character can move from left to right. In this kind of game, the interactions happen only with the elements present on the same plane. Still, this

pattern of mechanics is partially broken in the FEZ game as we are limited to interacting with elements present on the same platforms, though we can rotate the game camera to reveal new plans and platforms that previously could not be seen. Consequently, the mechanics of the FEZ game allow you to rotate the game camera by switching to four different positions, rotating at 90° and always having the controllable character Gomez as the center of the rotation. This mechanic opens to new exploration and possibilities that differ from other 2D platform games for the player needs to explore the scenarios in different perspectives to find items and paths that will help in their progress.

The mechanics of the FEZ game allow us to observe its graphics from different perspectives, which directs us to talk about the next element of Schell's tetrad: aesthetics. The aesthetics of a game is related to everything our senses capture when we play. It refers mainly to the artistic part of the artifacts of the game. Schell (2008) states that aesthetics also refers to what we hear, smell, flavor, and sense. Besides being the most noticeable element, aesthetics is closely related to the player's experience.

That said, the mechanics and aesthetics work together to create an innovative experience in the FEZ game. As we describe, the player can observe the graphics of the game in different ways depending on their perspective of vision. The screenshot below (**Figure 11**) illustrates an example of the aesthetics and mechanics of the FEZ game in operation, in which the character is inside a small room. On the screen on the left side, we observe the room without exits. However, when rotating the camera, we can observe in the screen on the right side that a door is revealed on another side of the room.

Figure 11. Example of the mechanics of the game FEZ; internal environment.

In this other situation represented by the screenshots in **Figure 12**, we can observe slightly more complex situations of the arrangement in the graphics of the game and the changes caused by the exchange of perspective, some of which will influence the character's displacement in the search for his goals.

In the left screenshot we can observe two floating platforms with the protagonist Gomez on one of them. There are also several elements of interaction and composition, namely an unmanageable character, a door further down, and a chicken at the top next to a stool.

However, when we look at the screen on the right, which rotates the player's view 90° clockwise, we can observe various changes in the scenario. Some elements change position, new elements are revealed, and others can no longer be seen. The chicken, which was once at the left end of the top is now on the right end and the stool that was next to it no longer appears in this view. In the lower area of the scenery, we can no longer see the uncontrollable character and the door are replaced by a large wall. Where once there were two platforms next to Gomez, now there's only one. New elements are also revealed with this change of vision. A new platform containing a chest appeared in the lower right corner of the screen and, at the top next to the chicken, some small mushrooms appeared on the right side.

If the player needs to move to the top of a platform to collect one of the cube fragments, as shown in **Figure 12** for example, he/she will need to rotate the scenery to understand the elements that will allow them to scroll there.

Figure 12. Example of the mechanics of the game FEZ; external environment.

The playability of FEZ is based on well-constructed and interconnected phases that require the player to change their perspective to reveal new information and overcome logic puzzles on challenging platforms. In this way, the narrative, mechanics, and aesthetics of the game work together towards a common goal of creating a new three-dimensional world that is both engaging and educational.

It is important to emphasize that the process of knowledge and appropriation described here is fundamental for the transformation of FEZ into an instrument to be used in teaching practices within the perspective of the Instrumental Genesis. Teachers must familiarize themselves with the game's unique characteristics and functionalities in order to fully appreciate its potential for enhancing their pedagogical activities.

4.3 Instrumentation - Thinking about Use Schemes for Teaching/Learning

After the conception of the instrument, the subject elaborates his own schemes of use integrating and modeling it according to his experiences and objectives (Silva, 2018). This is the second process of Instrumental Genesis: Instrumentation. From the moment a teacher interacts with the FEZ game, knowing its characteristics, playability, and mechanics, he/she can scheme its use for teaching and learning. We unfolded below the initial possibilities of FEZ Instrumentation, realizing how its aspects can be used to teach the concepts of the Orthographic Drawings System.

The narrative of the game, which puts a background story to contextualize the events for the player (Schell 2008), builds a first dialogue with elements and properties of Geometry by presenting the distinctions present in the two-dimensional and three-dimensional representation. The character, who previously could only move through a single view, gains powers to move around from different perspectives, which are the representations of three-dimensional elements by their different views.

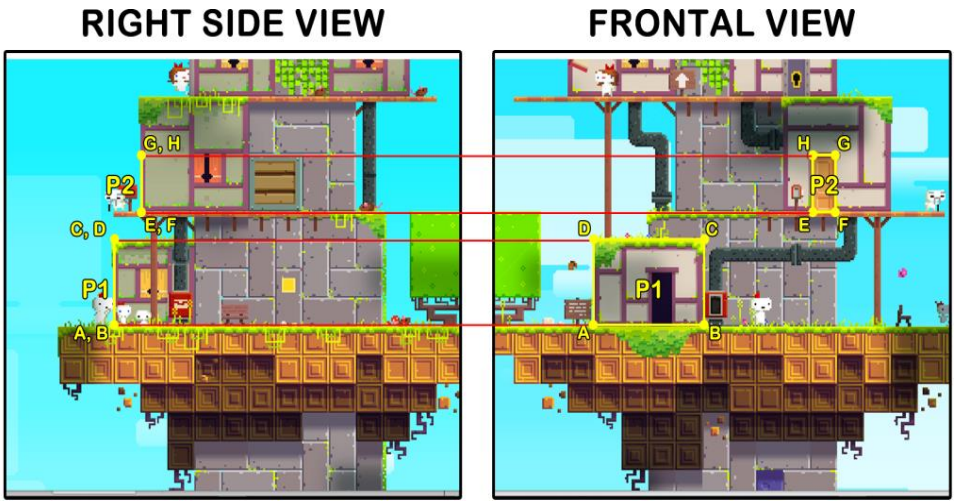

Figure 13. Disposition of Frontal View and Right-Side View.

The narrative also constructs the logic of the game generating its mechanics and aesthetics (fundamental elements of FEZ) to contemplate our object of investigation, because it is through them that geometric properties present in the Orthographic Drawings System is demonstrated.

In the first contact with the FEZ game, one has the impression that it is a classic two-dimensional platformer. However, the main mechanics playability is centered on the ability to rotate the environment at 90°, in which we realize that all scenarios in the game have four views, also found in the Orthographic Drawings System (Cruz, 2012). Thus, The player needs to understand how the elements are observed according to the current view and how they behave when views are exchanged for in several cases the player will only be able to have access to different elements that are necessary for their displacement and advancement in the game – which will be present in their different perspectives – by having an understanding of how these elements are positioned in space. It is worth noting that in FEZ we do not have elements of the scenario positioned obliquely in relation to the projection planes of the views, as can be observed in the example in **Figure 13**. In other words, we do not have slanted planes or lines that stray from both parallelism and perpendicularity (Cruz, 2012).

It means that, depending on the projection plane, the game elements will be displayed in basic view – where planes observed are reduced to straight lines and straight lines reduced to points – or in true magnitude, where we can observe the actual measures of planes and lines (Cruz, 2012). These are characteristics evidenced in the FEZ game that are related to the concepts addressed in the study of the Orthographic Drawings System, which give the possibility for teachers to use FEZ as an instrument in the approach of any content. This possibility will only be possible if educators appropriate the instrument, elaborating use schemes for the educational environment and properly exploring the functionalities of the game (Silva, 2018).

One of the Instrumentation possibilities of FEZ is in the development of the student's spatial vision. This ability is critical for the player to progress and succeed in the game. Therefore, understanding how the elements are arranged in the game and understanding what their new positions will be with the alternation of two-dimensional views requires the player to understand their positions and dimensions in a three-dimensional space. The game provides players the opportunity to develop their perceptions, starting from simple phases, but gradually becoming increasingly complex. Spatial vision, exemplified in the skills described above, are important to understand representations in the Orthographic Drawings System, because it is a system with the purpose of representing the views of three-dimensional objects on two-dimensional surfaces while recognizing in the same way the dimensions of objects, their characteristics, and their location in space (Neves Júnior, 2018).

Another approach of Instrumentation of the game to the Orthographic Drawings System can be elaborated based on the representation of the elements in the different views of the scenarios. These views, as stated earlier, can be exchanged by the player at any time, revealing details and passages that previously could not be seen due to the characteristics of each view. When representing an object in the Orthographic Drawings System, we need at least three views called basic views (Neves Júnior, 2018), because the purpose of the representations in the views is to see all the important details of the object.

Figure 13 shows some of the geometric properties of the Orthographic Drawings System in action in FEZ. Here we have two images of the game, one in the front view and the

other in the right-side view. In the image on the right, the front view, we have two planes, P1 and P2, which correspond respectively to the wall of a house (A, B, C, D) with a closed door on the first floor (E, F, G, H). In the representation of the front view, we can see these planes in true magnitude, because they are parallel to the projection plane, which in this case is the player's screen. When we look at these same planes from the right-side view, we see only lines and have the impression that they no longer exist. However, they continue to exist because what changes is the observer's view of them.

Figure 14. Views: Right-side, Front, Left-side, and Back Side.

In the lateral view, points A and B occupy the same position and this same relationship applies to points C and D, E and F and G and H. When these related points are together it does not mean that they are occupying the same place in space, but rather that in this two-dimensional perspective they are seen coinciding in the same position, that is the left side view. By relating the two views of the environment through the leader lines that relate the points, you can understand the change of the two-dimensional view of the planes when the environment is rotated. Understanding this feature is important to consolidate that in each view, we will have different information of the scenario as recommended by the Orthographic Drawings System (Neves Júnior, 2018).

In **Figure 14**, we have other situations that reinforce the similarities with the concepts of the Orthographic Drawings System. We have four views of a small room: right-side, front, left-side and back side. Some elements are highlighted: the red frame, the green frame, and the yellow door. Like what was described in the previous situation, we have some objects in true magnitude and others in basic view, depending on the view in question. In the front view, we have the red frame and the yellow door represented in true magnitude and the green frame reduced to a line in basic view on the left wall.

However, if we look at the representation of the yellow door and the red frame in the rear view – which is opposite the front view – the objects cannot be observed by the player. The dashed line drawing in the back view shows where they are positioned in the front view. This characteristic of the game dialogues with the different information, which can be obtained from an object in the Orthographic Drawings System depending on its representation in different views (Cruz, 2012). Hence, we can see that the concepts of representation in different perspectives can be noticed in the FEZ game not only in its mechanics, but also in the graphic elements (in aesthetics) present in the scenarios that make up the game.

We realized, therefore, that the game FEZ presents itself as a rich tool for the study of the concepts present in the Orthographic Drawings System through the different visible possibilities of approach in its narrative, mechanics, and aesthetics. We realized that the appropriation of the constituent processes of Instrumental Genesis can enable the transformation of FEZ into an instrument and the possibility of developing use schemes that are effective in the construction of geometry knowledge in an attractive way. The possibilities of instrumental approach of the game, depending on the experiences and previous objectives of teachers, enable the organization of different schemes and strategies for its use in pedagogical practices.

Conclusion

Most students nowadays are in constant contact with technologies and are increasingly showing disinterest in the outdated resources of traditional classrooms, generating low school support and little enthusiasm (Pivato and Oliveira, 2014). The classroom should have a dynamic that is consistent with the actions we carry out in our daily lives, which are increasingly mediated by digital information and communication technologies (Valente, 2018).

As seen before, some entertainment games may also present interesting features for the educational context. However, these games that were not designed for educational purposes, as is the case of the game FEZ, require that schemes must be considered relating the area of knowledge that one wishes to teach with the elements present in the game. In this research, the processes studied in the theory of instrumental approach are a viable possibility of designing these schemes of use regarding the Orthographic Drawings System.

To achieve success in the game FEZ, users must develop their spatial vision as they play and learn from the game in order to understand what the shape and arrangement of the three-dimensional objects will be represented in the plane, that is, in two dimensions, characteristics belonging to descriptive geometry and the Orthographic Drawings System. Consequently, the player handles these concepts in an exciting way making learning

dynamic and fun, which corresponds to the learning profile of the current generation. The characteristics of the FEZ game once appropriated by the teachers can be instrumented and schematized to be used as an educational resource.

Through the analysis carried out in this article based on Game-Based Learning - GBL (Sena, 2016), as well as by the Theory of Instrumental Approach (Rabardel 1995), we can affirm that it is possible to learn concepts of the Orthographic Drawings System through the Instrumentation of the FEZ game. This statement is supported in view of the analogous characteristics between the concepts of the Orthographic Drawings System and the elements of the narrative, design, and mechanics of the game.

The game can be used by high school, technical, and higher education teachers, as well as any other area of education that works with the System of Views. Overcoming barriers of age and gender, games can be used with younger students, as well as adolescents and adults.

The proposal of instrumental approach of FEZ for teaching/learning presented in this work is based on the conceptions and experiences of researchers, as recommended by the theory used, in which the processes that constitute Instrumental Genesis are processes of the experiences of each subject. In future works, we hope to validate the effectiveness of the FEZ game Instrumentation through tests and data collection. We also want to investigate other Instrumentation perspectives for the game by analyzing the experiences of other teachers. We hope that these contributions can encourage teachers and researchers to incorporate games into their teaching practices, understanding that not only educational games are provided with this potential.

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