Game-based Learning: Interaction in Educational Virtual Reality Games using the Virtual Reality Headsets

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Abstract

Game-based Learning is a learning method based on the application of elements of traditional games or video games in cognitive processes. As the process of playing has always been considered closely related to the human species (although this is not the case, an example of learning through play can also be found in the animal world), many distinguished researchers (like Johan Huizinga in his work *Homo Ludens*) and psychologists (like Carl Gustav Jung, who in the segment of his work interprets the importance of the role-playing games) emphasize the importance of learning through play using simulations of real life activities as well as solving real life problems.

This paper is structured in three sections. The first part deals with the theoretical study settings, models and principles of Game-based Learning (by authors such as James Pail Gee), the second part includes examples and testing of virtual game worlds that can be used in the learning process (various simulators of real jobs) and the third part of the paper includes analyzing practical possibilities of virtual reality headsets models of the latest generations (*Apple Vision Pro*, *Meta Quest 3* and other VR headsets). The final goal of the research, based on theoretical texts about learning and the available technology of VR technology, is to reach the necessary conclusions on how to successfully apply this learning model in practical teaching.

Keywords

Game-based leraning, VR games, VR headsets, practical application, education

1. Game, Play and Learning

The first segment of the work *Game-based Learning: Interaction in Virtual Reality Games using the Virtual Reality Headsets* is dedicated to defining the application of game elements through the activity of playing in cognitive processes. The terms *game* and *play* were defined by Johan Huizinga, a Dutch author who was among the first to systematically analyze games, in his work *Homo Ludens: A Study of the Play-Element in Culture* [1], first published in 1938. As in his research work, studying the concept of playing, he came to the knowledge that the concepts of *game* and *playing* in different languages do not have a clearly defined meaning and that in some languages they use several words to denote the very concept of playing. He decided to use the Latin word *ludens* as a general signifier of the concept of playing. *Homo ludens*, in translation, means *man of play* and emphasizes that play is a basic component of human progress. Although the book mainly deals with the aspect of playing related to humans, Huizinga states in [2] that it is not an activity that is exclusively related to the human species and that *animals play just like man*. Through play, animals, as Huizinga wrote down in [3], teach their young basic life skills, *according to one theory play constitutes a training of the young creature for the serious work that life will demand later on [...] play must serve something which is not play, that it must have some kind of biological purpose.* Although learning is considered a serious skill and games are considered a frivolous skill that has no other characteristics than being considered fun and a waste of time that could be used more usefully, here we come to the first

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disagreements that raise several questions. How can two seemingly opposite activities be combined? How can the combination of these two activities be maintained in the later, more complex stages of learning?

Modern researchers and psychologists have confirmed Huizinga's claims in [4] that children (similar to young animals) learn best through play and that *fun is the most important element that characterizes the essence of play*. Chodorow in his work [5] writing about Jung's work, points out a special part related to learning through playing: "*The dynamic principle of fantasy is "play" a characteristic also of the child, and as such appears inconsistent with the principle of serious work" but without this playing with fantasy no creative work has ever yet come to birth. The debt we owe to the play of imagination is incalculable" - Jung*. The game and the rules of the game are based on the element of imagination, because games are considered separate from real life and represent different simulations that provide different impulses of entertainment. *Play is not "ordinary" or "real" life,* as Huizinga states in his work [6], play *is rather a stepping out of "real" life into a temporary sphere of activity with a disposition all of its own* - interpreting that games are based on their own rules. they are isolated from outside influences and they are different from everyday life, by location, because it is often a fictitious, imaginary world, as well as by duration, because time during the game flows differently than in the real world.

The answer to the second question, based on the previously defined concepts of game and playing, can be found in the learning model that has been the subject of research by many authors in recent years - Game-based Learning (GBL). Bowman, an author who in his work [7] also wrote about Jung's doctrine related to games and play, that the games are *the only medium that has its own separate learning model,* and they are represent a *different way of thinking and a new way of engaging in contrast to the standard way of learning and thinking*. It is necessary to make a distinction between GBL and gamification. Plass, Homer, and Kinzer in their work [8] present the idea of Game-based Learning that refers to a game as an independent product, whether it is a traditional game or a video game, the end result of which is acquired or adopted knowledge, while the process of gamification refers to the application of game elements in various activities that aim to engage the user. Defining these two terms, GBL and gamification, in this way is somewhat limiting. If we look at them in this way, GBL games represent only one of the genres of games, and the gamification method only as an auxiliary tool. GBL should be understood much more broadly, not only as a separate game, but the elements of that game should go beyond the scope of the game itself and create a unique environment with unique content. This can be achieved through gamification, and here we come to the second point of contention. Is it possible to gamify the game itself?

If that game is used in the learning process, then we certainly can. In video games as unique learning media, those elements that are essential for the cognitive process can be additionally emphasized: a clear introduction (most video games have introductory tutorials that present and explain the learning problem), clear tasks (additionally emphasized problems that need to be mastered in the learning process as well as appropriate methodological approaches for solving those problems) and clear ends (depending on the achieved results, a final scale of success is formed). Teaching support during the application of educational games increases their effectiveness, by freely manipulating moving images and tasks.

Figure 1: *Second Life,* Linden Lab 2003

In addition to video game developers themselves, artists i.e. video game visual designers and video game narrative writers shape the cognitive segments of games. Historically speaking, the first language of learning was visual, through pictures, and later knowledge was transmitted through written words. *Artists and writers collaborated to try out new forms of illustration and typography, new configuration of text and image* – Shamdasani stated in [9]. Second Life, an online platform created by Linden Lab 2003, that also supports Virtual Reality (VR), is a good example through which educational materials could be implemented using its interactive components (Figure 1) or we have *Minecraft Education Edition* created by Mojang and Teacher Gaming LLC 2016.

2. Game Design for Learning

After defining the basic concepts of *game*, *play* and *learning* and their main aspects, in this part we discuss the creation of games for learning purposes. Video game design must follow learning mechanics. The games redesign the learning process itself, in which the learner finds himself in an artificially induced conflict, i.e. he is directly faced with a problem that he can solve in a more interesting and more engaging way thanks to game mechanics. The main and first definition of games, going back to the beginning, on Huizinga and his work [10], which was later supplemented by other authors, which can be applied in a GBL is: *Play is a voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted by a feeling of tension, joy and the consciousness that it is "different" from "ordinary life"*. Katie Salen and Eric Zimmerman have supplemented this generally accepted definition and defined the basic meaning of game mechanics in [11], which they claim that every game and gameplay must have a defined meaning. It is necessary *to learn to create a great game experiences for players – experiences that have meaning and are meaningful – is one of the goals of successful game design.* Salen and Zimmerman also point out in [12] that each element of game design must provide constant feedback. Thanks to the feedback that the player receives in the current time, he can take the appropriate steps. *The meaning of an action in a game resides in the relationship between action and outcomes.* The following definition by Salen and Zimmerman [13] that can be applied when designing games and what should be taken into account is: *Creating a game means designing the structure that will play out in complex and unpredictable ways, a space of possible action that players explore as they take part in your game.*

The specifics of learning through play take place in the closed circle of the playground, where the rules apply by themselves without the interference of events from the real world. The concept of a closed, magical circle, although first presented by Huzinga in the interpretation of the space of games, was presented by Emile Durkheim in his considerations of religious life in his work [14] he highlights two opposing principles of the sacred and the profane. *For the first time, he comes* (men) *out of the purely profane world, where he passed his childhood, and enters into the circle of sacred things,* this concept of entering and staying in a separate world, if we exclude religious perception, are other authors engaged in the study of video games have applied. Among them, an important author who stands out is Mihaly Csikszentmihalyi, who, in addition to popularizing the term magic circle, is also important for his theory of *flow*, thoroughly explained in his work [15], which refers to the necessary psychophysical states in which the player needs to be in order to enter the mentioned state. *What makes these activities conducive to "flow" is that they were designed to make optimal experience easier to achieve. They have rules that require the learning of skills, they set up goals, they provide feedback, they make control possible.* In order to achieve the state of flow, an ideal balance between the skills required to perform the task and the difficulty of the task is necessary (Figure 2). If we apply the theory of achieving the optimal experience in the learning process of children, we come to the conclusion that they will try harder and achieve greater progress that will result in better results if they have a skill that is one degree more challenging than their current level of knowledge. Psychologist Lev Vygotsky came to this conclusion in [16]: *Play (imitation) as a "leading factor" in children's development and thought that a vital role of play is to create a zone of "proximal development" for the child playing with adults, children's can achieve "beyond his average age"*. At the end of this part of the text, we rounded up the entire story related to the main ideas about the importance of learning through play and how to reach a state of optimal experience, *flow*, in which the learner will

be motivated to participate in mastering serious tasks in a creative way, and we move on to considerations about practical design of learning games and what elements it should contain.

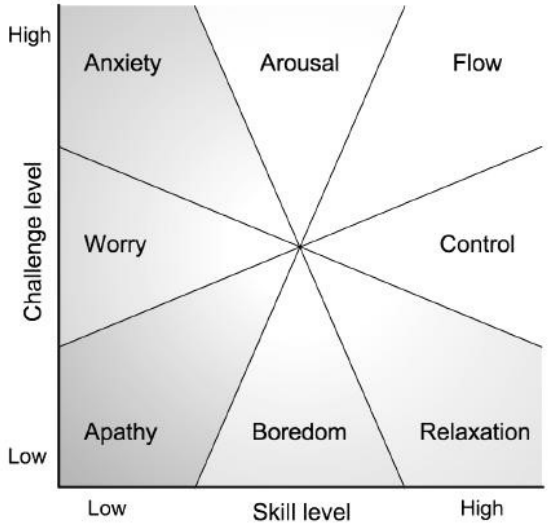

Figure 2. *State of "flow"*, after Mihaly Csikszentmihalyi 1990 (source of image: Research Gate, uploaded by Zhabiz Shafieyoun)

James Paul Gee points out in [17] that if a game has a good learning principle in its design, then it is played and sold. It is important that a video game has a good design so that each level can be adapted to the required levels of the students (to have the possibility of personalized learning) as well as constant feedback (in the form of points or rewards) about the progress of the students. Gee singles out 36 learning principles in his work [18], of which the first five listed are basic, and the other principles refer to the specifics of certain games and do not have to be present in all educational games.

Five basic principles according to Gee in [19] are:

1. Active Critical Learning Principle - creation of a learning environment in which active and critical learning is represented;
2. Design Principle – learning about and coming to appreciate design and design principles is core to the learning experience;
3. Semiotic Principle – refers to combining sign systems (through images, text, symbols...) to create a learning experience;
4. Semiotic Domains Principle – mastering semiotics domains, and being able to participate at the same level, in the affinity group or group connected to them;
5. Metalevel Thinking about Semiotics Domains Principle – includes active and critical thinking about the relationship between semiotic domains being learned to other semiotic domains.

The general model of learning presented by Gentile, Groves and Gentile in their work [20] can be also applied in a video game. The authors state in [21] that: *The General Learning Model (GLM) starts from the assumption that actors exist within an environment, and that both the person and the environment influence the learning opportunity.* The structure and learning steps are represented in the schematic model in the illustration on the next page (Figure 3).

Based on the research conducted by Gentile, Groves and Gentile, authors Plass, Homer, and Kinzer in their work [22] present a learning model that can be applied to video games and use the magic circle theory (Figure 4). What leads to staying in the magic circle are: challenge, response and feedback. In order to achieve the feeling of "flow", the following elements mentioned by the authors need to be satisfactorily designed. Before proposing the basic elements for game design, they distinguished which aspects of those elements, addressed in [23], are: *cognitive, motivational, affective, and sociocultural foundations.*

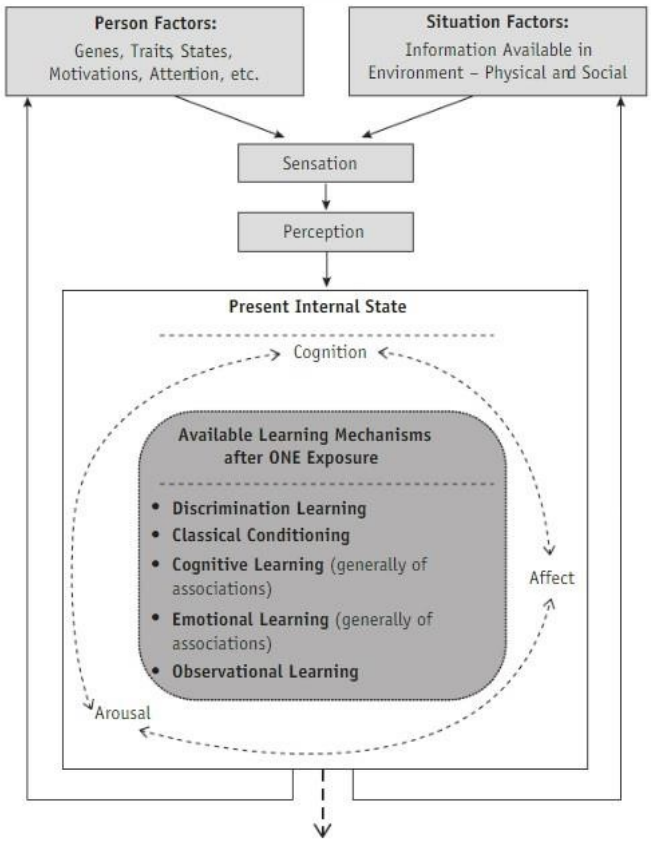

Figure 3. Detailed GLM single short-term processes prior to behavioral response, after Gentile, Groves and Gentile 2014 (source of image: Research Gate, the general learning model: unveiling the learning potential Gentile, Groves and Gentile)

Fundamental elements of game design for learning according to Plass, Homer, and Kinzer in [24] are:

1. Game Mechanics – activity or set of activities repeated by the learner through the game. Can be designed for single players or involve social features. Mechanics are often used to describe genres of games;
2. Visual Aesthetics – overall look and feel of the game and the game characters. By means of visual representation in the game, essential information is presented;
3. Narrative Designee – The story in the game is a very important element because it also provides important information. Games use various narrative methods: a narrator who is often a Non-Personal Character (NPC), introductory tutorials, cut-scenes, dialogues, voice-covers. Unlike movies or books where the plot is linear and has one ending, games provide the possibility that depending on the player's decisions during gameplay, the game has different endings;
4. Incentives System – motivational elements that encourage the player to continue playing. They consist of points, trophies and other awards that define the player's outcome or of special powers, power-ups, acquired during the game in order to perform certain tasks more easily;
5. Musical Score – sound effects that provide feedback based on player actions.

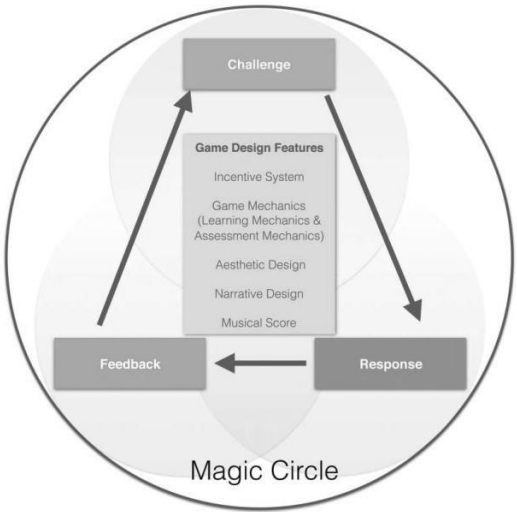

Figure 4. Model of Game-based Learning (source of image: Foundations of Game-Based Learning, Jan L. Plass, Bruce D. Homer, Charles K. Kinzer)

On the basis of the selected Gee principles and on the basis of Plass, Homer, and Kinzer basic elements in the design of educational games, we can divide the effectiveness of video games in application for educational purposes or on the basis of which we can create new games for the aforementioned purposes. When it comes to the genre of video games that are most often used in education, they are mostly Role-playing games (RPG) and simulation games. Role-playing games are tempting because players enter the role of a fictitious character, an avatar (which can be in fantasy games - *World of Warcraft* (Figure 5), or in games that replicate real life - *The Sim*s or *Microsoft Flight Simulator*). Today, the most popular genre related to educational games is RPG in virtual simulated spaces, because they provide the most optimal real experience and they completely separate the player from the outside world.

Figure 5. Exploring the *World of Warcraft* (source of image: Gamespot Staff)

3. Interaction in Educational Virtual Reality Games using the Virtual Reality Headsets

Oyelere et al. in their study [25] represent the advantages of Educational Virtual Reality Games (EVRGs) and they present important development features in the domain of technology, pedagogy and gaming. Educational games are defined as games that are specially designed and created for the purpose of teaching. Authors define in [26] EVRGs as games that use a 3D stereotypical screen and a wearable headset. Virtual reality (VR) games also can use much more advanced plugins that affect

other senses, the sense of touch and even the sense of smell. Christou in his work [27] points out that the advantage of VR educational games in training is reflected in safe access to material in artificially created lifethreatening conditions that are usually a reflection of situations from real life. Example presented by Udeozor et al. in their study [28] is an immersive VR environment created by LaboSafe game, an assessments were designed and embedded into a VR health and safety (H&S) game used for chemical engineering education. Students had the opportunity to work with dangerous chemicals in a safe and realistic environment, a digital replica of the laboratory, learning about possible adverse effects as well as safety protocols. Udeozor et al. also presented in [29] their learning model – Game-based assessment framework (GBAF, Figure 6) which can be applied during the design and implementation of the learning object using immersive technologies.

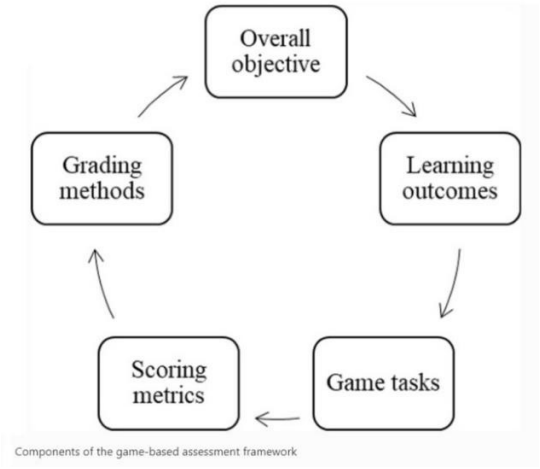

Figure 6. Game-based assessment framework - GBAF (source of image: Game-based assessment framework for virtual reality, augmented reality and digital game-based learning, C. Udeozor, P. Chan, F. R. Abegão & J. Glassey)

Game-based assessment framework includes next steps according to Udeozor et al. in [30]:

1. Overrall objective – describes broadly the purpose of the assessment and in general terms, the competence assessed;
2. Learning outcomes – describes the specific knowledge, skills, or expertise that students are expected to acquire from a learning activity. It also informs students about the competencies that will be assessed;
3. Game tasks – immersive technologies offer active learning environments where students interact with game elements or collaboratively with other students to complete given tasks;
4. Scoring metrics – design of assessments for immersive environment is the game metrics that provide evidence of the knowledge and skills of students;
5. Grading methods – are the criteria of formula for determining the competency level of student based on their performance on the scoring metrics.

Thanks to the latest generations of Virtual Reality Headsets, gaming immersion has reached a new level. The combination of VR Headset and VR games provide players with new areas of entertainment as well as new playgrounds for learning. New generations of students - *Games Generation*, as Marc Prensky define them in [31], have a different way of perception thanks to constant exposure to moving images on all possible portable digital platforms, and accordingly the teaching approach itself must be adapted to their ways of perception. Games-based learning method can ideally be applied in the implementation of teaching content. Prensky singled out in [32] ten important cognitive changes to which the new approach in education should respond:

1. Twitch Speed vs. Conventional Speed;
2. Parallel Processing vs. Linear Processing;
3. Graphics First vs. Text First;
4. Random Access vs. Step-by-Step;
5. Connected vs. Standalone;

6. Active vs. Passive;
7. Play vs. Work;
8. Payoff vs. Patience;
9. Fantasy vs. Reality;
10. Technology-as-Friend vs. Technology-as-Foe.

Ding with a group of authors in their study [33] they pointed out that: the students mastered the course material and showed better results in the scaffolded GBL learning design, students who interacted with VR educational games had more noticeable results than students who played desktop games and students with lower learning motivation performed better in the immersive VR than the desktop version. Virtual environments provide an ideal environment in which to exploit the potential of new cognitive changes in perception. Virtual reality games add a new dimension and a new possibility of expression - active movement. Classic games are based on the happenings on the screen and passively sitting in front, without physical participation. Thanks to the fictitious avatar and the active movements of the real player, their synergy occurs. Gee stated in [34] that *the virtual character or characters that one manipulates in a game — and many other aspects of the game world — are, in reality, "smart tools"* and *characters have skills and knowledge of their own that they lend to the player.*

Interaction in Virtual Reality and in Augmented Reality (AR) is possible with new expressive possibilities and improved optical presentations thanks to *Apple Vision Pro* (2023) and *Meta Quest 3* (2023) and other virtual reality headsets. The *Apple Vision Pro* (Figure 7) is a Mixed Reality (MR, between VR and AR) headset developed by Apple and has a high-resolution micro-OLED display that provides a sharp and immersive visual experience. It has an external display called EyeSight, which allows people around the user to see their eyes, creating a more natural interaction. Runs on a new operating system called visionOS, specifically designed for spatial computing. The interface is controlled using a combination of eye-tracking, hand gestures, and voice commands, eliminating the need for physical controllers. Spatial audio technology delivers immersive sound that feels like it's coming from the environment around you. Users can interact with 3D objects and applications in their physical space, enhancing both entertainment and productivity. Although Leffer stated in [35] that it can be used throughout the day, excessive exposure to virtual images can also lead to *motion sickness, a new type of social isolation or other unintended consequences.*

Apple Vision Pro and *Meta Quest 3* (2023) improve VR graphics and limited field AR allowing for a more realistic experience. The *Meta Quest 3* (Figure 8) is a virtual VR headset developed by Meta (formerly Facebook). It includes high-resolution displays with increased pixel density, providing clearer and more immersive visuals. The headset is powered by a next-generation Qualcomm Snapdragon XR2+ processor, which delivers improved performance and efficiency for a smoother VR experience. It uses improved cameras and sensors for accurate tracking and pass-through, allowing users to see their surroundings while interacting with virtual elements. The headset includes redesigned controllers with improved haptics and ergonomics, providing more precise and responsive input. The controllers feature built-in hand tracking capabilities, allowing for more natural interactions without the need for additional accessories. The headset is equipped with spatial audio technology, delivering immersive soundscapes that enhance the sense of presence in virtual environments. It has built-in speakers and a 3.5mm headphone jack for those who prefer using their own audio equipment.

Figure 7. *Apple Vision Pro* (source of image: Apple)

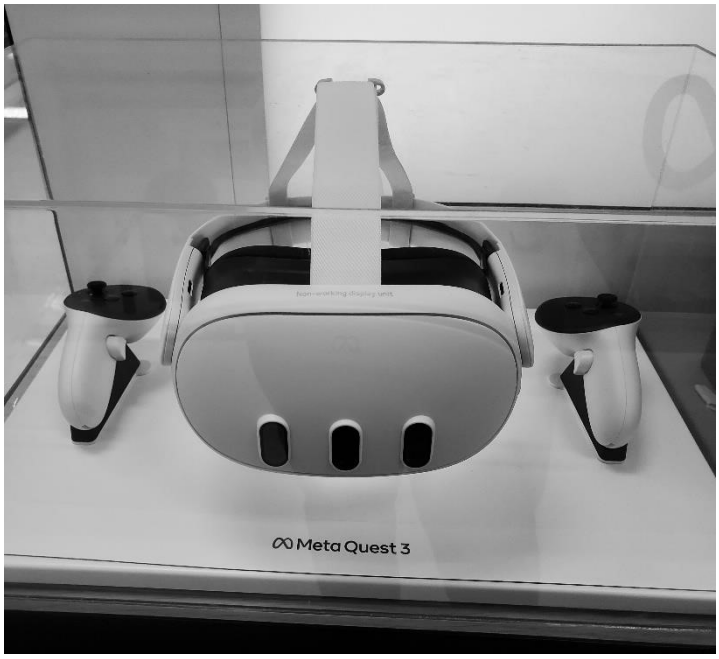

Figure 8. *Meta Quest 3* (source of image: Metaverse)

In the previous generation of devices, dominated by *HTC Vive* (2016) and *Oculus Rift* (2016) in terms of their expressive capabilities, there were also problems related to interaction. Oyelere et al. in their study [36] point out that most games rely on an interaction mechanism, but this is hardly complemented with a natural user interface, which facilitate interaction in VR worlds, resulting in the difficulty of using other input devices like keyboards. *Meta Quest 3* can overcome these problems thanks to adjustable standard facial interface feature and two *Meta Quest Touch Plus controllers*. But to perform more precise actions in VR educational games we need more advanced input devices, but certainly *Apple Vision Pro* and *Meta Quest 3* with their exceptional optical capabilities enable complete user immersion with the virtual worlds of educational games.

4. Conclusion

Game-based Learning has a lot of potential and opportunities to improve learning processes. As the current generations are growing up with smart devices and with digital content, among which video games occupy an important place, the application of this method could bring good results. As the perception has changed, it is necessary to change the same approach in learning. Game-based Learning is an interactive and fun way to approach teaching material. The material is structured like a game and therefore will be more acceptable to new generations, they will be more motivated to solve their tasks. First part of the paper, *Game-based Learning: Interaction in Educational Virtual Reality Games using the Virtual Reality Headsets* present the main ideas about the importance of learning through play are presented and relies on important sources from game theory and learning. The second part of the paper discusses the learning elements that should be implemented when designing games for educational purposes. And the third part of the paper presents VR educational games with an emphasis on the success of acquired knowledge in contrast to classical educational games. The success of VR educational games is reflected in the possibility of complete immersion of the student with the virtual world in which the educational activity takes place, thanks to the last generation of virtual reality headsets - *Apple Vision Pro* and *Meta Quest 3*. Thanks to the new virtual reality headsets, we have the opportunity to experience the real world, as well as possible fantasy spaces, in an unprecedented way. The original possibility of VR headsets is that they involve the student in solving tasks in an active, physical way.

Game-based Learning: Interaction in Educational Virtual Reality Games using the Virtual Reality Headsets through its three parts, it presents a rounded whole, starting from the basic theoretical settings about play and learning, through the process of implementing educational content in video games to the last generation of VR educational games that give the best results learning and task solving.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools

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