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LEARNING ENGAGEMENT IN A PRE-ALPHA VERSION OF AN EDUCATIONAL GAME:
EVALUATION AND PROPOSED SOLUTIONS

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Abstract

Game-based learning focuses on engaging and immersing students in playability, and User Experience is a good opportunity to improve the game experience and to engage students in real learning. A theoretical five-factor model of learning engagement is used to analyse the overall sense of engagement in primary and secondary school students in a playtesting setting in the early stages of developing an inclusive educational mathematics video game mainly designed for deaf and hearing students. A measuring engagement usability playtest was conducted to answer the following research questions: a) What do students perceive as a sense of engagement? b) What information about the engagement is worthwhile to improve the game design and game experience? Twenty-three hearing students (15 boys and eight girls) participated in the study. The participants are 2nd to 12th graders, with a mean age of 13.7. After students played the pre-alpha version of a video game, most agreed that the prototype was challenging, reporting motivation to undertake the game's mathematical challenge. They perceived the game activity as clear and achievable. The students also reported having control over different types of actions in the game, and nearly one-quarter of the students perceived the game activity as not immersive. Also, the older students expressed that the game's purpose seemed irrelevant to their age group, which ultimately affected the game's general rating on the clarity of the game's purpose. The playtesting sessions reveal that players need help separating the game from its educational goal, and the misalignment between the character's movements affects the game's action control. After collecting engagement problems in playtesting sessions, the study proposes solutions, including changing interface elements. The current work demonstrates the importance of evaluating engagement in playtesting sessions in the early stage of development to improve the game experience long before the final version.

Keywords: *video game, game-based learning, mathematics, engagement, playtesting*

Introduction

The usefulness of computer games in encouraging learning is often pointed out in game-based literature. In a meta-analysis focused on the learning principles used in game-based educational studies, Bakan and Bakan (2018) concluded that in game-based studies in educational technology journals, problem-based learning and cognitive load theory were found to be at the top of the learning approaches in game-based studies mainly focusing on how games can stimulate student's enjoyment, motivation, and engagement. In addition, according to Kim, Park and Baek (2009), over the past two decades, the number of game studies using game-based learning has grown due to its potential power to motivate and engage students in complex education, such as decision-making and metacognitive thinking including problem-solving (Barzilai & Blau, 2014). Hong and colleagues (2009) developed indices for assessing the educational values of digital games and established seven categories: mentality change, emotional fulfilment, knowledge enhancement, thinking skill development, interpersonal skill development, spatial ability development and motor coordination. Moreover, Qian and Clark's (2016) findings suggest that a game-based learning approach might effectively facilitate students' 21st-century skills development. Recent research points to cognitive enhancement while playing video games, specifically can improve cognitive skills, such as visual processing, attention, and spatial ability (Bediou et al., 2018; Cardoso-Leite et al., 2021); even argumentation skills (Noroozi et al., 2020). Nevertheless, three meta-analyses by Sala, Tatlidil, and Gobet (2018) concluded that playing video games activated specific cognitive processes during gameplay but found no evidence of a causal relationship between playing video games and enhanced general cognitive ability. In sum, these studies highlight video games' potential to transform the learning experience positively and provide an excellent opportunity to engage students in authentic learning (Prensky, 2001).

Learning and Engagement in Educational Video Games

Ludic digital games, such as video games, are considered a powerful tool for learning due to the variety of effective learning principles embedded within the game design (Mitchell & Savill-Smith, 2004). The player is the active agent of learning; he is encouraged to solve problems and produce things that demonstrate what he has learned; in addition, challenges and intrinsic rewards motivate learners to engage and persist in learning tasks (Gee, 2005).

The main reasons pointed out are: a) video games are fun and challenging, with a rules structure and clear goals (Malone, 1980; Wang et al., 2017); b) they provide a flow experience without overload cognition abilities like working memory, c) they give immediate and constant feedback that stimulates player's participation; d) they present well-ordered problems embedded in a story; e) besides, players can control his actions and personalise their game experience (Chang et al., 2017; Gee, 2005; Prensky, 2001).

An educational video game includes content in gameplay, meaning the "intrinsic integration of domain-specific learning in-game mechanics and game world design" (Ke, 2016).

These learning principles can help improve the player's game experience and are closely related to engagement principles. The learning engagement principles here rely on Whitton's five-factor model of engagement (Whitton 2007; 2011), that is used in the present study to analyse the overall sense of engagement in a specific game activity.

The author draws out factors from the literature that influence engagement with games by using them in the context of engagement with learning (Whitton, 2011). Two theories of engagement provide the basis of the model: the flow theory of Csikszentmihalyi (1992) and the work of Malone (1980; 1981), regarding Challenge, Immersion and Control.

The first factor is Challenge, and his subfactors Motivation, Clarity and Achievability imply that the game activity requires clear rules and goals that motivate the player enough to undertake the game mission. With some effort and progress, the game activity is perceived as achievable. The second factor is Control, and it covers the idea of the player feeling that he has control over the game, that their actions affect the outcome, and that he has the power to choose between game activities. Immersion encloses the idea that the game provides an immersive and engaging environment that allows him to feel part of the game's world and be absorbed in their activities. Interest covers the notion that the game is exciting enough and relevant to the player's purpose, arousing curiosity and interest. The last factor is that Purpose lies in a strategic approach in which the player perceives a purpose and meaning during game activities relevant to him, feeling that he is learning something valuable and perceiving the immediate and constant feedback as having value.

Engagement and User Experience

User Experience (UX) can significantly impact the level of engagement in a product, such as a digital game (Hodent, 2017) or a serious game. As described by Zhonggen (2019), an effective serious game will attempt to provide a positive experience that motivates the player to keep playing and undertake the game mission (Zhonggen, 2019). However, some concerns must be considered when designing a serious game such as an educational video game. In their meta-analysis review, Zhonggen identifies influencing factors - positive and negative findings gathered through their study regarding serious games for education in the past decade (Zhonggen, 2019). Some of these concerns - feedback, gaming easiness, or general interaction - will affect the user's game experience, inevitably diminishing its efficacy. When discussing the results gathered from the playtesting sessions, these elements help game designers understand the results related to user experience: what affected them and how they could be fixed.

Before presenting the game's characteristics and methodology, it is essential to mention that the term "serious game" is often mentioned in the literature as synonymous with "game-based learning". However, game-based learning (GBL) is a learning methodology that can be seen as an approach to teaching in educational contexts (Becker, 2021). In this perspective, serious games are a tool or product in which the GBL approach can make learning more exciting, effective, and different from entertainment games as they serve a purpose other than entertainment. They are entertainment tools for education (Zhonggen, 2019), training, or persuading players on specific topics and issues (Jacobs, 2021); players cultivate their knowledge and skills through the gameplay and its

challenges. In this study, we use the term "educational video game", a serious game incorporating the game-based learning approach.

The game

The "Planeta em Perigo: Uma Aventura Espacial" is an educational game for mathematics learning. The video game follows game-based learning principles as the intrinsic integration of domain-specific mathematics learning in-game mechanics and game world design. It was designed to avoid the perception that "serious education is boring" by complementing the balance between performance and arousal/engagement proposed by the Inverted-U Model of Robert Yerkes and John Dodson to achieve a state of optimal performance, which is often connected to the state of flow presented by Csíkszentmihályi (1992).

The video game is a research-based game to support a more inclusive education in primary maths for deaf and hard of hearing (DHH) students, including hearing peers. The player must use mathematical abilities to solve challenging puzzles to rebuild an abandoned space base.

Each challenge is a game area that requires the player to solve a problem using his mathematical abilities. It is based on well-ordered problems with three difficulty levels designed to provide advanced mathematical knowledge progressively, give immediate feedback, and reward the player with the resources necessary to build and upgrade his space base. The game includes a bilingual tutorial (Figure 1.)

The current study's pre-alpha version of the game includes only the first challenge consisting of an addition and subtraction puzzle in which the player must add or remove particles of the planet ore to create a resource, and there is no possibility of exploring the game environment.

The first challenge, the Refinery (Figure 2.), consists of a room with two particle cannons that fire particles to produce stable

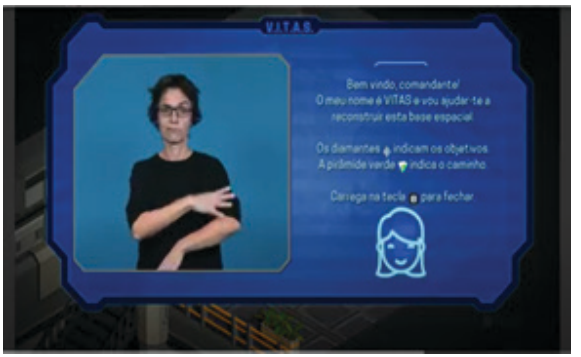

Figure 1.
Bilingual Tutorial - Pre-alpha production layout

Figure 2.
Challenge 1 - Pre-alpha production layout

matter (blue energy) and the other that fire antimatter (red energy), representing addition and subtraction, respectively. When the player starts the challenge, he stares at floating particles orbiting a core with a number line that he uses to know what he has to do. Firing red energy will reduce particles while firing blue energy will add particles that appear orbiting.

In the number line interface, the dark circle at the bottom indicates the current number of particles (Figure 2.). The goal is to match the number of dots shown in a number line by adding or subtracting using firing energies to produce a metal unit resource. To interact, the player uses the WASD keyboard interface and the D key to add particles and the A key to reduce particles; the Space key starts the operation, adding and subtracting all the assigned particles; and the Q key to skip.

Objectives of the study

Using the theoretical five-factor model of learning engagement proposed by Whitton (2017) and the importance of evaluating the sense of engagement in playtesting sessions in the early stage of development to improve the game experience long before the final version, the present study aims to analyse the overall sense of engagement learning principles by evaluating the experiential engagement of students after playing a pre-alpha version of an inclusive educational mathematics video game, mainly designed for deaf and hearing students. Therefore, a measuring engagement usability playtest was conducted to answer the following research questions:

1. What is the sense of engagement perceived by students?
2. What information about engagement is worthwhile to improve the game design and game experience?

The present work also intends to gather information about players' game habits and preferences and relate them to the sense of engagement.

Method

Participants

Twenty-three hearing students participated in the study. The participants are 2nd to 12th graders, fifteen boys and eight girls, aged between seven and 18 years old, with a mean age of 13,7 years old (*SD* = 3,4). There are differences between sexes by the level of education - only one male student attended the secondary level, and only two girls attended the primary level (Table 1). Female participants were mainly older (MD = 15,5; SD = 2,4) than the male participants (MD = 12,8; SD = 3,5) and having higher levels of education (MD = 9,8; SD = 2,5).

Table 1.
Demographic variables

Variable	Frequency	Percent
Sex		
Male	15	65,2
Female	8	34,8
Level of education		
Primary (Grade 1 - 6)	7	30,4
Low Secondary (Grade 7 - 9)	9	39,2
Secondary (Grade 10 - 12)	7	30,4
Total	23	100

Materials

"Planeta em Perigo: Uma Aventura Espacial" video game. The version used in the present study was a pre-alpha version of the video game developed as a tool to support mathematical learning for deaf and hearing students with and without special educational needs. The standalone game was designed under the [project name] using a GBL framework produced with the Unity game engine. The game is a single player, third-person camera game with a fixed perspective. The player is placed in an adventure sci-fi environment where he must solve mathematical minigames to perform in-game tasks. The player must use mathematical abilities to solve four challenging puzzles to build a space base, but only the first Challenge is under this study. The game challenge consists of an addition and subtraction puzzle in which the player must add or remove energy levels from an 'atom' until the desired quantity is attained. The game controller is a keyboard with a computer monitor as a display device and a PC as an electronic device for Windows 10.

Electronic device. Laptop and PC's with Windows 10 software and Zoom Platform for remote playtesting sessions.

Observational Grid "Got it/Don't got it" (Swink, 2008). The grid was adapted by Swink (2008) to analyse the tester's behaviour when going through certain key moments in the prototype. Each moment is rated using a dichotomous scale (got it/ don't got it) to rank the performance of participants in each item, and a 5-item Likert scale is used to observe participants' game experience (1= very low; 5 = very high). Additionally, specific observations regarding the players' individual sessions - their behaviour and performance in the game - are to be written by the test coordinator in the table to further contextualise the data collected regarding their engagement and experience while playing the game This is where the prototype's UX issues can be identified to then be reported to the game's developers.

Media usage questionnaire. Pre-testing questions were used to gather more information about players' preferences and experience with video games. Besides age, grade and gender, the questionnaire includes the choice of three video games participants play during their spare time. The game preferences include the selection of the video games and the match of one of the six categories proposed by Funk & Buchanan (1995): educational, general entertainment, human violence, fantasy violence, nonviolent sport, and violent sports.

Engagement Scale (Whitton, 2007). The engagement questionnaire is a self-perception for evaluating the level of engagement perceived in playability activity. The measure contains 18 items with five Likert points of agreement (1= strongly disagree; 5= strongly agree) distributed by five factors: Challenge, Control, Immersion, Interest, and Purpose. The factor Challenge has three subfactors: Motivation, Clarity, and Achievability. The measure reveals good internal consistency between the items, with a *Cronbach's Alpha of .87 (n= 23)*. The higher the extend to each factor is present the higher the sense of engagement - so high, moderate and low level of engagement are analysed: high when students mean response is equal or above five points of agreement (5 = strongly agree) ; moderate when the mean response is between three and four points (3 = neither agree nor disagree and 4= Agree); and low when the mean response is equal or below two points (2 = disagree and 1 = strongly disagree).

Procedure

After informed consent, a media usage questionnaire was applied regarding their media interests, specifically video game preferences and habits. Depending on remote or in-person sessions, the participant played the game on their computer or the one provided by the testers. The players had to play the prototype to the end, with the test administrators giving little or no direction on what the tester should do to progress. Ending the playtesting session, the players fill in the engagement and game habits questionnaire considering their experience while playing the game.

Results

Engagement

Considering the first research question: What is the level of engagement perceived by students? Overall, the results indicate moderate engagement, *MD = 4,0; SD = 0,3*. In the factor Challenge, most of the students agree (strongly agree = 49,3%; agree = 34,8%) that the prototype is challenging. They report *motivation* to undertake the games' mathematical challenge (strongly agree = 43,5%; agree = 32,6%), agree that the game's challenges are *clear* (strongly agree = 45,7%; agree = 37,0%), and perceive the game activity as *achievable* (strongly agree = 58,7%; agree = 34,8%) (Figure 3.)

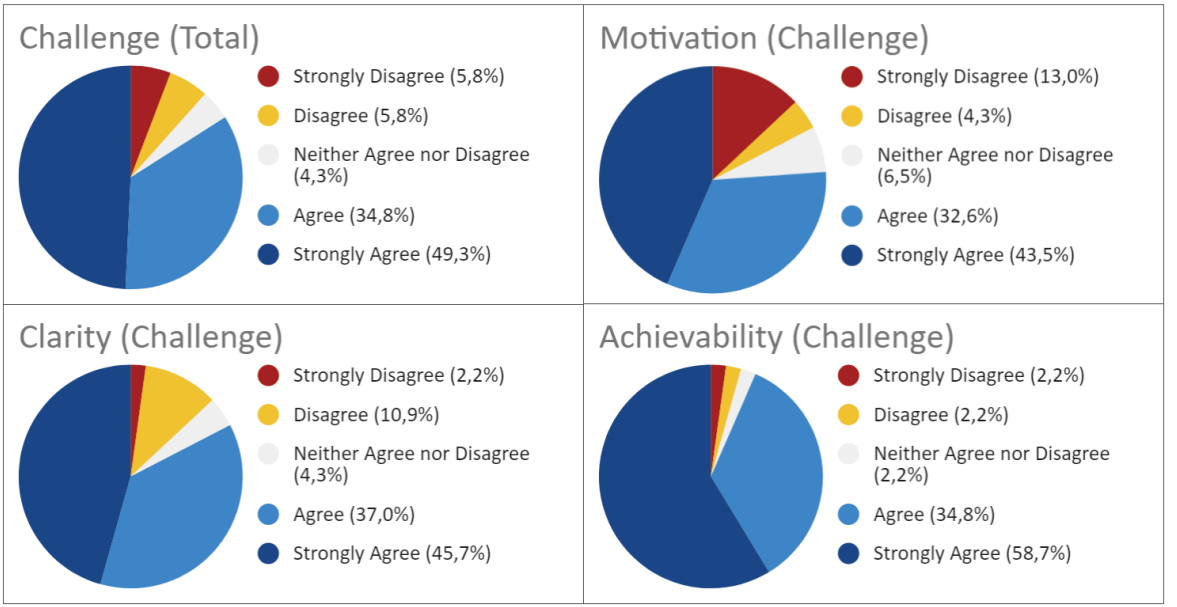

Figure 3.
Engagement Scale results of the Challenge sector and its sub-factors (Motivation, Clarity, and Achievability)

In the statement items of the factor Control about their level of choice over different types of actions in the game; 17,4% disagreed with the statement (5,8% strongly disagreed), and 15.9% gave a neutral answer (either agree or disagree). In the factor Immersion, nearly 10,1% of the students perceived the game activity as not immersive. In the factor Interest, the students reported intrinsic interest in the activity (strongly agree = 37,7%; agree = 37,7%). Lastly, 11,6% of answers regarding their perception of the Purpose of the game activity had a negative sense of engagement (Figure 4).

Considering the self-perception differences between gender, in every factor, female participants reported a slightly less sense of engagement after played the prototype (Table 1); however, the global average for both groups remained quite similar, with the male demographic averaging at 4,0 and the female at 3,8; meaning that participants mean levels of agreement sits on "agree" with the engagement questionnaire statements.

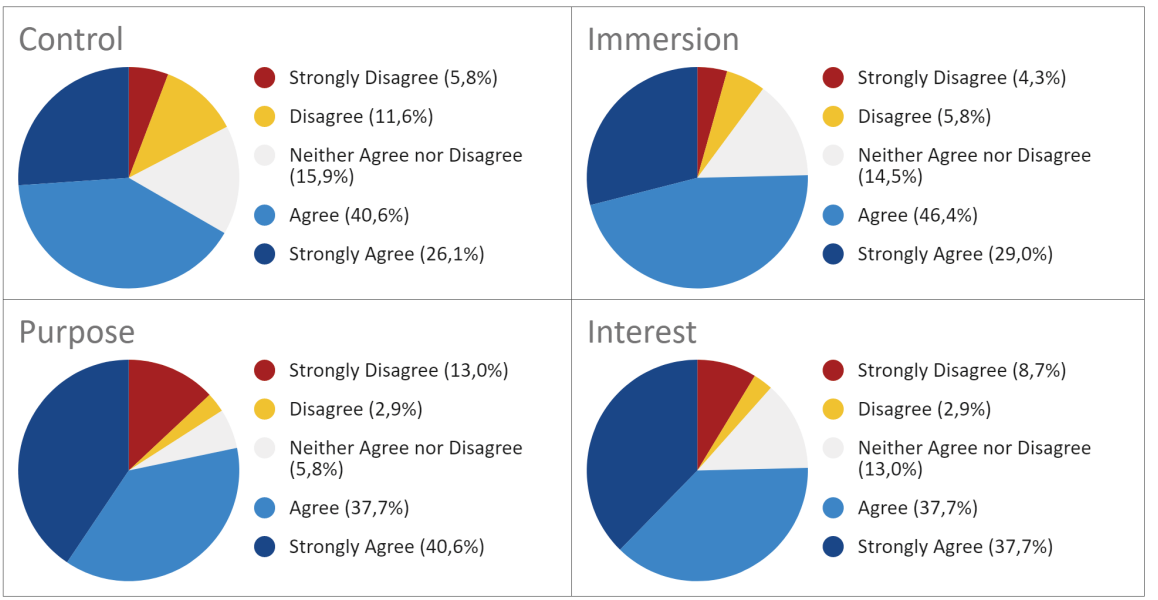

Figure 4.
Engagement Scale results for the Control, Immersion, Purpose, and Interest factors

Table 2.
Means and Standard deviation levels of agreement by gender.

Participants	MD (SD)	n
Male	4,0 (0,4)	15
Female	3,8 (0,4)	8
Total	4,0 (0,3)	23

In general, Challenge reached an average of 4,3 (SD = 0,5). Inside this sector, the analysis of its sub-factors reveals that the players considered the challenges of the game 'Achievable' (MD = 4,5; SD = 0,3), having the highest level of agreement; 'Clarity' (MD = 4,1; SD = 0,4) and 'Motivation' (MD = 3,9; SD = 0,7) both had a slightly less - though still - positive result, with both having an average of 3,8. In the remaining sectors, Interest had an average of 3,9 (SD = 0,1), and the remaining sectors (Control, Immersion, and Purpose) all shared an average of 3,8. The lowest average observed in the male group was 3,7 (SD = 0,3) in Control, and in the female group both immersion and purpose had an average of 3,5.

Playtesting results

The Observational Grid detected user experience issues by observing the players' sessions and writing their remarks as they played the game. These grids provide valuable context to the results obtained in the Engagement Scale as they help identify the more significant issues that affected the players' experience. The playtesting sessions of all participants identified three main problems that significantly impacted most players' sessions and are very likely to have affected their perceived engagement when answering the questionnaire.

First, players could only close the dialogue menu once the sign language video ends. The voice narration ends sooner than the sign language video, and the hearing students are told to 'Continue' - though unable to. This problem made players doubt the game's stability and may explain the lower values observed in the factor *Control*.

The second major issue identified by players during playtesting was that the player-characters' movement needed to be aligned with the game world's isometric layout, meaning that the players could not intuitively follow the game world's pathways. This issue affected every player's experience, though testers who - according to the media usage questionnaire - played more video games tended to have a more negative reaction.

Lastly, the game's other significant issue was identified in its mathematical challenge. The challenge involves adding and subtracting incrementally to a given number until a specific result is obtained. The problem arose when the UI element showed the intended result with a '+', with most players believing that the objective was to add the 'amount' shown in the UI to the starting number. After seeing the result wasn't accepted, most players figured out the correct result, though they commented on the 'useless' plus sign. This issue affects the challenge's Clarity, and its effect was observed in the observational grids and the sub-sector.

Media usage

Participants also reported their favourite games and categories of video games. Here, there are some differences

between male and female players. Boys prefer multiplayer action games, while girls feel favourably disposed towards single-player action adventures.

From the media usage questionnaire, we can see that from the female participants, only the eldest had contact with video games - being the ones capable of identifying at least one game they liked. Most of the boys had experience with video games, often placing more than one title. The games they named were mostly action or action-adventure. Female testers, there was a clear interest in multiplayer games, with several of these being identified in the questionnaire. Additionally, most types of games participants mention are Human Violence or Fantasy Violence categories, with only two mentions of Violent Sports and Nonviolent Sports.

Analysing the differences between male and female participants, boys have more experience with video games. Their game's genres are mostly action and/or adventure. There is a clear interest in multiplayer titles, with eight games of this genre. Fortnite, part of the multiplayer game group, is played by most participants, who mentioned it seven times. It is important to note that despite seeing a shift to single-player games at 16/18 years old (the oldest age range), interest in multiplayer games continues throughout the ages, with this age range mentioning games like Counter-Strike and Brawlhalla. The place where this genre shows to have the most success is in the group of subjects between 8 and 10 years old (the youngest of the age range); only Minecraft and Need for Speed are games that are not exclusively online/multiplayer (and even then, they have these elements) while all the others identified by this group are solely online. The results show that

Gender by school level & age range	Video game category	Video game name
Male		
Primary Grade 1 - 6 6 – 11 y.o.	- Fantasy Violence - Human Violence - Human Violence - Human Violence - Violent Sports - Fantasy Violence - Fantasy Violence	- Minecraft - Resident Evil - Tomb Raider - Fortnite - Need For Speed - Dauntless - Realm Royale
Low Secondary Grade 7 – 9 12 – 15 y.o.	- Fantasy Violence - Human Violence - Fantasy Violence - Human Violence - Human Violence - Human Violence	- Minecraft - Fortnite - League of Legends - Valorant - Grand Theft Auto - Call of Duty /Warzone
Secondary Grade 10 – 12 15-18 y.o.	- Human Violence - Human Violence - Fantasy Violence - Nonviolent Sports - Fantasy Violence - Fantasy Violence - Fantasy Violence - Fantasy Violence - Fantasy Violence	- Resident Evil - Counter Strike: Global Offensive -The Witcher 3: Wild Hunt - FIFA - Brawlhalla - Hyper Light Drifter - Dark Souls III - TheElder ScrollsV: Skyrim - Bloodborne
Female		
Secondary Grade 10 – 12 15-18 y.o.	- Fantasy Violence - Human Violence - Human Violence - Human Violence - Violent Sports - Human Violence - Fantasy Violence - Human Violence - Human Violence - Human Violence	- Minecraft - Resident Evil - Tomb Raider - Fortnite - Need For Speed - Overwatch - League of Legends - Valorant - Grand Theft Auto - Call of Duty /Warzone

Table 3.
Video game type, age rating, and electronic device by gender

only the oldest girls had contact with games, being able to identify titles of their liking. Apart from Minecraft - the game with the most votes (3) - most of the titles chosen are action or adventure. Overall, 44% of the subjects, aged between 10 and 16, had never had experience with gaming.

Discussion

The second research question "What information about engagement is worthwhile to improve the game design and game experience?" can be answered by crossing the results of the playtesting sessions, the sense of engagement and the game preferences of the participants.

The sense of engagement and user experience

Analysing the sense of engagement with the game activities (measured by the Engagement questionnaire), the results show that most participants reported that the prototype is challenging. However, looking at the sub-factors of Challenge and crossing with the factor Immersion, most of the negative responses possible explanations that may have affected the motivation to undertake the activity and the sense of being absorbed in the activity is considering the prototype as an educational product; the testers' (students) motivation to play the games' challenges may have been affected by possibly seeing the activity in the game explicitly as a mathematics problem rather than a game challenge. Regarding Immersion, most responses in the questionnaire were positive. Despite players commenting that they enjoyed the sci-fi setting, they saw the game as "only educational" - which relates to its presentation as an educational maths game. In this case, the perceived usefulness of the game may be compromised (Zhonggen, 2019) by considering the game just an educational product and not a game, giving the idea that it is too little fun and too much learning, complementing the perception that serious education is boring. There is no intrinsic integration of educational content in playability (Ke, 2016). Besides, the fact that the pre-alpha version was not yet able to explore different locations in the game environment in this video game version may have contributed to this perception.

A lower level of engagement in subfactors' Clarity and Achievability could be due to some users' unfamiliarity with the WASD keyboard interface. Some players only play video games on a console or don't play them. Another possible explanation concerns the conflicts detected with the UI in the game - primarily secondary students interpreted the requested "+[X]" quantities in the maths challenge in the game as values added and not as the quantity expected - this issue might not have affected the players' assessment of these Challenge sub-factors further since most players who were at first 'tricked' by the UI immediately understood what was requested. Clear goals and ease to use is an essential factor (Malone, 1980, 1981; Zhonggen, 2019; Chang et al., 2017; Gee, 2005; Wang et al., 2017).

Concerning the Control factor, most participants reported high engagement levels. However, one-third did not - a likely justification is the variety of issues that affected the participant's experience in the game. As mentioned, when analysing Challenge, some users needed to familiarise themselves with a keyboard interface and only play games on a console. As observed by the observational grid and the player's feedback, in the game, the

player-characters movement axis is misaligned with the game world's orientation, which makes the eases to use principle compromised (Malone, 1980, 1981; Wang et al., 2017).

The results indicate that the perceived Control of the game was also compromised. The game didn't allow the player to resume playing the game until the sign-language video for the instructions was over – even though they were prompted to do so by the audio narration. Since no player identified playing a game with an isometric perspective in the media usage questionnaire, the format chosen may be unfamiliar to most testers, possibly aggravated by the problems observed in the player-characters movement. Another possible cause is considering Control lower's rated for the male testers - they were more familiar with how these games are supposed to work, and the issue with the player-characters movement orientation - which broke the convention for how the player-character is supposed to move in this game - was especially prevalent for them, leading to the most negative evaluation. Overall, results falter most in this factor due to most of its issues being related to the flawed controls themselves - and problems that resulted in a lack of Control (ex., not being able to leave the instruction screen when told to do so), which collided with a younger demographic that showed some unfamiliarity with the keyboard interface. Players can not control his actions what might affect the sense of engagement (Chang et al., 2017; Gee, 2005; Prensky, 2001).

Engagement, media usage and demographic characteristics

Analysing the results obtained in the Engagement Questionnaire, the game's engagement perception across all participants was positive. Some gender differences are analysed - even though the Entertainment Software Association (ESA) annuals report containing statistics on American video game player demographics show that across years the tendency is to have no differences between gender players. For example, in 2006, 38% of video game players were female and 62% were male. In 2022, the percentage of female players increased to 48% (Entertainment Software Association, 2022; Romrell, 2013). However, the percentage of female players varies drastically depending on the type of game and it is consonant with the literature review of Romrell (2013) about gender and gaming where the percentage of female players decreased to around 20% when the games are multiplayer online and role-playing games.

Female participants show a slightly lower overall sense of engagement than male testers and have less contact with video games, which would have affected their familiarity with the WASD keyboard interface for playing games. Another explanation concerns Immersion and Purpose factors. Female players also present the lowest sense of engagement with the game's activities. The female participants were mainly older than the male, and having higher education would be unnecessary to invest in the maths challenges, removing the sense of Immersion, Purpose, and Interest.

Regarding the male testers, the Control factor showed a lower level of engagement, which might be related to the mentioned UX where players could not skip the sign language video once the narration ended and due to the player-characters misaligned movement in the game world's isometric perspective. The results from all testers may be affected by these

issues. However, the unintuitive movement may have been significantly worse for male testers, who, in most cases, had greater familiarity with video games - which might explain the lack of Control perceived by male testers compared to other engagement factors responses. In the Purpose factor of engagement, three-quarters of the players - knowing what the objective of the game was - saw its completion as a priority and aim of the game. Lower levels of Purpose had mainly to do with male students with a higher level of education who considered that the game had an educational goal, not for fun. Since they had already learned what the game was trying to teach them, the game did not have any purpose for them. Lastly, most players showed Interest in the prototype and its setting.

Players' comments during playtesting sessions allow evaluators to observe different interpretations of specific statements of the questionnaire. For example, one player "didn't have to work hard" because it was "too easy [for his level of education]" (relating to similar comments observed regarding Purpose in the game). Another participant commented that he "didn't want to explore" because he "knew what he had to do", which appears to relate to players seeing the game more as an educational task (being introduced as a game for teaching maths) rather than a ludic activity removing any desire to explore it further.

UX engagement problems and Proposed solutions

The results show that the level of engagement perceived by participants was moderate. Thanks to the granularity of the model used to gauge the players' sense of engagement, the information collected enables the identification of specific user-experience problems in the game, allowing the proposal of some solutions to improve the implementation of game-based learning.

Table 4.
UX engagement problems and proposed solutions

UX engagement problems	**Proposed Solutions**
1. Lack of game controls knowledge	To include an initial tutorial session explaining the game's controls.
2. Character's movement axis misalignment	To correct the character's movement axis aligned with the game world's environment.
3. Lack of Dialogue menu control	To introduce the skip game function to allow the player close the dialogue menu before the sign language narration ended
4. Plus signs from the UI ambiguity	To remove the plus signs from the UI number line. 

Another necessary correction was designed for the exercise featured in the game's prototype, as players (most commonly the older students) mistook the plus signs preceding the numbers as if signifying that these were quantities to be added instead of the total number requested. As the exercise works only with natural numbers, removing the plus signs from the UI makes sense. However, explaining in the game that the numbers represent the total quantity intended is also recommended and would further boost the clarity of the task's requisites.

The lack of knowledge of some players using the computer interface made it clear that an initial tutorial session explaining the *game's controls* while allowing for a risk-free practice phase is essential, as the "easiness and instruction" of the experience are some of the most influential factors to the learning effect of these type of games (Zhonggen, 2019).

As mentioned before, a correction to the *character's movement axis* aligned with the game world's environment is necessary, as it will contribute to removing unnecessarily added confusion for inexperienced players who may already be struggling to learn the controls and will greatly improve the user experience when navigating the game world, which again, is an important factor towards the intended learning effect (Zhonggen, 2019).

Moreover, enabling hearing students to close the *dialogue menu* before the sign language narration ended (even though the voice narration told them to) can be fixed by simply giving the players the option to skip once the narration ends; allowing players that have finished listening to the instructions to proceed to the next part of the game, and doing so reducing unnecessary downtime which could negatively impact the player's engagement.

Another necessary correction was designed for the exercise featured in the game's prototype, as players (most commonly those with higher education) mistook the plus signs preceding the numbers as if signifying that these were quantities to be added instead of the total number requested. As the exercise works only with natural numbers, removing the plus signs from the UI makes sense. However, explaining in the game that the numbers represent the total quantity intended is also recommended.

In general, it is essential to mention that the game's perception by the players as an educational tool interferes with players' having a genuine ludic experience. Several testers commented that because it was an educational mathematics game, they did not feel they should 'enjoy' the game; they interpreted the challenges more as a task to be completed rather than a ludic game. Presenting the title as a ludic experience might allow for a more significant - perceived - level of engagement from the players, with the educational contents integrated into its gameplay, keeping the principle of game-based learning.

Final considerations

There are some limitations to the study. The sample should be more homogeneous, considering demographic variables and size. Additional qualitative and quantitative instruments are also needed to measure engagement more accurately; more than one measure is required. As a final consideration, the current work shows the importance of evaluating engagement in playtesting sessions in the early stage of development to improve the game experience long before the last version. Harmonising how fun the game is with educational purposes is one of the biggest challenges of educational game implementation, and future studies that evaluate engagement in playtesting sessions with different types of games may contribute to a better understanding of creating effective learning using educational video games.

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