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Addition Games:
Challenges, lessons and reflections on the development of a effective educational video game

João Luís Alves Pires Ferreira

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Orientador:
Professor Doutor Ernesto Vilar Filgueiras
Coorientador:
Professora Doutora Sandra Carina Guimarães

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À minha família.

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“Compare yourself to who you were yesterday, not to who someone else is today.”

Abstract

This master's thesis explores the use of games in education. The aim of this research is to identify ways in which games and technology can be leveraged to improve the quality of education. Recognizing the need for educational renewal and considering the widespread availability of computers for students, the project aims to explore new pathways for teaching and learning.

Developing an intuitive educational game in an amateur and autonomous manner, without proper technical validation, poses a significant challenge. The absence of grounded references and the lack of mandatory technical validation introduce substantial risks in creating an Addition Game. This intuitive approach can lead to serious pedagogical errors, compromising the game's effectiveness in fulfilling its educational objectives. The importance of using reliable references and subjecting the game to rigorous technical validation cannot be underestimated, as it contributes to the quality and effectiveness of the final product, ensuring it meets pedagogical standards and provides a solid educational experience for users.

The research process involved a comprehensive exploration of existing educational games, books, and articles, providing insights into the current landscape. This exploration, coupled with an investigation of heuristics and gamification principles, served as the foundation for structuring the envisioned game.

The game exhibits multiple issues that became evident through the application of heuristics and expert reviews. These problems, ranging from pedagogical errors to usability concerns, highlight the need for immediate attention and rectification. Addressing these issues promptly is crucial to ensure the game's validity and effectiveness as an educational support tool. Swift repairs and enhancements are necessary to align the game with pedagogical standards, providing students with a reliable and beneficial tool for their studies.

This project embodies a holistic approach to educational game development, blending research, pedagogical considerations, and practical testing. It aims to contribute to the ongoing conversation about technology in education, emphasizing the vital role of informed design. The project stands as a testament to the principle that educational games should not be crafted haphazardly but should be meticulously informed by research, validated pedagogical practices, and thorough testing. This perspective underscores the commitment to creating educational tools that effectively cater to the learning needs of digitally immersed students in today's educational landscape.

Keywords
Education; Educational games; Elementary School; Expert Review; Heuristics**.**

Resumo

Esta dissertação de mestrado explora o uso de jogos na educação. O objetivo desta pesquisa é identificar maneiras pelas quais jogos e tecnologia podem ser aproveitados para melhorar a qualidade da educação. Reconhecendo a necessidade de renovação educacional e considerando a ampla disponibilidade de computadores para os alunos, o projeto visa explorar novos caminhos para o ensino e a aprendizagem.

Desenvolver um jogo educativo intuitivo de forma amadora e autônoma, sem validação técnica adequada, representa um desafio significativo. A ausência de referências fundamentadas e a falta de validação técnica obrigatória introduzem riscos substanciais na criação de um Jogo de Adição. Esta abordagem intuitiva pode levar a erros pedagógicos graves, comprometendo a eficácia do jogo em cumprir seus objetivos educacionais. A importância de usar referências confiáveis e submeter o jogo a uma validação técnica rigorosa não pode ser subestimada, pois contribui para a qualidade e eficácia do produto final, garantindo que este atenda aos padrões pedagógicos e ofereça uma experiência educativa sólida aos utilizadores.

O processo de pesquisa envolveu uma exploração abrangente de jogos educativos existentes, livros e artigos, fornecendo insights sobre o panorama atual. Esta exploração, juntamente com uma investigação sobre heurísticas e princípios de gamificação, serviu de base para estruturar o jogo idealizado.

O jogo apresenta múltiplos problemas que se tornaram evidentes através da aplicação de heurísticas e revisões de especialistas. Estes problemas, que vão desde erros pedagógicos a preocupações de usabilidade, destacam a necessidade de atenção imediata e retificação. Abordar esses problemas prontamente é crucial para garantir a validade e eficácia do jogo como uma ferramenta de apoio educacional. Reparações e melhorias rápidas são necessárias para alinhar o jogo com os padrões pedagógicos, proporcionando aos alunos uma ferramenta confiável e benéfica para os seus estudos.

Este projeto incorpora uma abordagem holística no desenvolvimento de jogos educativos, combinando pesquisa, considerações pedagógicas e testes práticos. Visa contribuir para a conversa contínua sobre tecnologia na educação, enfatizando o papel vital de um design informado. O projeto é um testemunho do princípio de que jogos educativos não devem ser criados de forma autónoma, mas sim meticulosamente

informados por pesquisas, práticas pedagógicas validadas e testes rigorosos. Esta perspetiva sublinha o compromisso de criar ferramentas educativas que atendam efetivamente às necessidades de aprendizagem dos alunos imersos digitalmente no panorama educacional atual.

Palavras-chave
Educação; Jogos Educativos; Escola Primária; Revisão de Especialistas; Heurísticas.

Table of Contents

List of Figures

List of Tables

Acronyms

UI - User Interface
AI - Artificial Intelligence
GDD - Game Design Document
NPC - Non-playable Character
AHJED - Heuristic Evaluation for Digital Educational Games
PHEG - Playability Heuristics Evaluation for Educational Computer Games
MEEGA - Model for the Evaluation of Educational GAmes
HEDEG - Heuristic Evaluation for Digital Educational Games
IN - Interface
JG - Gameplay
MM - Multimedia
HJ - Game Story
ED - Educational Elements
CN - Content
AE - Educational Agent
P2W - Pay to win
EVG - Educational Video Game

Chapter 1. Introduction

1.1 Scope of the Project and Motivation

In Portugal, math performance falls below acceptable levels, as per Ministry of Education data. At the elementary level, math ranks lowest among all subjects, with the highest failure rates. These challenges suggest issues in the learning process, indicating gaps in understanding and depth of math concepts.(Andrade et al,. 2021)

The provision of personal computers to students from the very beginning of their academic journey presents an opportunity to redefine the way technology is utilized in education. Recognizing the potential of these devices as tools for meaningful learning, this project aims to address the challenge of engaging students, particularly those with lower academic performance, through a dynamic and enjoyable approach.

The motivation behind this initiative is to transform the computer from a mere distraction into an effective educational tool. By harnessing the principles of gamification and educational games (edugames), the project aims to develop a captivating learning experience that focuses initially on multiplication, with the potential for broader applicability across the third-grade curriculum and beyond.

The primary goal is to offer a solution for students who struggle academically, providing them with an opportunity to improve their performance in a manner that is both fun and engaging. The ultimate aspiration is to stimulate students' enthusiasm for learning, shifting their perception from mundane exercises in grid-lined notebooks to interactive and immersive gaming experiences.

Through the development of engaging educational games, we aspire to broaden students' horizons by demonstrating that games can be more than mere pastimes – they can serve as valuable tools for enhancing cognitive skills and knowledge. By integrating gamification elements such as challenges, rewards, and competition, the project seeks to create an environment where students are motivated to excel and to assist each other in their learning journey.

Additionally, the project aims to foster healthy competition among students, encouraging them to push their boundaries and strive for excellence. By transforming

learning into a collaborative and exciting endeavor, we hope to reshape students' perceptions of education and motivate them to become more proactive and diligent learners.

As this project unfolds, the development of edugames will be carefully guided by sound educational principles, ensuring that entertainment aligns with educational content. This innovative approach holds the potential to reinvigorate the educational landscape, sparking interest in students who may have previously struggled to engage with traditional methods of learning.

Ultimately, this project is driven by the belief in the power of technology, gamification, and edugames to ignite a passion for learning among students, enabling them to unlock their full potential and strive for academic excellence in a way that is enjoyable, collaborative, and meaningful. The journey is embarked upon with the hope of nurturing a brighter future for all students.

1.2 Goals

This master's project aims to scrutinize an educational video game crafted through free-form deduction by a designer and programmer, focusing on a game designed to teach mathematical content. The primary objective is to assess its impact on learning and skill development among elementary school students. The study seeks to unravel the significant pitfalls encountered during the construction of educational games and identify the key constraints imposed by a small development team. Moreover, it endeavors to caution game developers about the intricacies of the subject, discouraging non-specialized ventures and shedding light on the principal risks associated with crafting functional and educational games and their implications for the teaching-learning process.

The overarching goal is to compose a heuristic evaluation for educational video games, drawing from an extensive literature review. This heuristic will serve as a valuable tool for assessing the effectiveness and educational value of such games. Additionally, the project aims to highlight the shortcomings and challenges faced by a free-form and non-educationally committed development approach. By doing so, it aims to contribute to the broader discourse on game design for educational purposes.

The project's focal points include understanding the nuances of game development for educational objectives, identifying common pitfalls in the process, and ultimately providing insights that can inform future endeavors in crafting educational games. Through this research, the intention is not only to evaluate a specific game but also to distill general principles and guidelines applicable to the broader field of educational game design.

Chapter 2. Related Work

2.1 Video Games

Defining the concept of a "videogame" is an important endeavor for scholars and enthusiasts alike, as these interactive digital experiences have become a prominent and influential form of entertainment and education. However, arriving at a precise and universally accepted definition is a challenging task, primarily due to several inherent complexities.

One key challenge lies in the sheer diversity of video games. They encompass an expansive spectrum of genres, styles, and mechanics, ranging from action-packed shooters to contemplative puzzle games. This diversity makes it difficult to encapsulate all video games within a single, rigid definition.

Moreover, videogames are an ever-evolving medium. Technological advancements continually expand the possibilities, blurring the boundaries between traditional gaming and other forms of interactive digital media. Thus, what defines a videogame today may not align with future iterations.

Additionally, videogames often serve multiple purposes. They entertain, educate, simulate, and even provide platforms for social interaction. This multifunctionality further complicates the task of crafting a succinct and comprehensive definition.

In essence, the challenge of defining videogames lies in their dynamic and multifaceted nature within a rapidly evolving digital landscape. Nevertheless, the pursuit of such a definition is crucial, as it forms the foundation for understanding how videogames impact various aspects of human life, from entertainment and education to culture and society. By addressing this challenge, scholars and enthusiasts can gain deeper insights into the unique and evolving world of videogames.

Nicolas Esposito's (2005) succinct definition of a video game as "a game which we play thanks to an audiovisual apparatus and which can be based on a story" (p.) encapsulates some of the essential elements of this digital medium. It highlights the interplay between audiovisual technology and gameplay, emphasizing the immersive nature of video games. Additionally, the acknowledgment of narrative elements

underscores the capacity of video games to offer engaging storytelling experiences, making them a unique fusion of interactive entertainment and narrative art.

Eric Zimmerman's (2004) definition of a game is "a voluntary interactive activity, in which one or more players follow rules" elegantly distills the essence of gaming. It underscores the fundamental concept of voluntary engagement, where players actively choose to participate in an interactive experience. The mention of rules highlights the structured nature of games, setting the stage for challenges, goals, and the dynamics that make games captivating. Zimmerman's definition emphasizes that at the core of every game is the willing interaction of individuals guided by a set of agreed-upon rules, making it a pivotal starting point for discussions on the nature and appeal of games.

Silva & Muller's (2012) definition of a game synthesizes key insights from prominent authors in the field of game studies. Their comprehensive definition, drawing from Salen and Zimmerman (2004), Schell (2008), and Adams (2006), offers a nuanced perspective on what constitutes a game. According to Silva & Muller (2012), a game is a meticulously crafted system where participants voluntarily engage in artificial conflict, navigating a structured environment defined by rules. These rules govern a problem-solving activity conducted with a playful spirit, set within the context of a simulated reality. Participants strive to attain non-trivial objectives, all while adhering to the established rules.

- A game is a system in which players engage in an artificial conflict, defined by rules, which result in something quantifiable (Salen and Zimmerman, 2004);
- A game is a problem-solving activity, conducted with a playful attitude (Schell, 2008);
- A game is a playful activity, carried out in the context of a simulated reality, in which participants try to achieve at least one arbitrary, non-trivial goal, acting in accordance with the rules (Adams, 2010).

This definition resonates for its ability to encompass the diverse nature of games, from the competitive to the educational, while emphasizing the interplay between rules, playful engagement, and structured conflict that defines the essence of gaming.

Dividing and categorizing games is a complex endeavor, akin to navigating the diverse, ever-evolving universe of interactive entertainment. Yet, it is a pursuit crucial for

understanding the multifaceted nature of games. Building upon the comprehensive definition provided by Silva & Muller (2010), which harmoniously incorporates perspectives from esteemed authors, we embark on a journey to explore the various lenses through which we can classify games. These lenses, or categorizations, offer insights into the fundamental characteristics, purposes, and player experiences that games encompass. By dissecting the world of games into these distinctive segments, we gain a deeper appreciation of the intricate tapestry of gaming, reflecting its capacity to entertain, educate, challenge, and inspire across a vast spectrum of forms and contexts.

- Action - These are real-time games, in which the player must respond quickly to what is happening on the screen, requiring skills such as quick reflexes and hand-eye coordination.
- Adventure - These are games based on a story and are related to exploration, in which the character goes on a journey to find things and solve puzzles.
- Construction and Management - In this type of game the objective is to build something within the context of a continuous process, and the more the player understands and controls the process, the greater success they will have.
- Educational - These are games that aim to teach specific knowledge content.
- Maze - These are games purely aimed at the intellectual challenge of solving problems.
- Sport - These are games that represent collective or individual sports.
- Strategy - These are games in which the player must manage resources to achieve a certain goal.
- Sandbox - These are games in which there is no winning condition; in general, these games provide attractive and fun activities, in which the player is free to choose or create.
- Fighting - These are games for one or two players, in which the character is controlled in order to carry out attack and defense actions against the opposing character.
- Massive Multiplayer Online - These are games, of any genre, played over the Internet, whether by one or thousands of players.
- RPG - These are games in which the player directs one or more characters, usually configured by him, on a mission, in different plots and scenarios.
- Simulator - These are games that reproduce situations and/or conditions of the real world, in a way that allows the player to do things that he would hardly be able to do in real life, in a controlled and safe environment.

- Artificial Life - These are games that simulate creatures that can interact with the environment, other players or agents.

In the diverse world of gaming, titles not only vary in genres but also cater to different player preferences and engagement levels. Games can be broadly classified into casual, midcore, and hardcore tiers, providing insights into player experiences and commitment levels. Unlike genres, which define thematic and gameplay elements, these categories reflect how games connect with players and the level of engagement they entail.

As Carla Fisher (2014) states:

- Casual - a player who tends to have limited time to play. Casual games are often designed to be played in short bursts.
- Core or Midcore - a player who enjoys a wide range of games but will invest time to play games that require a larger time commitment to complete.
- Hardcore - a player who invests a lot of time and energy in playing, often by playing games that require dozens of hours to complete. Hardcore gamers are often considered the stereotypical gamer.

Another crucial aspect in video games, is the synergy between immersion, engagement, and flow is pivotal in shaping memorable and rewarding player experiences. These three elements work harmoniously, forming a dynamic progression that begins with immersion, evolves through engagement, and ideally culminates in the state of flow. This sequential journey guides players from initial fascination with the game world, through active participation in its challenges, to a state of profound absorption and enjoyment. The interplay between these elements is at the heart of effective game design, where balance and alignment lead to deeply engaging and gratifying gaming encounters.

Immersion serves as the initial gateway to the gaming experience. Captivating storytelling, visually appealing graphics, and compelling audio design are essential to draw players into the game world from the outset. Immersion sets the stage by creating an emotional connection and a sense of curiosity about the game.

“Immersion is the feeling of being submerged in a form of entertainment, or rather, being unaware that you are experiencing an artificial world.” (Adams, 2014, p.)

Once players are immersed in the game world, engagement comes into play. This is where players actively interact with the game's challenges, mechanics, and objectives. Engagement can be fostered through well-designed gameplay that encourages exploration, problem-solving, and skill development. It's the stage where players invest their time and effort into the gaming experience.

“A value of user-experience that is dependent on numerous dimensions, comprising aesthetic appeal, novelty, usability of the system, the ability of the user to attend to and become involved in the experience and the user’s overall evaluation of the salience of the experience.” (H. L. O'Brien and E. G. Toms, 2008)

Flow is the pinnacle of the gaming experience and occurs when immersion and engagement align perfectly. In a state of flow, players are fully immersed in the game, and their level of engagement is so intense that they lose track of time. Flow often appears when the game presents challenges that are well-matched to the player's skill level, creating a sense of balance and progression. Achieving flow leads to a deep sense of enjoyment, satisfaction, and accomplishment.

“Most enjoyable activities are not natural; they demand an effort that initially one is reluctant to make. But once the interaction starts to provide feedback to the person's skills, it usually begins to be intrinsically rewarding.” (Mihaly Csikszentmihalyi, 1990)

2.1.1 Educational Video Games

Throughout history, a prevailing belief has persisted that children acquire valuable lessons through play. Research has revealed a strong alignment between the qualities of digital games and several modern learning theories. The theories most frequently referenced include constructivism (Jonassen, 1991; Piaget, 1962; Vygotski, 1978).

“The world has entered a bright new technology-driven era, yet the education system remains rooted in a gray industrial past” (Aaron M. Cohen, 2011, p.)

Educational games, often referred to as edutainment or serious games, are digital or analog games explicitly designed to facilitate learning or develop specific skills while engaging players in an enjoyable and interactive experience. These games incorporate educational content, objectives, or mechanics as a central component of gameplay.

“Games that do not have entertainment, enjoyment or fun as their primary purpose” (Michael & Chen, 2006, p.).

Educational games can cover a wide range of subjects and topics, including mathematics, science, language, history, critical thinking, and more. They are created with the intention of enhancing understanding, problem-solving abilities, and retention of information.

Educational games are used in various contexts, including formal education settings like classrooms and training programs, as well as informal learning environments, such as homeschooling or self-guided study. They cater to diverse age groups, from young children to adults, and are designed to accommodate different learning styles, and as stated by the National Research Council, the United States Department of Defense utilizes serious games since 1997.

Educational games distinguish themselves from traditional video games in fundamental ways. Where conventional video games prioritize entertainment and gameplay, educational games have a primary objective of facilitating learning, imparting knowledge, or honing specific skills

One intriguing concept associated with educational games is "tangential learning". This form of learning occurs incidentally, as players acquire knowledge or skills indirectly while engaged in gameplay. Tangential learning underlines the idea that both educational and non-educational games can provide opportunities for players to learn, often by exploring in-game narratives, solving puzzles, or enhancing problem-solving skills, as Mattar (2009) defends.

Deterding (2012) suggests, since the year 2000, the production of video games has been on the rise, and serious games have followed. This growth can be attributed to the fact that serious games were a relatively unexplored niche until then.

According to Simões (2013), since the term "serious games" gained prominence within the academic community, it has been observed that the fields of training and education have seen the most significant application of this concept, now commonly referred to as "game-based learning."

In line with Effelsberg & Gobel (2016), players can acquire theoretical concepts and practice at their own pace, independently. Based on their performance, they earn points that contribute to their advancement in a specific area of development.

Academically, there aren't many instances of universities developing their own math games. Instead, it's more common for educational institutions to adapt existing third-party games for classroom use, leveraging the expertise of established game developers (De Aguilera, M., Noguero, A., 2003; Lacasa et al,. 2010; Moreno-Ger et al., 2008)

While the academic creation of math games remains somewhat limited, the collaboration between game developers and education experts has yielded products that effectively teach math in an engaging and enjoyable manner.

In the context of educational games, it's essential to acknowledge that not all platforms offer engaging and immersive experiences. Some educational games, such as those found on the Porto Editora platform or any mobile distribution service, often fall short of creating truly interactive and captivating learning environments. Many of these games tend to resemble digital exercise workbooks, where students solve problems without much interactivity or motivation. This can result in a rather dull and uninteresting math learning experience for students(Aparício, 2019).

On the flip side, there are notable examples of math games that have achieved tremendous success and effectively engaged students, such as Math Prodigy or DragonBox.

Engage students by integrating interactive elements into the gameplay. Encourage them to actively participate in solving math problems, exploring virtual worlds, or completing challenges. Make sure the game mechanics are intuitive, ensuring that students can focus on learning rather than struggling with complex controls(Fisher, 2014).

Provide immediate and informative feedback. When students answer questions or complete tasks, offer clear responses indicating whether their answers are correct or not. Additionally, give hints or explanations for incorrect responses, promoting understanding and self-correction. Incorporate progress tracking features so that

students can monitor their performance and observe their progress over time.(Fisher, 2014)

Design games that adapt to individual student performance. Implement adaptive learning algorithms that tailor the game's difficulty level based on each student's abilities. This ensures that the learning experience remains appropriately challenging and avoids frustration or boredom, promoting sustained engagement and flow. (Fisher, 2014; Meftah et al., 2019)

Engagement is a vital component of effective educational video games. When students are engaged, they become active participants in the learning process, leading to improved comprehension and retention of information. (Hamari et al., 2016)

Interactive elements in games encourage students to apply what they've learned in real-time, fostering critical thinking and problem-solving skills. Additionally, the incorporation of storytelling or thematic elements can make the learning experience more immersive and relatable to students, while timely and informative feedback mechanisms offer students a sense of accomplishment and progress, motivating them to continue playing and learning as they witness the immediate results of their efforts.

“Educational adventure games are purposefully designed to provide “edutainment” (Surattana Adipat et all, 2021)

Rewards serve as potent motivators in educational games. They provide students with concrete objectives to pursue, ranging from collecting points to earning badges or in-game currency. These tangible rewards become the driving force behind students' engagement as they strive to accomplish tasks and overcome challenges within the game, as explained by Chaimar Meftah (Meftah et al., 2019). The allure of these incentives encourages students to invest time and effort in their learning, ultimately enhancing their educational experience.

Incorporating elements of competition and collaboration, rewards and recognition add an extra layer of depth to the educational game experience. Leaderboards and competitive features ignite healthy rivalries among students, compelling them to outperform their peers.(Redecker, Ala-Mutka & Punie, 2010) Simultaneously, collaborative aspects encourage teamwork and cooperation to achieve group goals. This

dynamic balance of competition and collaboration fosters a sense of camaraderie and shared achievement among students.

Within educational games, the persistent and immersive state of engagement, creates an environment conducive to optimal learning experiences, where students are deeply absorbed in their educational journey.

“When the entertainment aspects fail to shine in the design, most of the advantages of game-based learning in terms of motivation and engagement are lost and the learning experience suffers” (Koster,2004).

Flow, as defined by psychologist Mihaly Csikszentmihalyi, represents a state of complete focused concentration and elevated enjoyment during interesting activities, where individuals are so engrossed that they lose track of time and feel a sense of intrinsic reward. In educational game design, achieving flow is pivotal to fostering optimal learning experiences.

One of the key aspects of flow is maintaining an optimal balance between challenge and skill. Educational games must be designed to match the difficulty of tasks with the abilities of the players. If a game is too easy, students may become bored and disengaged. Conversely, if it's too challenging, they may become frustrated and give up. Striking this balance is a delicate art, as it requires adapting the game dynamically to the individual learner's skill level (Hamari et al., 2016).

Clear goals and immediate feedback are paramount in maintaining flow. Educational games should provide students with well-defined objectives and consistent feedback on their progress. This not only keeps them focused but also helps them gauge their performance and make necessary adjustments. (Colby & Colby 2008; De Aguilera & Noguero 2003)

Together, engagement and flow transform learners into active participants, igniting their motivation and driving them towards educational excellence as shown Hamari et al. (2016)

2.2 Gamification

As stated by Kai Eireli, observing young humans and animals, one can witness the natural inclination towards playful learning. This playful behavior persists throughout adolescence but tends to diminish as maturity sets in. Drawing a parallel with young students, it becomes apparent that the integration of playful elements in education often ceases after the elementary school phase(Eireli 2013).

The concept of gamification has traversed a remarkable journey, reshaping the dynamics of engagement and motivation in a multitude of fields. Rooted in various influences, gamification has emerged as a potent strategy, weaving elements from the world of games into non-game contexts.
The evolution of loyalty programs marked another stepping stone. In the 1980s and 1990s, businesses began adopting loyalty programs that incentivized repeat patronage. These programs often employed elements such as points, badges, and discounts to foster customer loyalty. While not explicitly recognized as gamification, they effectively utilized gamified components to enhance customer engagement(Djaouti et al., 2011).

There are two presumed origins of the term "gamification." Some experts attribute it to Daniel Burrus (2012), who is believed to have first used the term in 1980. On the other hand, there are experts who argue that it was British game developer Nick Pelling , founder of Conundra Ltd., who initially introduced the term in a consumer electronics context in 2002 (Dorfler, V., Macbryde, J. Spanellis, A.).

According to Deterding et al. (2011), the term "gamification" was officially documented only in 2008. However, it did not gain widespread adoption until the second half of 2010. During this period, although there were other parallel terms in use, such as "productivity games," "surveillance entertainment," "funware," "playful design," "behavioral games," "game layer," and even "applied gaming," "gamification" emerged as the popular and widely accepted term among the majority of the public. Nonetheless, it is worth noting that even today, "gamification" remains a subject of strong contention, particularly within the gaming industry and among the scientific community specializing in game studies(Deterding et al., 2011).

Human behavior is shaped by two distinct yet interconnected dimensions, intrinsic and extrinsic motivation. Intrinsic Motivation is rooted in personal interest, curiosity, and

enjoyment of an activity. It thrives when individuals have autonomy, the freedom to choose their actions, and aligns with their values and passions. Extrinsic Motivation is about external incentives such as rewards, recognition, or grades drive behavior in extrinsic motivation. While effective in promoting action, it relies on external influences and can diminish intrinsic motivation when overemphasized (McGonigal, 2011; Yukai Chu, 2015)

We should create different motivational game elements, and different kinds of reward systems. The effective integration of feedback mechanisms, a well-defined points system, and thoughtfully crafted rewards can significantly impact learner engagement, motivation, and overall educational outcomes.

Zanello (2014) summarize gamification elements as:

- Game based - Gamification revolves around creating a system in which users, whether students, players, or employees, willingly engage in an abstract challenge defined by the game's interactive elements, rules, and feedback mechanisms.
- Mechanics - Game mechanics, often associated with elements like levels and reward systems such as trophies, medals, or badges, may not inherently transform mundane tasks into enjoyable ones. However, they play a pivotal role in constructing the building blocks of gamification progress.
- Aesthetics - This element pertains to the visual aspect. A pleasant graphical environment and good design are essential for a rewarding gamification experience.
- Game design - It's the ability to transform a mundane everyday activity into a competitive one, enabling a narrative and fostering cooperation among users. This is the cornerstone of gamification.
- Engagement - It captures the user's attention, involves them in the created process, and keeps them motivated to stay engaged.
- People - These are the users of the gamified activity, which can be players, learners, students, consumers, or employees.
- Motivation - These are elements that drive users to perform the desired actions within the gamified activity.
- Promote learning - This element is based on educational psychology and aims to instruct, train, or prepare the user for a real-life situation.

- Problem solving - This final element of gamification seeks to stimulate problem-solving by harnessing the inherent competitiveness of the concept. Users strive to achieve objectives and win, employing creativity and seeking new ways to overcome obstacles.

In essence, by leveraging game mechanics and embracing a game-thinking approach, gamification aims to innovate and transform routine, typically tedious activities into engaging and enjoyable experiences. An appealing visual aspect further enhances user engagement, with correct aesthetics and game design ensuring a pleasing visual outcome. However, the full potential of gamification, which includes motivating actions, promoting learning, and enhancing problem-solving motivation through competition, can only be realized when all the aforementioned elements are present. It is through this comprehensive integration that the phenomenon of gamification comes to life.(Zanello, 2014)

As Aparicio stated, in schools, students earn grades as rewards for their academic performance, while good behavior may lead to positive recognition. Advancing to the next grade or year signifies passing a level. In gamification, points, badges, and virtual rewards are often used to motivate users, simulating progression and achievement.

Games evoke a range of emotions in learners, including positive ones like optimism and pride (McGonigal, 2011). Nevertheless, they can also elicit negative emotions such as frustration. In many instances, these negative emotions can be transformed into positive ones. This transformation is often a result of the repetitive trial-and-error nature of many games. In some cases, the only way to learn to play a game is through consecutive failures, with each failure providing a learning opportunity. This leads players towards a positive experience of self-improvement and accomplishment (Salen, 2008).

Today's youth represent the generation of gamers and social media enthusiasts, deeply immersed in the digital realm. They are accustomed to this form of language and approach, considering it the norm. To capture their attention in education, we should align our methods with these characteristics of the new generation (Sheldon, 2011).

Gartner states that approximately 80% of current gamified applications will fail due to inappropriate design and fine-tuning.

“But to be successful, it must include game design, not just game components” (Deterding, 2012)
As a glimpse of the potential future of gamification, who envisions a phenomenon Schell calls the "gameapocalypse". This concept is rooted in the idea of a hypothetical future where every aspect of daily life is gamified. From mundane tasks like brushing teeth to daily physical exercise or even the act of working, all aspects become game-like experiences (Schell, 2010).

This vision bears a striking resemblance to recent phenomena like Pokémon GO, Pokémon Sleep, and Pokémon Smile. These applications have gamified everyday activities, turning exercise, sleeping routines, and dental hygiene into engaging, game-driven experiences. They exemplify how gamification can extend into various facets of our lives, aligning with Schell's forward-thinking concept of a fully gamified future.

2.2.1 Octalysis Framework

The Octalysis Framework was created by Yu-kai Chou (Chou, 2015). He is one of the pioneers in applying game design elements to motivate actions in non-gaming contexts such as business, education, and marketing.

Chou (2015) developed the Octalysis Framework to provide a comprehensive and effective structure for understanding human motivation and how to apply it in different scenarios. The framework is designed to help people design more engaging, inspiring, and motivating experiences using gamification principles.

The Octalysis Framework is a valuable tool for designers, entrepreneurs, educators, and marketing professionals looking to create systems and products that captivate and motivate their target audience. With its eight-point approach, it offers a clear framework for analyzing and enhancing user motivation and engagement across various contexts.

Epic Meaning & Calling (Core Drive 1): This drive emphasizes the human desire for a sense of purpose and making a significant impact. In gamification, it involves creating a compelling narrative or mission that players feel connected to, inspiring them to take actions that contribute to a greater cause.

This core drive keeps players deeply engaged, as they feel a personal calling to utilize their math skills for a grand cause. The game's narrative reinforces the idea that math is not just a subject to study but a tool that can make a real difference. As the hero's journey progresses, players develop a strong connection to the game's epic meaning, ultimately making the mathematical challenges more enjoyable and inspiring.

Development & Accomplishment (Core Drive 2): This drive taps into our innate need for growth, achievement, and overcoming challenges. Gamification elements like leveling up, earning badges, or setting achievable goals can trigger this drive, encouraging users to progress and accomplish tasks.

The hero begins at a basic level, armed with a limited set of math skills represented by cards. These cards act as the hero's abilities during battles, allowing them to tackle math problems and challenges. As players successfully defeat enemies and complete levels, their hero's experience points increase. This experience leads to leveling up, where the hero's hit points (HP) and mathematical capabilities improve. This improvement enhances the effectiveness of their math cards, enabling the hero to tackle more challenging problems as they progress through the game.

Moreover, players can earn badges for significant achievements within the game. These badges serve as visible symbols of accomplishment, providing a tangible representation of a player's progress and mastery. Players accumulate these badges by excelling in various aspects, such as solving specific math problems, defeating powerful enemies, or reaching certain in-game milestones.

Empowerment of Creativity & Feedback (Core Drive 3): Core Drive 3 focuses on enabling users to express themselves, be creative, and receive feedback on their actions. Gamification often leverages this drive through customization options, creativity challenges, and prompt, constructive feedback.

Players can exercise their creative abilities by customizing their characters and fine-tuning the layout of their in-game village. This creative empowerment allows them to add a personal touch to their adventure, fostering a sense of ownership and connection to the game world.

The game also provides instant and constructive feedback when players attempt math problems. If a player's answer is incorrect, the game offers guidance on the correct solution, facilitating learning and improvement.

Ownership & Possession (Core Drive 4): People have a natural inclination to possess and own things. In gamification, this core drive can be engaged by offering virtual goods, collectibles, or in-game currency that players acquire and value.

The game incorporates a virtual economy, allowing players to earn in-game currency as they tackle math challenges and achieve milestones. This in-game currency empowers players to make choices regarding character customization, purchase power-ups, or acquire other desirable items.

Within the game, players accumulate virtual possessions, such as unique customization options, village upgrades, and badges.

Social Influence & Relatedness (Core Drive 5): This drive highlights our need for social connections and the influence of others. Gamification frequently incorporates social features like leaderboards, cooperative gameplay, or competition to tap into this drive, fostering a sense of community and social interaction.

Students engage in 1v1 competitions, cooperative battles against game monsters, and chat to enhance their learning experiences. Students can explore each other's islands. Beyond this, the game extends the social dimension by enabling inter-school competitions, creating a friendly yet competitive atmosphere among students.

Scarcity & Impatience (Core Drive 6): Core Drive 6 capitalizes on our fear of missing out, creating urgency and excitement through limited-time events, rewards, or exclusive content. This drive motivates users to act promptly to avoid missing opportunities.

The game introduces special timed events, daily and weekly bonuses encourage consistent engagement, enhancing the sense of anticipation and urgency to participate regularly, and the player can only play one level per day. These strategies leverage the desire for immediate gratification and the appeal of unique opportunities to maintain player motivation and interaction.

Unpredictability & Curiosity (Core Drive 7): Gamification leverages the appeal of unpredictability by introducing surprise elements, random rewards, or new challenges. This keeps users engaged and curious about what's coming next, encouraging them to explore and participate.

The game offers a mix of challenges, keeping players engaged by unpredictably alternating between question complexities. Periodic introductions of new math concepts ensure the gameplay remains fresh and intriguing.

Loss & Avoidance (Core Drive 8): This drive focuses on the desire to prevent losses or negative consequences. Gamification uses loss aversion by introducing consequences for inaction or mistakes, pushing users to take action and avoid undesirable outcomes.
Players have a set number of chances to answer math questions correctly. If they fail and exhaust their lives, they face a consequence of losing progress and possibly having to replay the level. This core drive encourages players to avoid losing lives by improving their math skills and staying engaged. Frequent reminders and notifications prompt players to return to the game, further invoking loss avoidance to maintain engagement.

2.3 Educational Games Analysis

In this section, I will delve into a selection of educational games that have served as foundational inspiration for the development of Math Masters. I will focus on those games that have notably distinguished themselves in the realm of educational gaming, providing a more in-depth review and analysis. For a comprehensive overview of additional games, please refer to the Reference Sheets available in the Game Design Document.

The games in this review can be played across various platforms, including PC, tablet, and smartphone, with some requiring web access through the Porto Editora website. Our analysis will encompass both free and paid games, providing insights into a diverse range of educational gaming experiences.

These diverse influences offer valuable insights and ideas as we strive to create an engaging and effective learning experience in Math Masters.

2.3.1 Prodigy Math

Prodigy Math is an online educational game designed primarily for students in the elementary age group, typically ranging from 1st to 8th grade. The game's primary focus is on math concepts, making it an effective tool for reinforcing mathematical skills while engaging students through an interactive gaming experience.

The game combines a role-playing game (RPG) format with math exercises. Players create a character, which they use to explore a magical world filled with challenges and adventures. To progress through the game and defeat various foes, players must correctly solve math problems. The difficulty of the math questions adjusts dynamically based on the player's performance, ensuring an appropriate level of challenge.

Figure 1. Prodigy Math battle

It offers both free and paid versions. The free version allows access to basic features, while the paid version provides additional benefits such as faster progression, more in-game rewards, and access to exclusive content. Premium Membership is available on a subscription basis.

Prodigy Math features a wide range of math exercises, covering topics from basic arithmetic to more advanced concepts like algebra and geometry. The game uses an adaptive learning system to select questions based on the player's skill level and progress.

Positive aspects:

- The game covers a wide range of math topics, allowing users to find content that aligns with their learning needs.
- It often adapts the difficulty level of questions based on user performance, providing tailored practice.
- Users can track their math progress and monitor their improvement over time.
- Character and pets customization

Negative aspects:

- Free version penalizes the player, making it a Pay to Win game (P2W).
- Premium Membership options can be costly.
- UI and visuals outdated.

Overall, Prodigy Math successfully combines gamification and mathematics, making it an engaging tool for reinforcing math skills in elementary and middle school students. The dynamic adaptability of the game's content ensures that each player receives a tailored learning experience, making math learning both effective and enjoyable.

2.3.2 Fun Math Facts: Games for Kids

Fun Math Facts Games for Kids is designed for young learners, typically in elementary school, who are looking to reinforce their math skills in an engaging and enjoyable way. It caters to kids aged 6 to 12.

Figure 2. Fun Math Facts Games for Kids

The game offers a collection of interactive math games and quizzes that cover various math topics, including addition, subtraction, multiplication, and division. Players can choose from a variety of game modes, such as timed quizzes or puzzle-solving activities. The goal is to provide a fun and interactive way for kids to practice and improve their math skills.

Fun Math Facts Games for Kids is available for free on mobile app stores, making it accessible to a broad audience. While it may offer in-app purchases, the core functionality is free.

The game presents math questions and challenges in an interactive and playful manner. It often includes colorful graphics, animations, and rewards to maintain engagement. Questions are typically tailored to the player's grade level and math proficiency, ensuring that the content remains relevant and challenging.

Positive aspects:

- The game offers a diverse range of math activities to cater to different learning styles and preferences.
- Interactive quizzes and games make math practice enjoyable and less intimidating for young learners.
- Parents and educators can track a child's progress, identifying areas where they excel and those that may require additional practice.

Negative aspects:

- Only covers basic math practice.
- Some free versions may include advertisements, which could distract young players.

In summary, Fun Math Facts Games for Kids serves as an effective tool to reinforce math skills in elementary school students. By offering a variety of interactive math activities, it keeps young learners engaged and motivated to practice essential math concepts. While it may have limitations in terms of advanced math coverage, its primary focus is on creating a fun and educational math experience for kids.

2.3.3 Learn Math & Math Problems

Learn Math & Math Problems is designed for a broad audience, spanning from elementary school to high school students. It offers math learning resources and practice problems suitable for a wide age range.

The game provides a platform for learning and practicing mathematics through a variety of exercises and quizzes. Users can choose math topics based on their grade level or specific areas they want to focus on. The game aims to enhance math comprehension and problem-solving skills by presenting questions and challenges in a format that may not be very engaging.

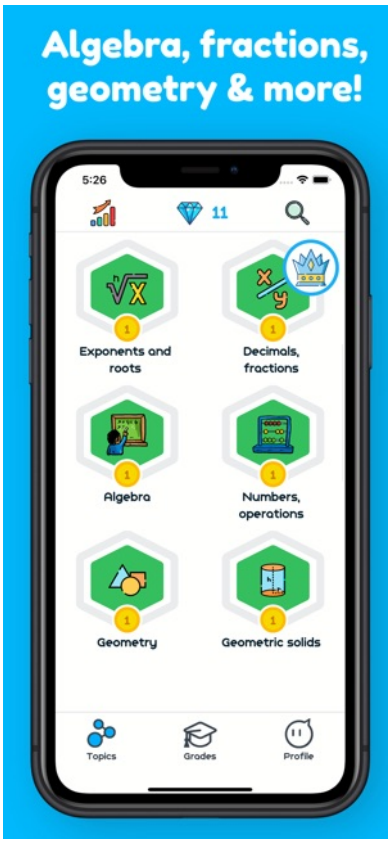


Figure 3. Learn Math & Math Problems simple UI

Learn Math & Math Problems offers a variety of math exercises, ranging from basic arithmetic to more advanced concepts like algebra and calculus. Users can select exercises that match their grade level or math proficiency. The game typically presents questions in a text-based format, requiring users to input their answers.

This game is often available for free, making it accessible to a wide range of users. In some cases, it may offer premium features or ad-free versions for a fee, but the core math content is typically accessible without charge.

Positive aspects:

- The game covers a wide range of math topics, allowing users to find content that aligns with their learning needs.
- Users can track their math progress and monitor their improvement over time.

Negative aspects:

- While effective for math practice, some users may find the interface less engaging compared to gamified math apps.
- It primarily focuses on presenting math problems and may benefit from additional interactive features to enhance engagement.

In summary, Learn Math & Math Problems serves as a valuable resource for math learning and practice, appealing to a broad audience of students. Its wide range of math topics and progress tracking features make it a useful tool for improving math skills and understanding. Because it does not have gamified elements like other math apps, it is practically a digital notebook.

2.3.4 Porto Editora

Porto Editora offers a range of games tailored for various academic years. The one depicted above is designed for third-grade students, focusing on addition, though similar games exist for all four basic arithmetic operations.

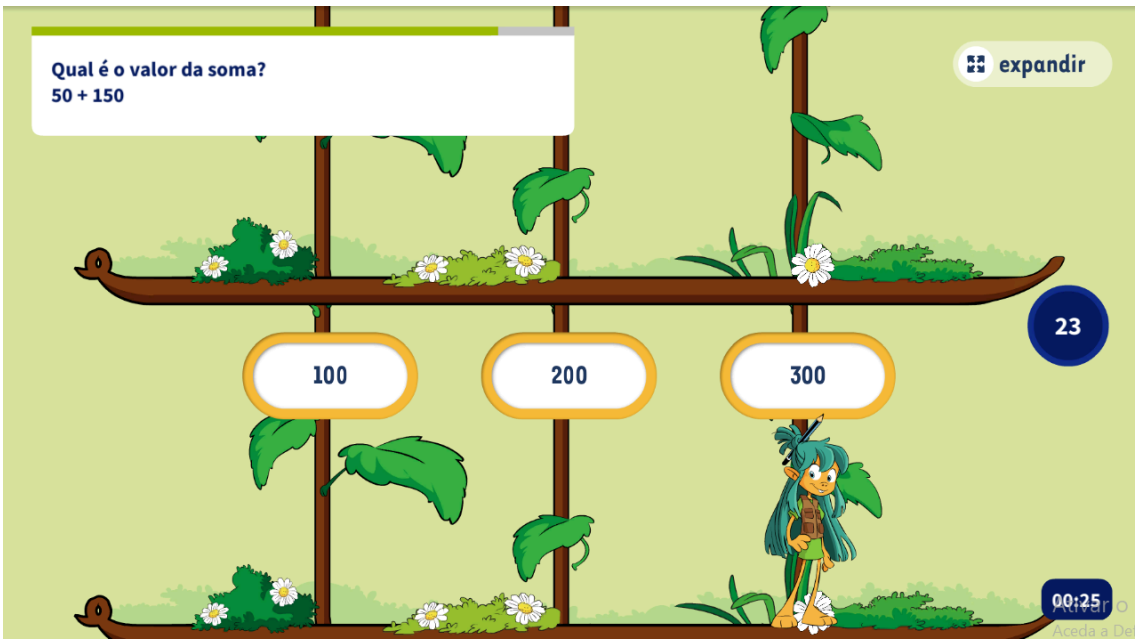


Figure 4. Game published by Porto Editora

At first glance, the game appears straightforward in terms of gameplay and user interface (UI). Winning is easily achievable as players only need to select the correct answer. Even in the event of an error, there are no penalties, players can continue selecting responses until reaching the correct one.

Positive aspects:

- Simple gameplay
- Simple UI

Negative aspects:

- No penalties
- Easy to cheat the game

In summary, the game seems simple in terms of gameplay and UI. It is easy to win in this game because players only need to choose the correct answer. However, there are several ways to improve the game to make it more challenging and engaging.

2.4 Heuristics

Heuristics, derived from the Greek word "heuriskein," meaning "to discover" or "find," are problem-solving techniques that human beings have employed since time immemorial. The concept has roots in ancient philosophy, with Aristotle and other early thinkers contemplating the methods by which individuals arrive at solutions without exhaustive reasoning.

The emergence of heuristics in psychology gained prominence in the mid-20th century, notably through the work of Nobel laureate Herbert A. Simon and his collaborator Allen Newell. They brought attention to these problem-solving strategies, suggesting that individuals frequently rely on heuristics for decision-making in intricate environments where exhaustive analysis may be impractical. This shift in perspective marked a significant contribution to the understanding of human cognition and decision-making processes.

As cognitive psychology delved into how humans think and make decisions, heuristics became recognized as essential mental shortcuts that enable efficient problem-solving. They manifest in various forms, such as availability heuristics and representativeness heuristics, each catering to distinct aspects of decision-making.

Availability heuristics involve relying on readily available information when making judgments or decisions. If information is easily accessible or prominent in one's memory, it is more likely to influence the decision-making process. For example, if recent news reports emphasize a specific event, individuals might overestimate the likelihood or importance of that event due to its increased availability in their minds.

Representativeness heuristics, on the other hand, involve making decisions based on how well an individual or object matches a prototype or stereotype. Rather than objectively evaluating probabilities, people often use representativeness to categorize information quickly. For instance, if someone encounters a person who fits their mental prototype of a librarian, they may assume that the person is a librarian, even if the available information is insufficient to make such a conclusion. Both availability and representativeness heuristics showcase the brain's remarkable ability to simplify decision-making processes, although they can lead to biases and errors in judgment. (Amos Tversky & Daniel Kahneman, ano)

Heuristics, in the context of game design, serve as guiding principles or rules of thumb that facilitate effective problem-solving and decision-making. When applied to the evaluation and enhancement of the user experience in games, heuristics become essential tools.

One of the key advantages of heuristics lies in their practical approach to identifying potential issues and areas for improvement. Game designers and developers can systematically assess various dimensions, including user interface design, instructional clarity, and overall gameplay experience, by using heuristics as a comprehensive checklist (Vieira et al, 2018).

Heuristics act as a lens through which designers can view their games from the perspective of the player. By doing so, they provide valuable insights into potential design flaws or usability challenges that might compromise the educational effectiveness of the game. This user-centric approach ensures that the game remains engaging, intuitive, and conducive to the intended learning outcomes.

In the realm of educational game design, heuristics play a crucial role in aligning the game's objectives with pedagogical goals. They help in creating a seamless and enjoyable learning experience, balancing entertainment with educational content. Heuristics also contribute to the iterative design process.

The application of heuristics to game design represents a natural extension of their utility. In the gaming realm, heuristics serve as invaluable tools for designers to streamline the user experience, identify potential issues, and enhance overall gameplay. By incorporating these cognitive shortcuts, game developers create experiences that align with players' mental models and facilitate engagement. The journey of heuristics from ancient philosophical ponderings to modern-day game design illustrates their enduring relevance as powerful instruments for efficient problem-solving in diverse contexts.

2.4.1 Heuristic PHEG

The heuristic "Playability Heuristic Evaluation for Educational Computer Game" (PHEG) suggests a heuristic evaluation method focused on educational computer games, with an emphasis on playability. This method was developed based on the Heuristic Evaluation (HE) technique, which is an expert-driven usability evaluation

approach to identify usability problems in products or systems during the interactive design process.

PHEG consists of five specific heuristics: Interface (IN), Educational Element (ED), Content (CN), Playability (PL), and Multimedia (MM). Each heuristic has associated sub-heuristics, totaling 37 sub-heuristics. Experts from different areas, such as interface design, educational, multimedia, and game developers, are involved in the evaluation process.

The method aims to overcome common challenges in heuristic evaluation processes, such as presenting usability problems based on the mean severity ratings. Instead, it proposes a quantitative analysis, taking into account the number of severity ratings for critical problems found in each heuristic. This approach aims to provide a more accurate insight into usability problems, highlighting the most critical ones in specific parts of the educational game.

To conduct the evaluation, an online tool called AHP_HeGES was developed to bring together experts from various backgrounds, enabling them to collaboratively conduct the evaluation process. The quantitative analysis of the collected data is performed through percentage calculations for each heuristic and sub-heuristic.

The evaluation results indicate that the Educational Element and Content heuristics have the highest percentage of critical usability problems, while Playability has the lowest percentage. The overall average of critical problems found, indicated as an indicator of the overall usability level, is 42.42%.

This innovative approach in Heuristic Evaluation for educational games provides a structured tool and method for assessing the usability of educational games during development. Developers can use these results to understand critical areas that need improvement, thereby enhancing the quality of educational games.

2.4.2 Heuristic HEDEG

Named HEDEG (Heuristic Evaluation for Digital Educational Games), this initiative aims to extend the existing PHEG heuristic set . The primary objectives of this extension include creating new heuristics that encompass additional quality elements in Educational Video Games (EVGs), addressing limitations in the original PHEG set.

Additionally, the adaptation of some PHEG heuristics is undertaken to enhance objectivity, facilitating a more confident assessment by evaluators. The overarching goal is to enable effective evaluations, even when conducted by less-experienced evaluators (non-experts).

HEDEG stands out as a set of specific and objective heuristics tailored for the assessment of Educational Video Games (EVGs). Its design addresses limitations in previous sets, making it accessible for non-expert evaluators. Covering categories such as Interface, Education, Content, Gameplay, and Multimedia, HEDEG provides clear guidelines for a comprehensive evaluation. The evaluation process involves a detailed analysis of the game, with evaluators assigning severity levels to identified issues. Notably, HEDEG demonstrates superior performance in problem identification compared to previous sets, particularly when compared to the PHEG heuristic. It emerges as a valuable tool for assessing quality in Digital Educational Games. (Pedro Valle et al, 2013)

Interface (IN): refers to elements that facilitate communication between students and the game environment.
Educational elements (ED): encompass features that aid in the construction of knowledge by students.
Content (CN): is associated with the subject matter that students will engage with during the game.
Gameplay (JG): includes elements related to the player's experience during interaction with the game.
Multimedia (MM): pertains to multimedia elements within the game, such as sounds, images, videos, among others.

In conclusion, the HEDEG heuristic represents a significant evolution from PHEG, addressing additional areas of evaluation in EVGs and aiming to make the guidelines more objective. The inclusion of new heuristics and adaptations to make existing ones clearer demonstrates an effort to enhance the quality of evaluation, enabling its application by non-expert evaluators. However, it is evident that the heuristic can still benefit from additional improvements to more comprehensively address the various elements involved in EVG evaluation, aiming for a more complete and refined assessment. This ongoing progress in heuristics highlights the commitment to seek more effective methods to assess and enhance the quality of Digital Educational Games.

2.4.3 Heuristic MEEGA

This heuristic assesses various factors, with an emphasis on learning outcomes, motivation, user experience, and usability. Learning is a central aspect, often evaluated through test scores or self-assessments post-gameplay. Motivation is measured using the ARCS model, which considers attention, relevance, confidence, and satisfaction. User experience is multifaceted, encompassing elements like fun, social interaction, challenge, immersion, and more.

MEEGA (Model for Educational Evaluation of Games), was specifically designed for educational games. MEEGA concentrates on assessing learning and user experience during gameplay, also incorporating the motivation promoted by the game. Systematically developed, MEEGA employs an explicit decomposition of evaluation goals into measures and defines a questionnaire validated through case studies. Its practical application spans seven different studies, indicating practical acceptance.

This model appears to be widely adopted, with seven different studies from various authors employing MEEGA to evaluate distinct games in different educational contexts. Its versatility is reflected in its application, showcasing its relevance not only in computing education but potentially across diverse knowledge areas. The fact that multiple studies utilize MEEGA underscores its acceptance and effectiveness as an evaluation framework.

Unlike some studies that lack clarity in defining evaluation objectives, measures, or data collection instruments, MEEGA offers a systematic and validated approach. By using this model, researchers and educators can establish a common ground for evaluating the impact of educational games. The inclusion of motivation as an integral aspect in MEEGA aligns with the broader trend in educational game evaluations, recognizing motivation as a crucial factor in effective learning experiences.

2.4.4 Heuristic AHJED

After careful consideration, I ultimately chose AHJED as my preferred framework for assessing educational digital games. My decision was based on its comprehensive

nature, drawing upon insights from the other heuristics, as well as its capacity to provide a more holistic evaluation. It stood out as the most well-rounded and robust choice for evaluating the educational quality and user experience of digital games, reaffirming its value in the field of educational game assessment and development.

While PHEG, HEDEG, and MEEGA have their merits, AHJED emerges as a more comprehensive and integrated approach to assessing educational games. AHJED draws inspiration and insights from these earlier heuristics but goes a step further by incorporating elements that address various aspects of game design, educational effectiveness, and user experience. AHJED outperforms the others in providing a more robust and thorough evaluation of educational games, highlighting its significance as a valuable tool in the field of educational game assessment. (referência)

The AHJED framework consists of various dimensions, each tailored to evaluate specific aspects of an educational digital game:

Interface (IN): The interface dimension assesses the elements that form the basis of player interaction with the game. It examines the clarity, consistency, and overall user-friendliness of the game's interface.

Gameplay (JG): JG evaluates the player's experience while interacting with the game. It encompasses elements such as control mechanisms, progression, and the level of challenge provided.

Multimedia (MM): MM is dedicated to evaluating the multimedia elements present in the game, including sounds, animations, and videos. This dimension ensures that these elements contribute effectively to the overall learning experience.

Artificial Intelligence (IA): IA assesses the complexity and consistency of challenges presented by the game. It delves into the game's adaptability and responsiveness to the player's actions.

Game Story (HJ): HJ focuses on the narrative aspects of the game, considering how the story engages and immerses the player. A compelling story can enhance the learning experience in an EDG.

Educational Elements (ED): ED is a critical dimension that evaluates the educational experience that players gain through their interactions with the game. It examines the alignment of the game's design with educational objectives.

Content (CN): CN is responsible for scrutinizing the accuracy and completeness of educational content presented in the game. Educational accuracy is paramount in ensuring that learning objectives are met.

Educational Agent (AE): AE assesses any virtual characters or sensors within the game environment that support the player during interactions, thereby enhancing the educational experience.

To categorize identified issues, AHJED employs a system of quantifiers, ranging from 0 (no issues found) to 4 (critical issues). This scale helps prioritize the identified problems for game developers and designers.

Even though I had carefully considered and documented the heuristics, it's important to note that not every aspect could be fully implemented in the game at this moment. Time constraints posed limitations on what could be incorporated into the current version of the game. However, the heuristics served as invaluable guidelines for making informed decisions and prioritizing the most critical elements to enhance the player experience.

Chapter 3. Methodology

This chapter provides an in-depth look at the development methodology behind Math Masters. It covers the vision, design principles, production process, content selection, and reception of the game.

The project's inception aimed to create an innovative educational tool for primary school children, with the primary objective of improving their mathematical performance through an engaging and enjoyable gaming experience. The underlying vision was to seamlessly blend gameplay and learning, encouraging continuous math practice, providing constructive feedback, and granting students the autonomy to choose their learning path.

The game's design philosophy emphasized simplicity and accessibility. The visual aesthetics adopted a low-poly 3D style, characterized by vibrant colors and a whimsical storyline. Interactions within the game mirrored those of tablet or smartphone apps, employing intuitive drag-and-drop or click-and-drag mechanics. These design choices were intended to make the game relatable and enjoyable for young players. Importantly, the game tracked player data, enabling future analysis of performance and behavior.

The game's structure was conceived to be linear, offering players a progressively challenging journey. The central focus of the game centered on multiplication, with mathematical calculations serving as the foundation for both combat mechanics and progress through the game.

Unity was selected as the development platform due to the team's familiarity with the engine. The game was tailored for Windows-based computers, ensuring compatibility with the prevalent hardware found in Portuguese primary schools. Online connectivity was an integral component of the game's functionality.

All in-game assets, including character models, environments, and animations, were sourced from the Unity Asset Store. These assets cohesively contributed to the game's visual appeal, creating a vibrant and engaging world. Although the user interface (UI) initially presented some visual inconsistencies, subsequent refinements enhanced its integration with the overall game aesthetic.

The game's development unfolded in two distinct phases: pre-production and production. During the pre-production phase, extensive research was conducted, encompassing heuristic analyses of educational games, narrative crafting, character conceptualization, and mechanics formulation. The production phase focused on implementing these design elements into the Unity 3D engine.

Prototyping played a pivotal role in refining the game's design. Iterative processes were employed, particularly for the village and battle components, to optimize camera perspectives, character animations, and level layouts. This iterative approach ensured the best possible player experience.

The game was distributed via the itch.io (https://thejokelion.itch.io/math-masters), ensuring accessibility for all students. To gain insights into player behavior and experiences, two questionnaires were included, focusing on study habits and game satisfaction.

It is essential to address the disparities between the game's initial conceptualization and its ultimate realization. The original vision encompassed a more extensive gameplay experience, incorporating a city management aspect where students could relax, modify the island's layout, and customize their homes and avatars. Unfortunately, due to time constraints and limitations in using the game engine, these envisioned features had to be omitted.

The finalized version primarily focused on the mathematical component, although in a more condensed form than initially intended. The game lacked the adaptive elements that were originally conceptualized, meaning it did not dynamically adjust to each player's progress or explore a broader range of mathematical exercises. The absence of the relaxation and customization component, which was initially conceived as an integral part of the gameplay, is a notable deviation from the original plan.

These divergences were not a result of oversight or lack of consideration but were necessitated by practical challenges during the development process. Despite these constraints, the implemented features were designed to align with the educational objectives for third-grade students, emphasizing engagement and learning through interactive gameplay.

In game design and educational technology, heuristics play a crucial role in guiding the evaluation and development of products. They are practical rules that streamline problem-solving, enabling quicker decision-making. When assessing educational games, heuristics offer a structured framework to evaluate key dimensions essential for the game's effectiveness as a learning tool.

The AHJED heuristic provides a structured approach to assess various dimensions of educational digital games, ensuring a holistic evaluation. Its dimensions cover interface, gameplay, multimedia, artificial intelligence, game story, educational elements, content, and educational agents.

To apply AHJED to the evaluation of the developed educational game, a systematic process was followed. The game underwent a detailed analysis, with a focus on each dimension outlined in the AHJED framework. Interface aspects were scrutinized for clarity and user-friendliness, while gameplay elements were assessed for player experience and progression challenges. The multimedia dimension evaluated the effectiveness of audiovisual elements in enhancing the learning experience. Artificial intelligence was analyzed for adaptability and challenge consistency, and the game story was examined for its engagement and immersion qualities.

Educational elements and content were fundamental components of the evaluation, ensuring alignment with educational objectives and accuracy of presented information. The educational agent dimension focused on assessing virtual characters or sensors supporting player interactions within the game environment.

Identified issues within each dimension were categorized using a quantifier system, ranging from 0 (no issues found) to 4 (critical issues). This scale facilitated prioritization for subsequent development phases. The evaluation process provided valuable insights into the areas of improvement for the educational game.

It is crucial to note that while AHJED served as a robust evaluation tool, some limitations were encountered during implementation. Time constraints influenced the extent of incorporation of certain aspects into the current game version. Despite these limitations, the AHJED framework guided informed decisions, prioritizing enhancements that would most positively impact the player experience.

The use of AHJED in this evaluation not only ensures a rigorous examination of the educational game's quality but also contributes to the broader field of educational game design and assessment. The insights gained from this evaluation methodology serve as a foundation for future iterations and improvements to the educational game, fostering its continued development and effectiveness in facilitating learning experiences.

After the completion of the Math Masters game, I conducted a series of interviews with education and games professionals to gain valuable insights into its strengths and weaknesses. These interviews, lasting approximately 20 minutes each, comprised nine questions aimed at comprehensively assessing the game's impact and user experience.

The Expert Review questions covered a spectrum of aspects, starting with the participants' overall impressions of playing Math Masters. Subsequent inquiries delved into the perceived educational value of the game, evaluating its effectiveness in enhancing multiplication skills. Participants were also prompted to share their perspectives on the game's difficulty level, interactivity, ease of use, variety of activities, and visual design.

Furthermore, the interview sought feedback on the perceived progression within the game, its balance, and its potential utility in an educational setting. The professionals were encouraged to articulate their opinions on specific areas for improvement or immediate implementation.

These interviews served as a valuable post-launch assessment, allowing for a nuanced understanding of Math Masters' reception within the target audience and providing crucial insights for refining and enhancing the game.

Despite challenges, Math Masters marks a foundational step in leveraging gamification for education. Ongoing development, incorporating suggested enhancements, contributes to the broader discussion on effective technology integration in education, emphasizing iterative improvement and user feedback for meaningful learning experiences.

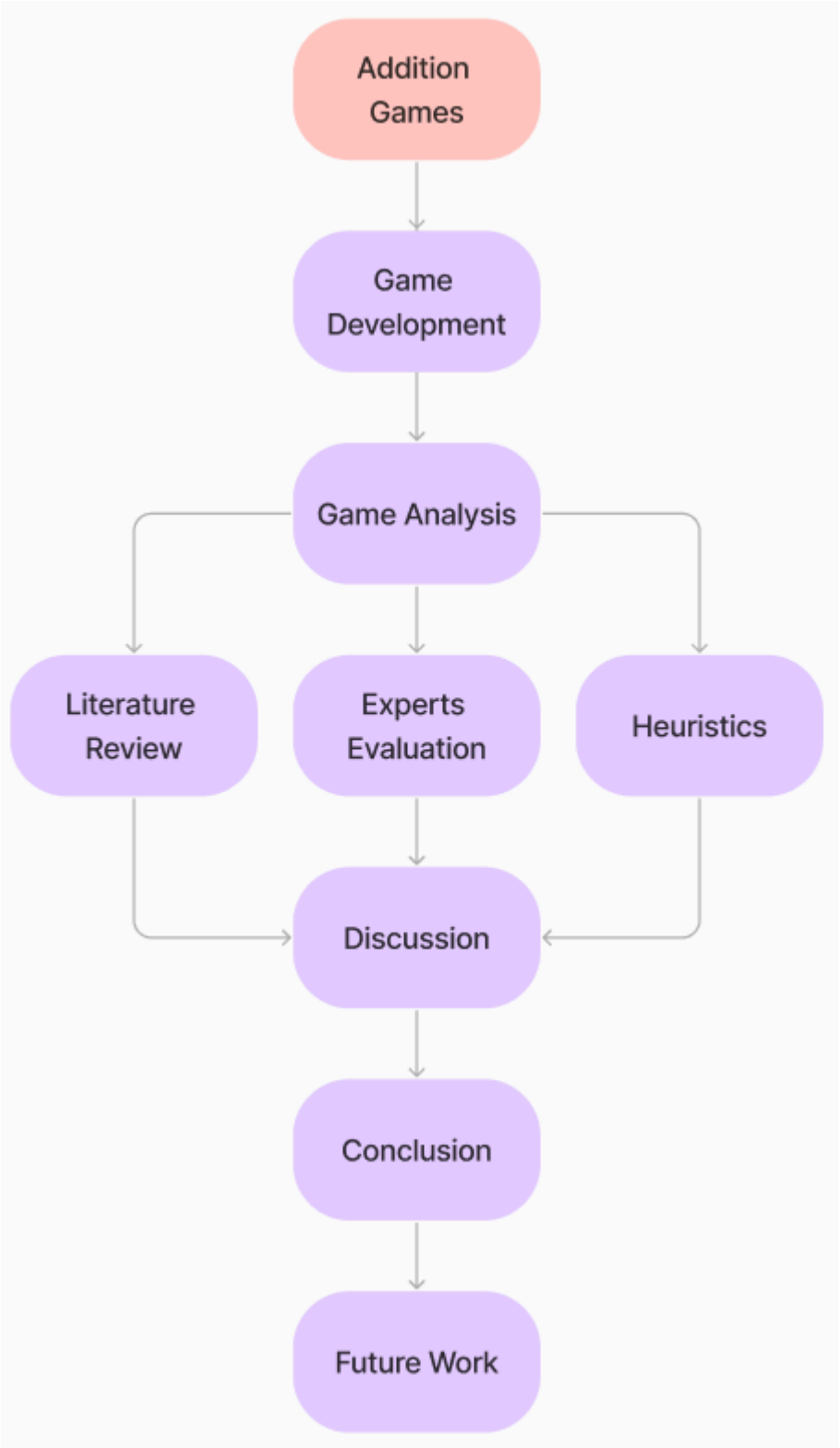


Figure. 5 - Methodology flowchart

Chapter 4. Game Development

The development of the game was guided by a blend of inspiration from various sources, including key insights from books like Designing Games for Children by Carla Fisher and the principles of gamification, in Actionable Gamification by Yu-kai Chu, as well as ideas from successful educational games like Prodigy Math. These invaluable resources laid the foundation for our game's creation.

Within this creative journey, we carefully honed game mechanics, opting for a user-friendly, interactive style that resonates with our primary audience—young learners. The game's visual style was meticulously chosen to be engaging, employing colorful, low-poly 3D graphics to create an inviting and vibrant world.

The cast of characters and storyline were crafted with a keen understanding of what would captivate our target demographic. Our game is primarily aimed at primary school students, aiming to foster engagement and enthusiasm for mathematics.

Throughout development, rigorous testing and prototyping ensured that our game effectively combines gameplay with educational objectives, resulting in a delightful learning experience. These elements collectively contributed to the game's evolution and effectiveness as a captivating educational tool.

4.1.1 The Team

The inception of the 'Math Masters' concept was rooted in the desire to make math education more engaging and enjoyable for elementary school students. Recognizing the growing prevalence of video games among young learners, I envisioned a game that seamlessly blended gameplay with math learning to create an effective educational tool.

To bring this vision to life, I needed a skilled programmer who could navigate the technical complexities of game development. This is where Abel Marques came into the picture. Abel, with his programming expertise, was the ideal collaborator to transform this concept into a fully functional game. His proficiency in Unity, a popular game development platform, made him an invaluable asset to the project.

We believed that by merging our respective skills and interests, we could create a unique and effective learning experience for students. Our collaboration proved to be a harmonious blend of creativity and technical know-how, culminating in the development of Math Masters.

4.1.2 Game Engine

Unity, a versatile and powerful game development engine, was the natural choice for developing 'Math Masters.' This decision was influenced by several key factors, primarily its familiarity and the expertise we gained from using it during our course.

Moreover, Unity offers a wide array of assets and plugins that greatly facilitate game development. For Math Masters, we leveraged these resources to create a visually appealing and dynamic world. Unity's compatibility with various platforms, including Windows, allowed us to ensure accessibility to a broad audience, aligning with our goal of making the game available to as many students as possible.

One of the key advantages, the Unity Asset Store is its vast library of 3D models, animations, textures, and audio resources. These assets provided us with a wide range of options to craft a visually appealing and engaging game world. Instead of dedicating extensive time to creating custom assets from scratch, we were able to select and integrate premade assets that aligned with the game's vibrant and child-friendly aesthetic.

Furthermore, the Unity Asset Store offered a selection of plugins and tools that enhanced our game's functionality. From UI elements to particle effects, we could access and incorporate these resources seamlessly into our project. This not only accelerated development but also ensured a polished and professional result.

Unity, as our development platform, and the Unity Asset Store were pivotal in Math Masters creation, streamlining our workflow and elevating the game's visual and functional aspects.

4.1.3 Platform

The choice to develop Math Masters exclusively for Windows stems from the widespread accessibility of computers and internet connectivity among primary school

students in Portugal. Given these circumstances, Windows serves as a reliable platform to ensure that the game can be accessed by the majority of young learners.

As for the current limitation to PC play, this decision primarily arose from initial development constraints and practical considerations. While the intention is to make the game available on other platforms in the future, starting with Windows allowed for a smoother development process and ensured that the game could be quickly deployed to its target audience.

To facilitate easy access for both students and teachers, we opted for the itch.io platform for game distribution. Itch.io offers a user-friendly interface that aligns with the needs of our primary school audience, simplifying the process of accessing and enjoying Math Masters.

4.2.1 Description

In Math Masters, players embark on an educational adventure as a heroic character set on saving their island from impending doom. The game's primary focus is to gamify education, stimulating learning among elementary school students by integrating mathematics into a captivating gaming experience.
Math Masters focuses on making mathematics enjoyable and accessible to elementary school students. By incorporating math exercises into battles and city management, the game aims to reinforce mathematical concepts, problem-solving skills, and critical thinking. The gamified approach sparks curiosity, motivation, and a positive attitude towards learning.
Overall, Math Masters is an adventure game that combines the excitement of a heroic quest with the educational benefits of mathematics. By integrating math exercises into engaging gameplay mechanics, customization options, and interactive features, the game offers an immersive and enjoyable experience for students, fostering a love for learning and building essential skills.

4.2.2 Game Concept

Math Masters is an adventure game where players embark on a heroic quest to save their island from a villain and his army of monsters. In this unique educational project, the power of mathematics becomes the hero's magic, allowing them to overcome

challenges and defeat enemies. The game aims to gamify education and promote learning among elementary school students.

The game's mechanics are divided into two main parts. Firstly, there is a city management aspect where players are tasked with rebuilding and restoring the island. They must strategically allocate resources, construct buildings, and develop infrastructure to enhance the island's prosperity.

The second part of the game involves engaging in exciting battles against the villain and his monsters through a card-based system. Players use cards to select math exercises, and upon successfully solving them, they launch powerful attacks against the enemy. This innovative gameplay mechanic intertwines educational content seamlessly into the adventure, making learning an integral part of the gaming experience.

Math Masters also offers a high level of customization. Players can personalize their avatars, allowing them to create unique characters that reflect their individual style. They can also customize their island, shaping it according to their preferences and unlocking new features and areas as they progress. Additionally, players can interact with their peers through in-game messaging, fostering collaboration and friendly competition. Joint missions and challenges can be undertaken together, promoting teamwork and engagement.

Overall, Math Masters provides an immersive and entertaining adventure that combines the excitement of an epic quest with the power of mathematics. Through city management, card-based battles, customization options, and interactive features, the game aims to make learning math engaging and enjoyable for elementary school students, fostering a love for education while fostering social interaction and cooperation among players.

4.2.3 Gameplay

Math Masters offers an engaging gameplay experience where players embark on an adventure to save their island by utilizing the power of mathematics. The game combines exploration, turn-based combat using cards, and educational challenges to create an immersive learning journey.

Players navigate the village using the mouse, freely exploring its surroundings without restrictions. Throughout the village, players can engage in dialogue with their mentor, who provides guidance and hints on what needs to be done. Additionally, interactions with NPCs in shops and buildings add depth to the world and provide valuable information.

The game's levels are linear, consisting of multiple stages where players must defeat enemies. Each level comprises a minimum of three stages and a maximum of six, with some levels featuring mini-bosses as final challenges.
Combat in Math Masters follows a turn-based approach, using cards as the primary mechanic. Players must solve math problems correctly to unleash attacks on the monsters they encounter. However, if an answer is incorrect, the player loses a life.
While there are no specific puzzles or logic challenges, the core gameplay revolves around math exercises and problem-solving. Players are rewarded with experience points, coins, cards, weapons, new buildings, and medals as they progress through the game and defeat enemies.
In addition to combat and exploration, Math Masters offers various activities for social interaction and cooperative play. Players can challenge their friends or classmates, engage in cooperative missions, and even compete against other schools or classes. The game also provides access to educational videos that explain exercises and concepts, allowing players to deepen their understanding of math topics.
To facilitate progression and resource management, players earn money by defeating enemies and can set up plantations and mines to gather additional resources. These resources are used to feed NPCs, rebuild buildings, and enhance the island's infrastructure.
The math exercises presented in Math Masters vary in complexity and format. Depending on the card used, players may encounter simple arithmetic problems requiring keyboard input, image selection, or multiple-choice answers.

4.2.4 Target Audience

Math Masters targets elementary school students, typically aged 8 to 12 years, with an emphasis on engaging and empowering them through educational gameplay. It aims to captivate young learners and inspire their interest in mathematics, providing an entertaining and rewarding gaming experience.

4.2.5 Monetization

To generate revenue with the game, Math Masters adopts a monetization approach through a paid subscription. Players have free access to the game for a 1-month trial period, allowing them to explore and engage with the gamified educational experience. After the trial period, players have the option to subscribe to an annual membership for 10€-20€. This subscription offers exclusive benefits, including unlimited access to

additional content, regular updates and ongoing support. By embracing this affordable subscription model, the game aims to provide a quality experience while ensuring the sustainability and continuous development of the educational project.

4.2.6 Retention

To retain players in Math Masters, we can implement several strategies inspired by Yu-kai Chou's book "Actionable Gamification." These strategies are tailored to enhance player engagement and commitment:

Core Drive 1: Epic Meaning & Calling

- Establish a compelling narrative within the game that makes players feel like heroes embarking on an important quest to save the virtual world.
- Emphasize the significance of math mastery in overcoming in-game challenges, fostering a sense of purpose.

Core Drive 2: Development & Accomplishment

- Implement a leveling system that allows players to progress and earn rewards as they complete math challenges.
- Provide achievements and badges for reaching specific milestones, encouraging players to strive for continuous improvement.

Core Drive 3: Empowerment of Creativity & Feedback

- Offer players choices in customizing their avatars, creating a sense of ownership and personalization.
- Provide immediate and constructive feedback on math problems to help players learn and improve.

Core Drive 4: Ownership & Possession

- Incorporate a virtual economy where players can earn in-game currency through math achievements.

- Allow players to spend their earnings on avatar customization, power-ups, or other desirable items.

Core Drive 5: Social Influence & Relatedness

- Introduce social features such as leaderboards or friendly competitions among classmates to foster a sense of community.
- Enable players to form study groups or teams to solve math problems together, promoting collaboration.

Core Drive 6: Scarcity & Impatience

- Players can only unlock one level per day..
- Offer daily or weekly bonuses to incentivize regular gameplay.

Core Drive 7: Unpredictability & Curiosity

- Introduce variability in the difficulty of math problems. This unpredictability keeps players engaged as they don't know what to expect in terms of difficulty.
- Occasionally introduce new math challenges or concepts to keep the experience fresh and exciting.

Core Drive 8: Loss & Avoidance

- Incorporate a limited lives mechanic where players have a set number of chances to answer math questions correctly.
- Use gentle reminders and notifications to encourage returning to the game.

By applying these gamification strategies, Math Masters can enhance player retention by tapping into the intrinsic motivations and psychological triggers that keep players engaged and committed to improving their math skills while having fun.

4.2.7 Mechanics

Exploration
Players can freely explore the town, interact with NPCs and discover new areas.

Quests and Missions

Players receive quests and missions from NPCs, guiding them through the game's storyline and providing objectives to accomplish.

City Management

Players manage and rebuild the island's structures, including constructing new buildings, upgrading existing ones, and maintaining resources for the island's development.

Deck Building

Players collect and manage a deck of math-based cards representing various abilities, spells, and attacks. They strategically select and customize their deck to optimize their combat effectiveness.

Turn-Based Battles

Battles are fought in a turn-based format, where players and enemies take turns executing actions. Players use their math cards to perform attacks, defend, cast spells and utilize special abilities.

Math Problem Solving

To perform attacks and cast spells during battles, players must solve math problems associated with their chosen cards. Correct answers result in successful actions, while incorrect answers may lead to consequences or missed opportunities.

Character Progression

Players earn experience points by completing quests and defeating enemies, allowing them to level up their character. Leveling up unlocks new abilities, increases stats, and enhances the player's combat capabilities.

Resource Management

Players gather resources, such as coins and materials, to support the island's development and upgrade buildings. Effective resource management is essential for progress and success in the game.

Customization

Players can customize their avatar's appearance, as well as the layout and design of their house and the island itself. This allows for personalization and a sense of ownership in the game world.

Social Interaction
Players can interact with NPCs, engage in conversations, and form relationships with characters in the game. They may also have opportunities for cooperative missions with friends or competitive challenges against other players.

While not all mechanics have been fully implemented at this stage, the following description outlines the intended final form and functionality of the game.

4.2.8 Game Art

The art style of Math Masters is characterized by its vibrant and colorful visuals. Inspired by the Greek aesthetic, the game features a low-poly art style with cartoony elements, creating a visually appealing and playful atmosphere.
The characters, both the hero and the NPCs, are brought to life with smooth and lively animations, enhancing the overall charm of the game. Each character has a distinct design, reflecting their personalities and roles within the story. The special effects during combat, level-ups, and victories add excitement and visual flair to the gameplay, immersing players in the magical world of math.

4.2.9 Badges

Players are rewarded with badges for accomplishing significant milestones and noteworthy achievements during gameplay. These badges serve as symbols of their progress and accomplishments, stored in their personal profile as a virtual trophy case. By earning and collecting badges, players can track their achievements and showcase their success in the game.

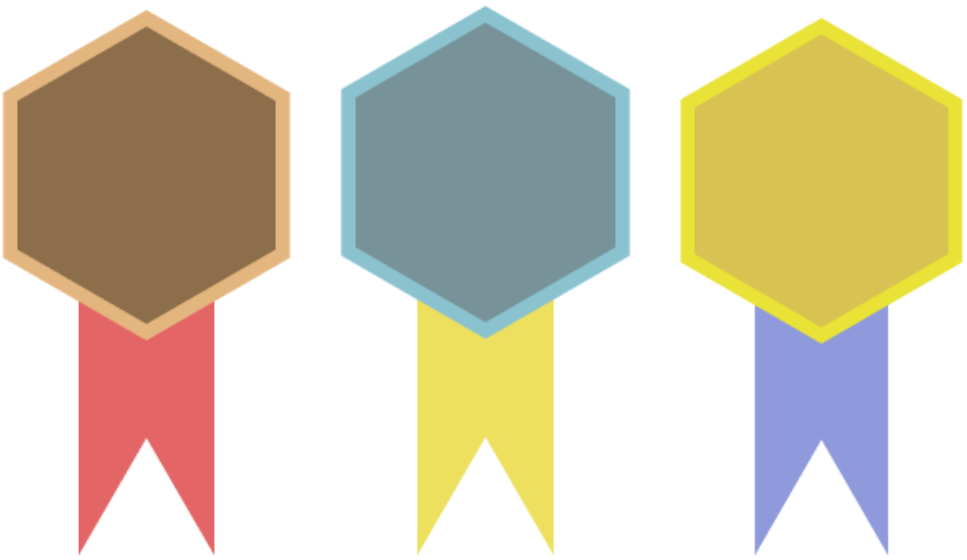


Figure 6. Badges

4.2.10 Levels

The game consists of multiple levels that offer engaging challenges and exciting gameplay for players. Each level is carefully designed to provide a progressive learning experience while keeping the gameplay enjoyable and rewarding.

Figure 7. Layout of Samos Town

In the town, players can engage in various activities such as interacting with NPCs, visiting shops to purchase items and upgrades, customizing their avatar's appearance and house, and managing resources to rebuild and improve the island.

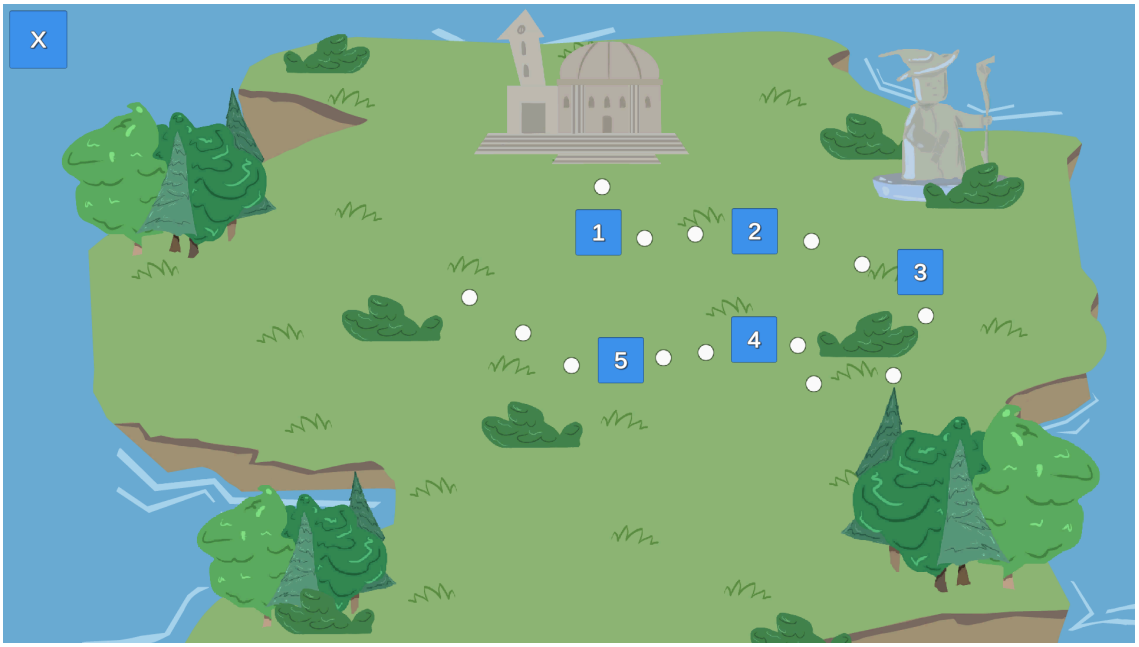


Figure 8. Layout of the Level Selector menu

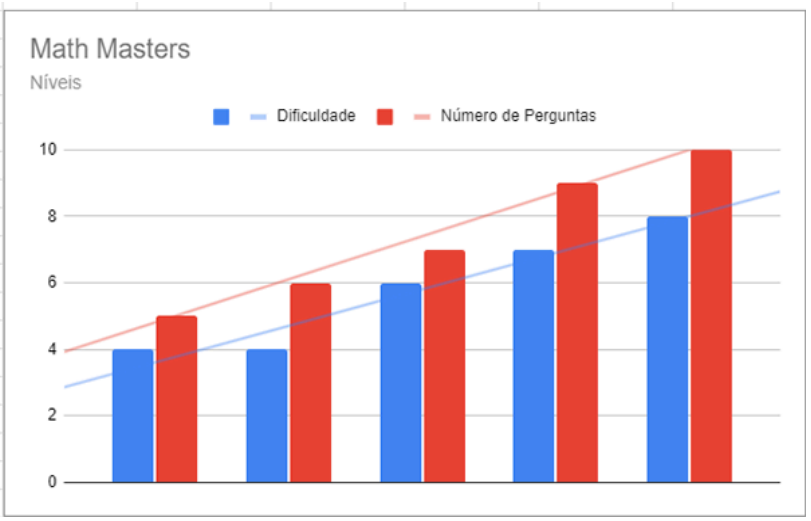
The level selector allows players to choose from a variety of levels, each with its own unique challenges and objectives. Players can navigate through an interactive map, selecting and unlocking levels as they progress. Only two levels are unlocked each day.

Figure 9. Different combat phases

In combat, players engage in turn-based battles using their mathematical skills as magical abilities. They must solve math problems to unleash powerful attacks and defeat enemies, combining strategy and problem-solving in exciting and dynamic battles. Each level has three to six phases.

Table 1. Game progression and balance

Level	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Level Difficulty	Numer of Questions
1	Red Slime	1	Red Slime	1	Spike Slime	1	Red Slime	1			4	5
2	Red Slime	1	Spike Slime	1	Monster Chest	2					4	6
3	Red Slime	1	Monster Chest	2	Red Slime	1	Beholder	2			6	7
4	Red Slime	1	Red Slime	1	Monster Chest	2	Horned Bug	3			7	9
5	Red Slime	1	Spike Slime	1	Beholder	2	Mini Lich	4			8	10
												37



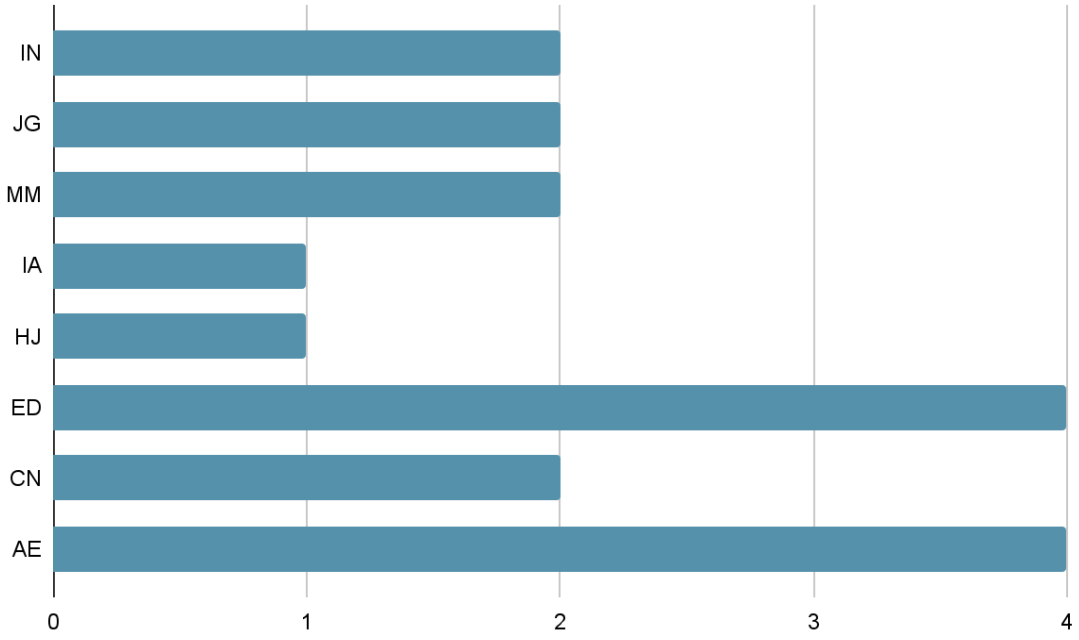
The game features a gradual difficulty progression, with increasingly complex mathematical challenges, ensuring continuous and engaging learning for the players. Additionally, the difficulty adapts to the player's performance, offering more challenging exercises for those who consistently answer correctly and providing a smoother pace for those who need more practice.

Chapter 5. Heuristic and Tests

The development of educational games often presents challenges in aligning prototypes with initial design plans. This introduction explores the current disparities between the developed prototype and the intended features outlined in the AHJED heuristic. The AHJED heuristic, encompassing Interface, Gameplay, Multimedia, Artificial Intelligence, Game Story, Educational Elements, Content, and Educational Agent serves as a comprehensive guideline for designing effective educational games. By examining the existing discrepancies, this study aims to identify areas for improvement and guide future iterations of the game prototype to better adhere to the AHJED principles. Through this analysis, we endeavor to enhance the educational value and user experience of the game, ultimately fostering more effective learning outcomes.

Below there is a table illustrating the heuristic evaluation quantitatively, highlighting the shortcomings of the prototype.

Table 2. Graph of the heuristic values in the game



Given that interface design is categorized as a low-priority issue (2), it will be addressed towards the latter stages of the project as part of the refinement process. The focus will be on enhancing the visual aesthetics of the game and refining its color palettes to create a more engaging and cohesive user experience. By prioritizing other critical

aspects of the prototype first, such as functionality and content, we ensure that the core elements are robust and functional before dedicating resources to cosmetic improvements. This approach allows us to iterate on the interface design with a solid foundation in place, ultimately leading to a more polished and visually appealing end product.

Similarly to the interface, gameplay is considered a low-priority issue (2) and does not have a significant negative impact on the prototype right now. However, to ensure a smooth gameplay experience and mitigate any potential issues, implementing a tutorial with voice-over guidance and improving what was done by being more obvious will be beneficial. This tutorial will provide players with clear instructions on how to navigate the game mechanics, helping them understand key concepts from the first playthrough. Additionally, allowing players to customize their avatar and village adds a layer of personalization and engagement, enhancing the overall gaming experience and encouraging continued interaction with the educational content.

This point is also identified as a low-priority issue (2), and like before, it will not be addressed immediately. However, there are still some issues to be corrected, such as improving movement and combat animations, enhancing the clarity of actions when clicking or hovering over cards, and refining sound effects. These improvements will contribute to a more polished and immersive gameplay experience, ensuring that players can engage with the game mechanics effectively and enjoy a more satisfying overall experience.

The artificial intelligence is classified as a low-priority issue (1), and there are no major adjustments needed. However, implementing adaptive gameplay based on the number of correct/incorrect answers could enhance the experience. This feature would enable players to encounter more difficult or easier monsters depending on their performance in answering questions. By incorporating adaptive elements into the gameplay, the game can dynamically adjust its difficulty level to better match the player's skill level, providing a more tailored and engaging experience for each individual player.

Expanding upon the narrative and dialogue elements of the game is considered a low-priority (1) task. While enhancing the storyline and character dialogues can greatly contribute to the overall immersion and enjoyment of the game, these aspects do not directly impact the fundamental gameplay dynamics or mechanics. Therefore, addressing narrative development and dialogue improvements can be deferred to later

stages of the project, allowing more immediate issues and higher-priority tasks to be addressed first. By prioritizing tasks based on their impact on gameplay and overall player experience, development efforts can be allocated more efficiently to ensure the game's success and quality.

Addressing the educational elements is deemed a high-priority task (4). To improve this aspect, modifications to the combat mechanics are necessary, transforming the cards into exercises that players must solve rather than standalone numbers. Additionally, it's essential to provide access to progress tracking, including the ability for students, teachers, and parents to monitor incorrect and correct responses. Enhancements to player progression and leveling systems should also be implemented to ensure a more comprehensive educational experience. By prioritizing these improvements, the game can better align with its educational objectives and offer more meaningful learning opportunities to players.

Content's rating of 2, indicating a low priority problem, it's essential to focus on creating interactive tutorials separate from the main game to guide players in solving each exercise. These tutorials should offer comprehensive explanations and step-by-step guidance to ensure that players grasp the concepts effectively. By providing dedicated learning resources, players can enhance their understanding of the content and improve their problem-solving skills within the game. This approach aims to address the identified content-related issues and elevate the overall educational value of the game.

Regarding the Educational Agent, which was also rated as a 3, it stands out as another critical aspect to be addressed promptly. It is imperative to ensure that players, as well as those supervising them, such as teachers and parents, have access to progress tracking, including information on incorrect and correct answers. Additionally, providing feedback to students at the end of each exercise is crucial for reinforcing learning and facilitating improvement. By implementing these features, the game can effectively support the educational journey of players while fostering collaboration between students, educators, and parents.

The heuristic evaluation has provided valuable insights into the strengths and weaknesses of the educational game prototype. By prioritizing the identified issues based on their severity and impact, it is evident that certain aspects, such as the Educational Elements and the Educational Agent, require immediate attention due to

their crucial role in supporting learning and user engagement. By systematically addressing these issues, the educational game can evolve into a more effective and engaging learning tool, better fulfilling its intended purpose of supporting students' educational goals.

5.1 School

Considering the dissertation on this topic by André Aparício in 2018, the short testing timeframe didn't yield results significant enough to showcase improvements in students' development. To observe meaningful progress, students would need to engage with the game over an extended period, not just in a few sessions. For conclusive improvement results, a master's thesis comes short. It should involve long-term testing throughout the academic year, comparing the performance of students using the game with a control group that doesn't have access to it.

Moreover, the game should ideally be played at home to provide a calmer environment free from classroom pressures and teacher influence. In these tests, my focus was primarily on studying students' study and gaming habits. This allowed me to gain insights into the potential impact of an educational game on students who increasingly have access to and spend more time playing games or using screens for various activities.

The tests were conducted at the Mirandela and Miranda do Douro elementary schools during the third term of the 2022/23 academic year, specifically on the 15th and 27th of June. This time frame corresponds to the final weeks of the school year. In Mirandela, a third-grade class participated, while in Miranda do Douro, there were classes from the second, third, and fourth grades involved. To facilitate this process, prior arrangements were made with the school district, which subsequently approved the activity. Following this approval, and with the consent of the respective teachers, permissions were sent to parents or guardians. These permissions allowed the students to participate in the activity.

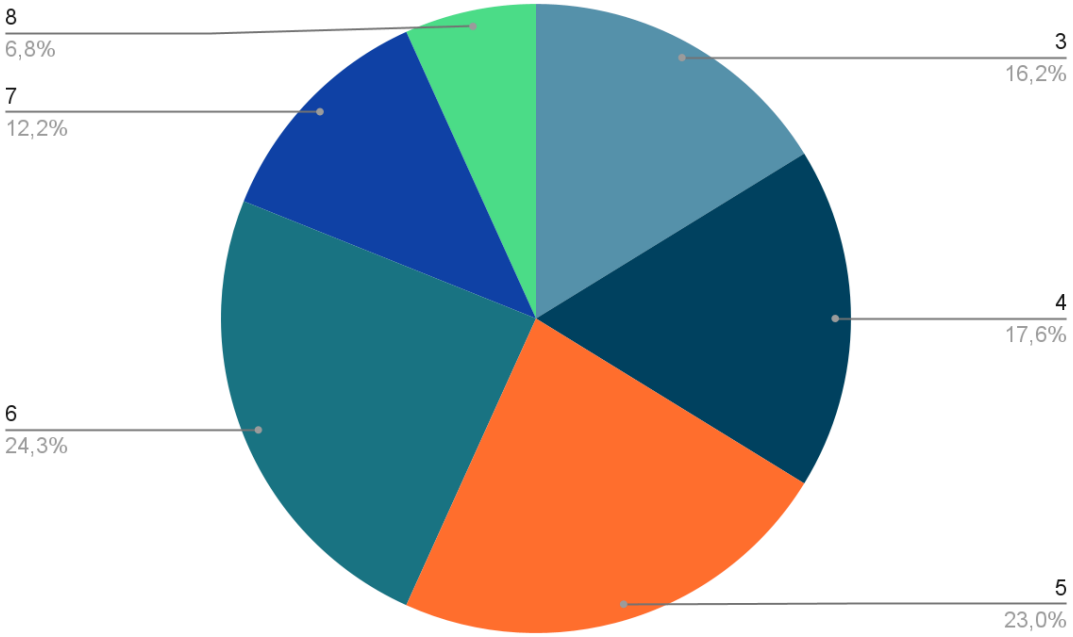
In the school environment, I conducted the activity with separate classes. The students displayed enthusiasm for the activity, and the teachers appeared intrigued, without showing any resistance.

The activity consisted of three main phases. Initially, students completed a questionnaire regarding their study and gaming habits. Subsequently, the students played the Math Masters game. Finally, they filled out a questionnaire to express their opinions and feedback on the game.

According to the American Academy of Pediatrics, more than 90% of children older than 2 years play video games (Daniel Alanko, 2023), students are increasingly introduced to gaming at a young age, often through friends or family.

As children grow older, their engagement with gaming intensifies, with many dedicating several hours each week to playing various types of games. The age distribution of gaming initiation among children and adolescents, depicted in the graph below, highlights this trend.

Table 3. Ages students start to play videogames.



Understanding when students begin gaming and how their gaming habits evolve over time is crucial for educators and game developers to tailor educational interventions and game designs effectively. This insight enables them to create engaging and developmentally appropriate experiences that cater to the diverse needs and preferences of young learners.

The number of hours students spend on both studying and gaming is remarkably similar, ranging from 10 to 15 hours per week.

Table 4. Number of hours students play per day

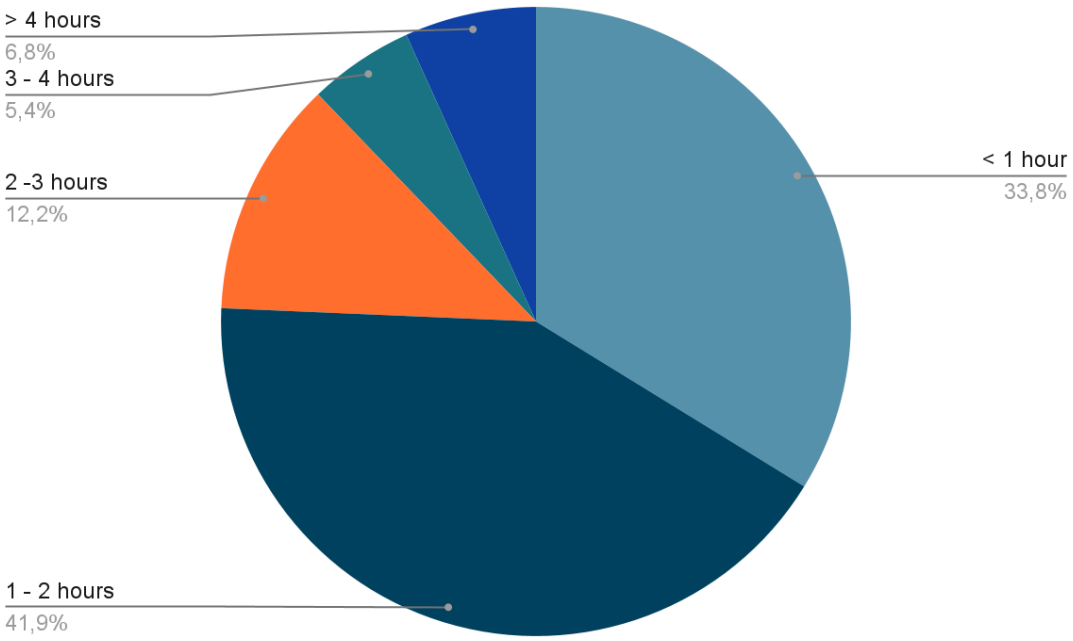
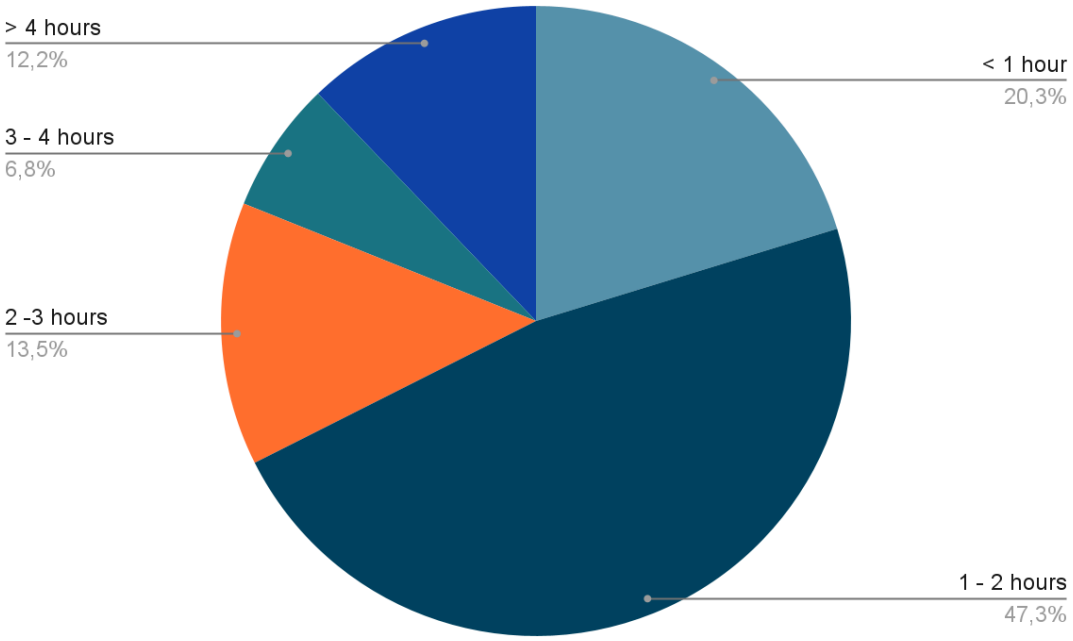


Table 5. Number of hours students study per day

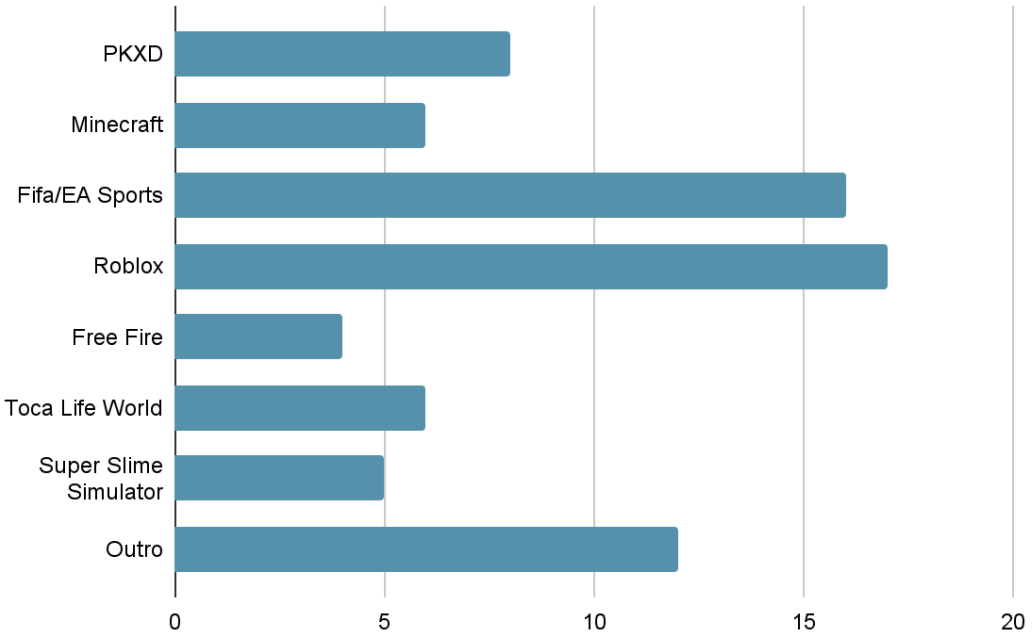


This parallel in time allocation underscores the significance of gaming in the lives of students, alongside their academic pursuits. Understanding the balance between gaming and studying is essential for educators and parents to support students effectively. Additionally, it highlights the importance of incorporating educational content within games to complement traditional learning methods.

"So video games, like any other technological device, are simply media through which young people engage in particular activities. Or, seen from another angle, they are no more than another feature with symbolic, economic, and technological dimensions in a complex social context that is constantly subjected to an intense and accelerated process of change that affects all spheres of everyday life." (Miguel de Aguilera & Alfonso Mendez, 2003)

Their gaming preferences often lean towards titles that offer freedom and adventure, such as Roblox and PK XD, which rank among the most popular games among students. These choices reflect a desire for immersive experiences where they can explore virtual worlds, interact with other players, and unleash their creativity.

Table 6. Games most played by the students



For students, gaming serves not only as a source of entertainment but also as a medium for socialization and relaxation. Understanding these preferences provides insights into how educational content can be integrated into gaming experiences to engage students more effectively, as stated by Prensky (2001), an effective educational game design must achieve a balance between fun and educational value.

Concerning the gameplay aspect, students accessed the game via their computers through a website where the game was readily available for download. This website was accessible to anyone (https://thejokelion.itch.io/math-masters). After downloading the game and assisting the students in logging in, I allowed them to play independently without any assistance or hints.

The duration of the activity ranged from 1 to 2 hours, mainly dependent on the students' proficiency in using computers. Several challenges were encountered, notably internet connectivity issues caused by multiple students accessing it simultaneously. This disruption occasionally forced players to restart levels. Additionally, some classes did not realize they needed to bring their computers, while a few students exhibited limited familiarity with computer usage despite it being included in the curriculum.

Overall, the feedback from both teachers and students indicated a positive experience with the game. Teachers recognized its potential as a supplementary tool for enhancing extracurricular studies, while students expressed excitement and eagerness to continue playing. The enthusiasm displayed by students suggests that the game effectively captured their interest and engaged them in learning activities. Further exploration of incorporating educational content into gaming experiences holds promise for enriching students' learning experiences and fostering a more dynamic educational environment.

5.2 Experts Evaluation

This chapter involves the participation of six experts—three from the field of gaming and three from the field of education—who were tasked with testing and analyzing the game. The goal was to identify what aspects of the game are well-executed and what areas require improvement to ensure that the game meets the standards of a high-quality educational game.

Here, I introduce the six experts who participated in the evaluation of the game. Their diverse backgrounds in gaming and education provide a comprehensive perspective on the game's strengths and areas for improvement.

Starting with one of my advisors, Professor Ernesto Vilar Filgueiras is a recognized expert in UX Design for Product Design and Digital Artifacts and video games. He is an Associate Professor in Design at the University of Beira Interior, with extensive academic experience and over 80 publications in international journals and scientific book chapters. His research spans UX Design, ErgoDesign, Digital Product and Video Game Design, and has been referenced in over 220 international studies. Professor Filgueiras is renowned for his innovative approaches to technology transfer between academia and the market, improving usability, accessibility, and user satisfaction in various contexts. Additionally, he actively supervises doctoral and master's students, contributing significantly to both academic and professional communities.

Vitaliy Davydovych is currently pursuing a PhD in Media Arts at the University of Beira Interior. He holds a Master's degree in Design and Development of Digital Games from the same university, and a Bachelor's degree in Games and Multimedia from the Polytechnic Institute of Leiria. He is an Assistant Professor at the Polytechnic Institute of Leiria, teaching courses in 3D Modeling, 3D Art, and 3D Production in the Games and Multimedia program. Additionally, he works as a 3D artist at AstralShift.
Theodore Hilhorst is a Level and Game Designer with over seven years of experience in the gaming industry. He currently works as a Senior Technical Designer at 2K Czech, working on various AAA projects. His tenure at 2K Czech includes roles as a Mission Designer and Senior Technical Designer, where he contributed to developing main story missions and implementation of game mechanics and features.
Since June 2017, Theodore has also been a Dungeon Designer for Lordbound, where he creates open-world dungeon and level designs.
Theodore has a Bachelor of Applied Science (BASc) in Game Architecture and Design from Breda University of Applied Sciences, which he completed in 2020.

Sandra Carina Machado Guimarães holds a PhD in Psychology from the University of Beira Interior (2016), a Master's degree in Psychology with a focus on School Psychology from the University of Minho (2006), and a Bachelor's degree in Psychology from the University of Minho (1999). She has extensive experience as a psychologist and educator, having worked at the Psychological Consultation and Human Development Service at the University of Minho and various educational

institutions. She has taught at the Polytechnic Institute of Porto and the University of Minho. Currently, she is an Assistant Professor in the Department of Psychology and Education at the University of Beira Interior, where she lectures on multiple courses across different programs. She is a member of the Education and Psychology Research Centre at the University of Évora and a collaborating member of the LabCom-Communication and Arts Research Unit at the University of Beira Interior.She has published numerous book chapters and journal articles, supervised doctoral theses and participated in various research projects. Her work focuses on teaching and learning processes, motivational and emotional variables in mental health, self-regulation of learning, emotional regulation, inclusive education, and environmental psychology.

Alice Imbana holds a Bachelor's degree (1995) and a Licentiate degree (2004) in Basic Education from the Instituto Jean Piaget in Macedo de Cavaleiros. She has extensive teaching experience, having worked in various schools across the districts of Bragança, Braga, and Porto, and is currently teaching in Miranda do Douro. Alice has been a dedicated educator since 1995 and is currently at the 6th level of her teaching career. She has also pursued additional training in Artistic Education in Basic Education, Numbers and Operations in Mathematics for the 1st Cycle, and Literary Education in the 1st Cycle of Basic Education.

Paula Vaz holds a Bachelor's degree (1995) and a Licentiate degree (2004) in Basic Education from Instituto Jean Piaget in Macedo de Cavaleiros. With a teaching career spanning since 1995, she has taught in various schools across the districts of Bragança, Braga, and Porto, and is currently teaching in Mirandela. Paula is in the 5th tier of her teaching career and has completed additional training in areas such as Artistic Expression: Development and Creativity, Numbers and Operations in Mathematics for the 1st Cycle, and Educational Continuity and Transitions in Portuguese.

The evaluation process began with the experts playing the game, followed by brief interviews to gather their feedback and insights on their gaming experience. This method was designed to collect comprehensive data on the game's effectiveness and areas for enhancement from a professional perspective. The interviews were structured around six questions, aimed at obtaining detailed responses regarding various aspects of the game. Following the interviews, I will compare the responses from all the experts to identify common points of agreement as well as areas of disagreement. This

comparative analysis will help pinpoint the strengths of the game and highlight specific aspects that need improvement.

The first question posed to the experts was: "What was your overall impression from playing Math Masters?"

The experts noted several strengths. They highlighted that the game features good graphics, which contribute positively to the overall visual experience. Additionally, they appreciated the simple yet effective game mechanics, which were easy to understand and worked well in practice. The game was also praised for being intuitive and easy to pick up and play, making it accessible to a wide range of players.

However, there were several areas identified for improvement. The user interface was described as weak, needing significant enhancements to be more intuitive and user-friendly. Another key point was the lack of animations, particularly in providing feedback during battles. Adding such animations would greatly improve the feedback mechanism, making the gameplay more engaging and informative. Furthermore, while the game was generally intuitive, the spells were noted as being less so, indicating a need for clearer instructions or a better tutorial to explain these elements.

The second question asked was: "Did you feel that the game could improve skills or knowledge in the specific area (multiplication)?"

The design experts had mixed opinions. They agreed that the game sparks interest and can be engaging for children. However, they also pointed out that the game doesn't significantly improve multiplication skills on its own, suggesting that while the game is appealing, it may lack depth in its educational content.

Similarly, the education experts had nuanced views. They acknowledged that the game could serve as a motivational tool. Nonetheless, they also emphasized that the exercises are basic multiplication problems without intentional training or a focused approach on a single domain. This suggests that while the game may be useful for sparking interest, it might not provide the in-depth practice needed for substantial improvement in multiplication skills.

The third question asked was: "How did you feel about the game’s interactivity? Was it easy to understand and use?"

There was unanimous agreement that the game is easy to understand and intuitive. One of the experts, Theodore, even managed to complete the game without knowing Portuguese, highlighting its user-friendly design. However, they pointed out that the spell cards were somewhat confusing.

The design experts also mentioned additional issues. They noted that the overworld or hub seemed unnecessary for the final product, suggesting that the focus should be primarily on the battle mechanics, especially given the limited development time. They also reiterated the need for more animations to provide better feedback during battles.

The fourth question asked was: "How did you find the game progressing as you went along? How do you rate the game's difficulty level?"

The experts, especially those in education, found the game's difficulty to be appropriate or even slightly easy. They observed a small progression in difficulty, as indicated by the increasing number and variety of monsters/exercises. However, the designers pointed out that there was no noticeable progression in the player's character. They suggested that more visible indicators of character growth and development would enhance the sense of progression and achievement within the game.

Question number 5 asked: "Do you believe this game would be useful in an educational environment?"

The education experts unanimously agreed that the game could be useful in an educational setting. They emphasized that students are more enthusiastic about learning when engaged with such interactive methods. By needing to know their multiplication tables to play, students would be motivated to learn and remember them. However, they also noted that in its current form, the game might serve more as a supplementary tool for homework rather than a primary educational resource. The visual design was praised for being attractive, and with some adjustments, the game could be a valuable tool for knowledge consolidation. They suggested that explicitly stating the game's educational objectives at the beginning, incorporating obstacles that require strategic problem-solving, and progressively increasing complexity would make the game more effective.

The design experts also believed the game would be beneficial in an educational environment. They noted that educational games are well-established as effective tools for knowledge retention. For example, one expert suggested that instead of simply selecting the correct number, players could choose how to reach the final numbers by combining cards. Introducing concepts like "reusing cards", giving the player more creativity. One expert shared a personal experience, recalling how educational games played a significant role in their learning journey and are commonly used in the Netherlands to enhance math skills in a fun and competitive way.

Question number 6 asked: "What are the areas that should be improved/implemented as quickly as possible?"

Both sets of experts emphasized several key areas that require immediate attention. They highlighted the need for clearly defining the essential learning objectives to be promoted and reinforced, enhancing the game's interactivity, improving progression mechanics, and increasing the variety of activities and challenges.

The design experts provided additional specific feedback. They suggested finding ways to encourage creative answers to multiplication questions and rewarding "creative play". For instance, rewarding quick answers with increased damage could enhance the game loop. They also stressed the importance of integrating mathematical concepts into the narrative, adding more social interaction, diversifying scenarios, and improving aesthetics through customization options. Furthermore, they recommended adding a system for spending in-game currency, such as purchasing upgrades in the village, to provide players with additional motivation and progression opportunities.

In summary, the evaluation conducted with experts from both educational and game designers provided valuable feedback on Math Masters, highlighting its strengths and areas for improvement. While praised for its engaging graphics and intuitive gameplay, the game could benefit from clearer learning objectives, improved interactivity, and deeper integration of mathematical concepts. Addressing these aspects will be essential for enhancing the game's educational value and player engagement, ultimately contributing to a more effective learning experience.

6. Discussion

The main challenges faced during the development of the educational game included the lack of resources and time constraints. The absence of a professional with in-depth knowledge of education on the team was a significant obstacle, as it hindered proper guidance in developing the educational content. Additionally, the available time was significantly consumed by the need to acquire a solid background in education and educational games, reducing the time dedicated to practical game development. The initial project was ambitious and demanded more time and human resources to be successful.

Heuristics played a crucial role in quickly identifying the game's weaknesses and understanding why certain aspects did not function correctly. Using AHJED (Heuristic Evaluation for Digital Educational Games), it was possible to focus on the areas that needed improvement. This heuristic was chosen for its comprehensiveness, incorporating various heuristics from games and educational games, facilitating a more complete and detailed analysis. There was a significant convergence between the errors identified by the heuristics and those pointed out by the experts, with few discrepancies. The experts' feedback was valuable in finding solutions to problems that were not initially obvious, providing specific insights that helped refine and improve aspects of the game.

For educational game developers, it is crucial to involve education specialists from the beginning of the project, ensuring that the educational content is correctly addressed. Using heuristics like AHJED can help quickly identify and correct design problems. Developers should also be prepared to invest time in acquiring knowledge about education and educational games to create effective products. To avoid the errors faced in this project, it is recommended to have a multidisciplinary team that includes educators and game designers, as well as to plan a realistic schedule and clearly define the game's objectives from the start. Avoiding overly ambitious projects without adequate resources can prevent failures and frustrations during development.

The main limitations of this study were the lack of human resources with expertise in education and the limited time for game development, which affected the depth and quality of the final product. In future projects, ensuring a well-balanced and specialized team, as well as a schedule that allows for the acquisition of essential knowledge before

starting development, can help overcome these limitations. Continuous collaboration with educators and constant iteration based on heuristic and expert feedback are crucial.

This study demonstrates the importance of a well-structured, heuristic-based approach to developing educational games, highlighting the need for collaboration between developers and educators to create effective and engaging products. It also adds value to existing knowledge on applying heuristics in educational game development, providing a practical example of how these tools can be used to improve design and efficacy. The study offers a solid foundation for future developers and researchers to understand the challenges and best practices in creating educational games, promoting more effective and user-centered development.

Future research could focus on effective methods of integrating complex educational concepts into games in an engaging and intuitive way. Additional studies on the application of different heuristics in educational games would also benefit the developer community. Longitudinal studies tracking the impact of educational games on learning over time can provide valuable insights.

7. Conclusion and Future Works

Developing an educational game without adequate prior knowledge and without the necessary care is extremely challenging. This research demonstrates that creating educational games requires a careful and thoughtful approach, rather than an autonomous and imprudent effort. It is crucial to have a solid understanding of both education and educational game design, and ideally, a multidisciplinary team should be involved to address the various facets of development.

The results of this research highlight the complexity and necessary precautions when producing an educational game. The field is more difficult and specific than it appears, demanding detailed planning and precise execution. Moreover, the research emphasizes the importance of considering all pedagogical and technical aspects involved in creating a game that truly contributes to learning.

The main lessons learned include the need for a strong foundation in education and educational game design, and the practical challenges faced throughout development. This research contributes to the field by highlighting the difficulties and necessary precautions, serving as a guide for future developers who want to explore this area.

One of the major limitations encountered was the lack of time to develop the game, in addition to the time needed to learn about the subject. The original project was overly ambitious, and the required development time was not compatible with the available time for the project.

Future research and developments could focus on implementing the city management aspect, aimed at exploring students' creativity and improving battles, as initially planned in the GDD. Testing new ways to allow students to be more creative would also be a valuable area to explore.

The heuristic used and the tests with experts in the fields of education and game design were essential for identifying the game's flaws. These methods can be applied to any educational game project, providing a critical and detailed analysis of areas for improvement.

It would be interesting to conduct long-term studies to assess whether a complete game, which accompanies a student throughout the school year, could increase students' interest in studying and effectively improve their grades.

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Appendix

Appendix I. School Request

Exmo(a). Sr(ª)
Diretor(a) do Agrupamento de Escolas _____

João Luís Alves Pires Ferreira, aluno do Mestrado em Design e Desenvolvimento de Jogos Digitais da Universidade da Beira Interior, vem mui respeitosamente requerer a vossa excelência a permissão da realização de testes de usabilidade de um jogo desenvolvido no âmbito da tese de mestrado, sob a orientação científica da Professora Doutora Sandra Carina Guimarães e do Professor Doutor Ernesto Vilar Filgueiras que procura avaliar a sua introdução no ambiente escolar.

Na tese em questão, após um estudo sobre a utilização de videojogos na educação, procurou-se desenvolver um jogo divertido e dinâmico para alunos do 3.ano (a confirmar) do 1.ºciclo na área curricular da Matemática sobre o tema Números e Operações, em particular, para os objetivos de aprendizagem: i) reconhecer relações numéricas e propriedades das operações e utilizá-las em situações de cálculo e ii) reconhecer e memorizar factos básicos da multiplicação.

Num primeiro momento será apresentado o estudo ao(à) coordenador(a) da escola e aos professores responsáveis pelo ano escolar em estudo explicitando objetivos, procedimentos, estrutura e organização do jogo. Em seguida serão envolvidos os pais/encarregados de educação solicitando a sua autorização e o seu consentimento informado descrevendo igualmente o estudo, os objetivos e os procedimentos

O jogo será disponibilizado de forma gratuita a todos os alunos cujos pais assinaram o consentimento informado e que poderão experimentar o mesmo nos seus computadores pessoais, em casa ou na escola de acordo com a conveniência da Direção do(s) Agrupamento(s) e da(s) Escola(s).Após o primeiro contacto os alunos serão convidados a explorar e a treinar o jogo várias vezes. Ainda no âmbito do estudo será solicitado a colaboração dos alunos no preenchimento de dois questionários sobre os seus hábitos de utilização dos videojogos e a avaliação que fazem do jogo e da experiência de utilização.

O jogo grava apenas os resultados obtidos pelos alunos, estes dados serão recolhidos no final da experiência a fim de serem analisados na dissertação que está a ser realizada.

No final, será solicitado aos alunos uma pequena avaliação do jogo e dos seus contributos aos alunos e aos professores.
Com os melhores cumprimentos,
João Ferreira.

Email:j----------@-------l.com Telemóvel: 9-------3

_____ de maio de 2023

O requerente:

_____

Appendix II. Guardian consent

UNIVERSIDADE
BEIRA INTERIOR

Consentimento Informado

No âmbito da Dissertação de Mestrado dos estudantes João Ferreira e João Marques do 2.º ciclo de estudos de Design e Desenvolvimento de Jogos Digitais da Universidade da Beira Interior está a ser desenvolvido um estudo de usabilidade de jogos educativos na área curricular da Matemática sobre o tema Números e Operações.

Para aprofundar este conhecimento, gostaríamos de solicitar a colaboração do vosso educando neste estudo e na exploração do jogo em contexto de sala de aula e em casa bem como no preenchimento de dois questionários sobre os seus hábitos de utilização dos videojogos e a avaliação que faz do jogo e da experiência de utilização. Toda a informação recolhida será tratada de forma anónima e confidencial, sendo que apenas a equipa de investigação responsável terá acesso aos dados e nenhum dado pessoal que identifique diretamente os seus participantes será recolhido.

☐ Declaro que tomei conhecimento dos objetivos do estudo e que compreendi os procedimentos associados à participação de meu educando no presente estudo, a qual autorizo.

☐ Não autorizo a participação do meu educando no presente estudo.

___ junho de 2023

Assinatura do Encarregado de Educação:

_____

Appendix III. Game Design Document

Math Masters
GAMES DESIGN DOCUMENT

João Ferreira

TABLE OF CONTENTS

GAME OVERVIEW

In Math Masters, players embark on an educational adventure as a heroic character set on saving their island from impending doom. The game's primary focus is to gamify education, stimulating learning among elementary school students by integrating mathematics into a captivating gaming experience.
Math Masters focuses on making mathematics enjoyable and accessible to elementary school students. By incorporating math exercises into battles and city management, the game aims to reinforce mathematical concepts, problem-solving skills, and critical thinking. The gamified approach sparks curiosity, motivation, and a positive attitude towards learning.
Overall, Math Masters is an adventure game that combines the excitement of a heroic quest with the educational benefits of mathematics. By integrating math exercises into engaging gameplay mechanics, customization options, and interactive features, the game offers an immersive and enjoyable experience for students, fostering a love for learning and building essential skills.

GAME CONCEPT

Math Masters is an adventure game where players embark on a heroic quest to save their island from a villain and his army of monsters. In this unique educational project, the power of mathematics becomes the hero's magic, allowing them to overcome challenges and defeat enemies. The game aims to gamify education and promote learning among elementary school students.

The game's mechanics are divided into two main parts. Firstly, there is a city management aspect where players are tasked with rebuilding and restoring the island. They must strategically allocate resources, construct buildings, and develop infrastructure to enhance the island's prosperity.

The second part of the game involves engaging in exciting battles against the villain and his monsters through a card-based system. Players use cards to select math exercises, and upon successfully solving them, they launch powerful attacks against the enemy. This innovative gameplay mechanic intertwines educational content seamlessly into the adventure, making learning an integral part of the gaming experience.

Math Masters also offers a high level of customization. Players can personalize their avatars, allowing them to create unique characters that reflect their individual style. They can also customize their island, shaping it according to their preferences and unlocking new features and areas as they progress. Additionally, players can interact with their peers through in-game messaging, fostering collaboration and friendly competition. Joint missions and challenges can be undertaken together, promoting teamwork and engagement.

Overall, Math Masters provides an immersive and entertaining adventure that combines the excitement of an epic quest with the power of mathematics. Through city management, card-based battles, customization options, and interactive features, the game aims to make learning math engaging and enjoyable for elementary school students, fostering a love for education while fostering social interaction and cooperation among players.

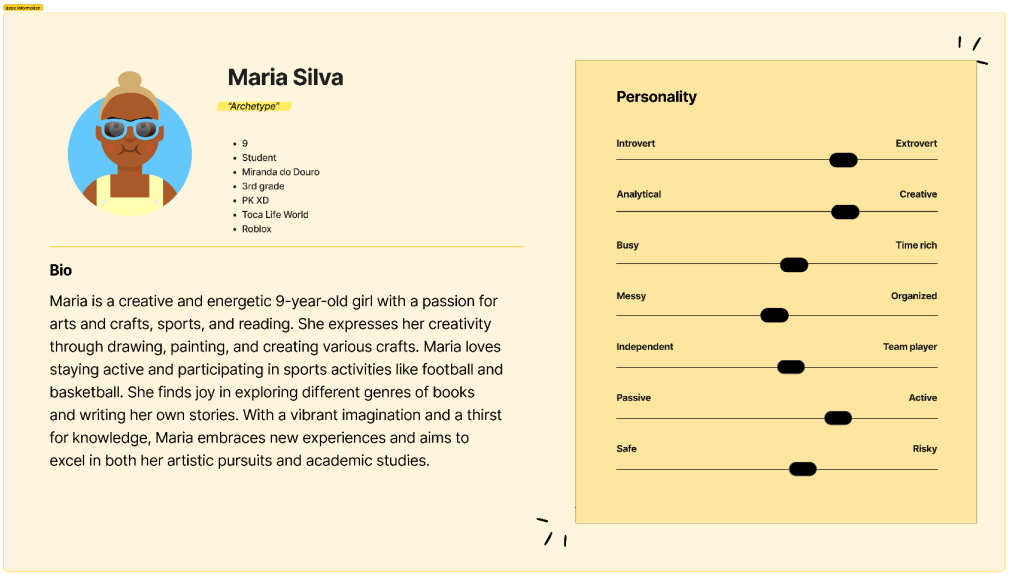
GENRE

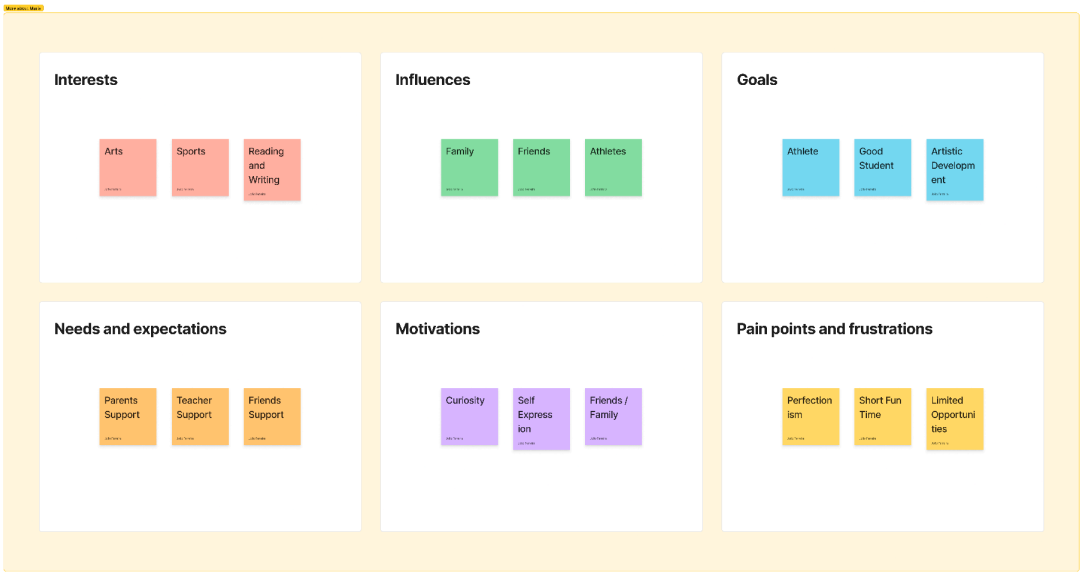
Edugame; RPG; Deck builder; City Manager.

Math Masters is a unique blend of two genres: educational game (edu-game) and turn-based deck builder. As an edu-game, its primary purpose is to engage and educate players by integrating mathematics seamlessly into the gameplay. By incorporating math exercises into battles and city management, the game aims to reinforce mathematical concepts and problem-solving skills in an interactive and entertaining manner. Additionally, Math Masters incorporates elements of a turn-based deck builder, where players strategically choose math exercise cards to engage in battles, adding a layer of tactical decision-making and deck optimization to the gameplay. This combination of edu-game and turn-based deck builder genres creates a compelling and educational gaming experience that promotes learning while keeping players engaged and challenged.

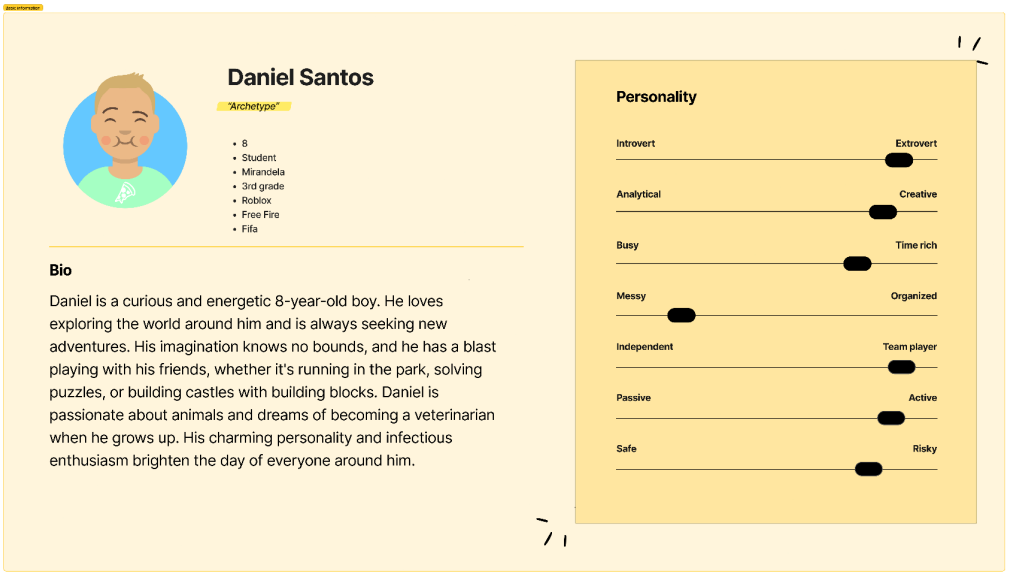
TARGET AUDIENCE

Math Masters targets elementary school students, typically aged 8 to 12 years, with an emphasis on engaging and empowering them through educational gameplay. It aims to captivate young learners and inspire their interest in mathematics, providing an entertaining and rewarding gaming experience.





Girl user

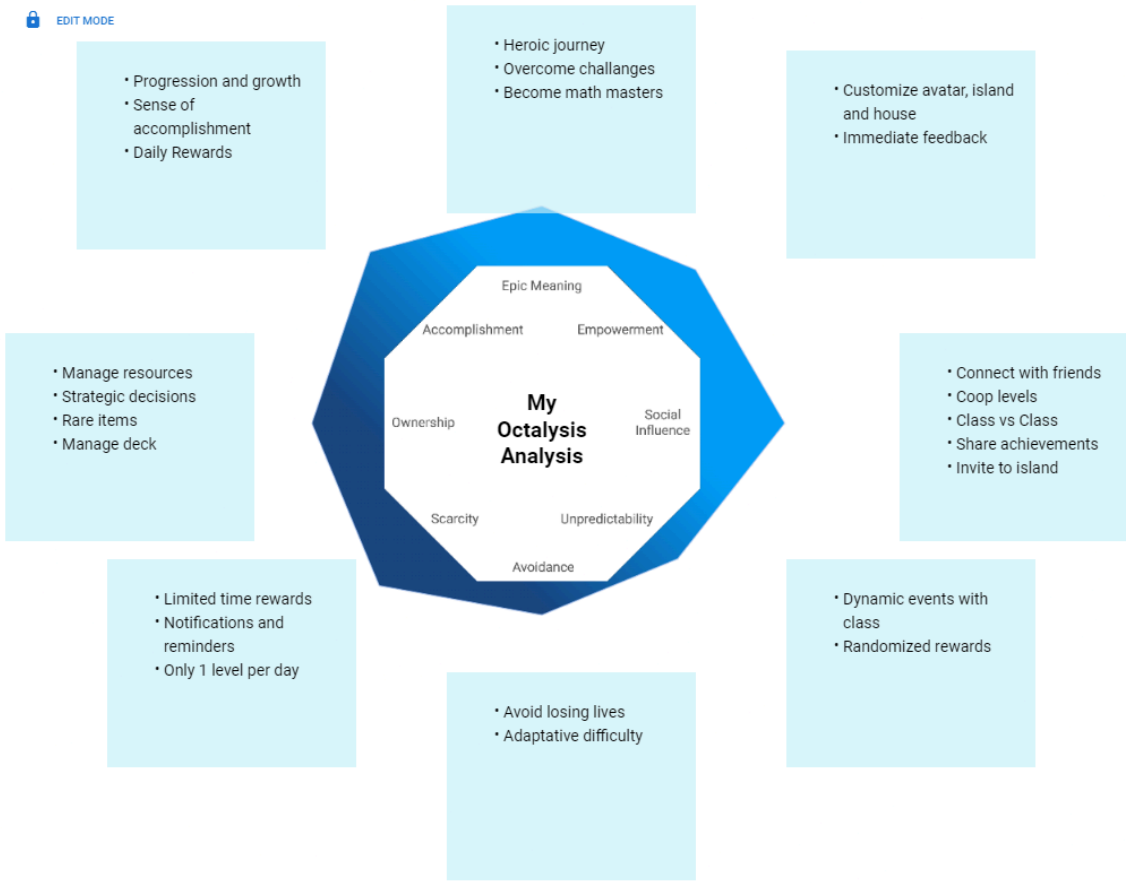

Daniel Santos
"Archetype"
8
Student
Mirandela
3rd grade
Roblox
Free Fire
Fifa
Bio
Daniel is a curious and energetic 8-year-old boy. He loves exploring the world around him and is always seeking new adventures. His imagination knows no bounds, and he has a blast playing with his friends, whether it's running in the park, solving puzzles, or building castles with building blocks. Daniel is passionate about animals and dreams of becoming a veterinarian when he grows up. His charming personality and infectious enthusiasm brighten the day of everyone around him.
Personality
Introvert
Extrovert
Analytical
Creative
Busy
Time rich
Messy
Organized
Independent
Team player
Passive
Active
Safe
Risky


Interests
Animals
Outdoor Activities
Video Games
Influences
Family
Friends
TV
Goals
Veterinarian
Good Student
Have lots of friends
Needs and expectations
Parents Support
Teacher Support
Friends Support
Motivations
Curiosity
Love for Animals
Friends / Family
Pain points and frustrations
Study
Short Fun Time
Limited Independence

Boy user

MONETIZATION

To generate revenue with the game, Math Masters adopts a monetization approach through a paid subscription. Players have free access to the game for a 1-month trial period, allowing them to explore and engage with the gamified educational experience. After the trial period, players have the option to subscribe to an annual membership for 15€. This subscription offers exclusive benefits, including unlimited access to additional content, regular updates and ongoing support. By embracing this affordable subscription model, the game aims to provide a quality experience while ensuring the sustainability and continuous development of the educational project.



Octalysis diagram

GAME FLOW SUMMARY

Math Masters is divided into two main parts: the village and battles. In the village section, players focus on rebuilding the island, purchasing new weapons, and utilizing resources earned throughout the game. In the battle section, players face off against monsters and enemies to level up, gaining more health or new cards. Players have access to two levels per day, which provide experience and resources. This allows them to grow stronger and improve the village. The story remains simple, with the objective of defeating enemies to unlock new levels and progress towards the final level.

The village aspect allows players to rebuild essential buildings such as the guild, blacksmith, and fields. They can also customize the layout of the island as well as the interior and exterior of their own house.

Battles involve using cards, similar to Ring Fit Adventure, where each card represents a math operation. Depending on the operation, the player can deal double or single damage to the enemy. The hero receives new cards every 2 or 3 levels.

Players unlock two levels each day, with progression to the next level requiring completion of the previous one. Certain equipment, buildings, and cards are unlocked at specific levels. Players also earn medals for achievements such as hitting 20 consecutive correct answers or reaching a certain level.

In addition to the main story, there are missions involving the entire class or a certain number of students. These missions are separate from the main storyline. There are also school duels where players compete against each other to answer questions correctly in the shortest amount of time.

The game gradually increases in difficulty for all players, introducing new educational content and more challenging exercises. Similar to Resident Evil 4, if players get the questions right a few times, they become more difficult, while if players fail many times, the questions become easier.

Throughout the game, there are mini-boss encounters every 10 or 15 levels, providing small climactic moments. The final boss, the nemesis of the hero, appears at the end of the game. This character was once a member of the hero's island but was corrupted by dark magic.

Math Masters offers a dynamic game flow that combines village management, card-based battles, progression through levels, customization options, and multiplayer interactions. Players engage in an educational and exciting journey, defeating enemies, improving their mathematical skills, and ultimately saving their island from impending darkness.

VISUAL STYLING

Math Masters features a charming and vibrant visual style that combines 3D low-poly graphics with a cartoony aesthetic. The game world is set on an island inspired by Greece, with a focus on capturing the beauty of the Mediterranean landscapes.

The characters in Math Masters are designed with a cartoony flair, featuring exaggerated proportions and expressive facial features. They move with smooth animations that bring them to life and add a playful touch to the gameplay.

The environments in Math Masters embrace a low-poly art style, with simplified geometric shapes and vibrant colours. The island is dotted with white-washed buildings, cobblestone streets, and picturesque scenery. Special effects accompany attacks, level ups, victories, defeats, and building construction, adding excitement and visual impact to these moments.

The UI of Math Masters follows a minimalistic design approach. It is clean, uncluttered, and intuitive, allowing players to easily navigate through menus, access their inventory, and track their progress. The UI elements feature simple shapes and icons, ensuring clarity and ease of use.

GAMEPLAY & MECHANICS

Core Gameplay Mechanics:

- City Management: Players assume the role of rebuilding and restoring the island. They must strategically manage resources, construct buildings, and develop infrastructure to enhance the island's prosperity. The city management aspect encourages players to utilize math-related concepts to optimize their decision-making and foster an understanding of real-world applications.

- Card-Based Battles: Engaging in battles against the villain and his monsters relies on a card-based system. Players choose from a selection of math exercises represented as cards. Successfully solving these exercises empowers the character to launch powerful attacks against enemies. This mechanic intertwines educational content seamlessly into the gameplay, providing a fun and interactive way to reinforce mathematical skills.

Key Features:

- Customizable Avatar: Players can customize their character's appearance, allowing for personalization and self-expression throughout the game.

- Island Customization: Players have the ability to shape and customize their island, unlocking new features and areas as they progress. This feature enhances creativity and a sense of ownership over the game world.

- Interactive Communication: In-game messaging enables players to interact with their peers. They can collaborate on joint missions, solve problems together, and engage in friendly competitions, fostering social interaction and teamwork.

GAMEPLAY

Math Masters offers an engaging gameplay experience where players embark on an adventure to save their island by utilizing the power of mathematics. The game combines exploration, turn-based combat using cards, and educational challenges to create an immersive learning journey.

Players navigate the village using the mouse, freely exploring its surroundings without restrictions. Throughout the village, players can engage in dialogue with their mentor, who provides guidance and hints on what needs to be done. Additionally, interactions with NPCs in shops and buildings add depth to the world and provide valuable information.

The game's levels are linear, consisting of multiple stages where players must defeat enemies. Each level comprises a minimum of three stages and a maximum of six, with some levels featuring mini-bosses as final challenges.

Combat in Math Masters follows a turn-based approach, using cards as the primary mechanic. Players must solve math problems correctly to unleash attacks on the monsters they encounter. However, if an answer is incorrect, the player loses a life.

While there are no specific puzzles or logic challenges, the core gameplay revolves around math exercises and problem-solving. Players are rewarded with experience points, coins, cards, weapons, new buildings, and medals as they progress through the game and defeat enemies.

In addition to combat and exploration, Math Masters offers various activities for social interaction and cooperative play. Players can challenge their friends or classmates, engage in cooperative missions, and even compete against other schools or classes. The game also provides access to educational videos that explain exercises and concepts, allowing players to deepen their understanding of math topics.

To facilitate progression and resource management, players earn money by defeating enemies and can set up plantations and mines to gather additional resources. These resources are used to feed NPCs, rebuild buildings, and enhance the island's infrastructure.

The math exercises presented in Math Masters vary in complexity and format. Depending on the card used, players may encounter simple arithmetic problems requiring keyboard input, image selection, or multiple-choice answers.

GAME PROGRESSION

The progression in Math Masters is designed to provide a rewarding and educational experience for players. As they navigate through the game, players will encounter various challenges and activities that contribute to their overall development.

Progression in Math Masters is primarily driven by completing levels and defeating enemies. Each level consists of multiple stages, with players needing to defeat all enemies in each stage to progress. The levels are designed to offer a gradual increase in difficulty, introducing new math exercises and stronger opponents as players advance.

Successful completion of levels and defeating enemies rewards players with experience points, coins, and various items. Experience points contribute to the player's overall level, unlocking new abilities, cards, and customization options for their avatar. Coins can be used to purchase new weapons, cards, and resources to enhance the island's infrastructure.

In addition to leveling up and acquiring new items, players can also customize their avatar, the layout of the island, and the interior and exterior of their house. This allows for personalization and creates a sense of **ownership** within the game world.

As players progress, they will unlock new buildings and areas within the village. These buildings serve various purposes, such as providing additional resources, educational materials, or access to special features. Players must manage their resources wisely to ensure the growth and development of their island.

Math Masters also features cooperative missions and competitive challenges, allowing players to engage with their friends and classmates. By collaborating on missions or competing in math-based duels, players can further enhance their skills and earn additional rewards.

Overall, Math Masters offers a well-paced progression system that combines educational content, character development, customization options, and engaging activities. The game's progression mechanics are designed to motivate players to continue their math-learning journey.

OBJECTIVES

Rebuild the Island: Players embark on a quest to restore the magical island, which has suffered due to the villain's actions. They must gather resources, repair buildings, and restore the island's vibrant atmosphere.

Defeat the Villain: The primary goal is to vanquish the powerful villain and his menacing monster army. The players journey through multiple levels, engaging in math-based battles, and employing strategic thinking to overcome the challenges posed by the villain and their minions.

Master Math Skills: As an educational game, a key objective is to enhance math proficiency. Players tackle math problems and exercises, advancing their skills and knowledge as they progress in the game. Successful math mastery unlocks rewards and strengthens their abilities for future encounters.

Unlock and Customize: Players have the opportunity to unlock a diverse array of content, including new cards, weapons and buildings. Additionally, they can personalize their gameplay experience by customizing their character's appearance and tailoring the island's layout to their preferences.

Collaborate and Compete: Math Masters encourages collaboration and competition among players. Players can collaborate with friends or classmates by undertaking cooperative missions, fostering teamwork and collectively working towards shared goals. Additionally, they can challenge others in math battles, striving for victory and earning recognition in leaderboards.

Explore the Archipelago: As part of the adventure, players explore not only the main island but also the surrounding archipelago. They embark on quests, venture to different islands, and uncover hidden areas brimming with secrets. This exploration expands their knowledge of the game world, unravels the island's history, and provides a deeper understanding of the villain's motivations.

PLAY FLOW

Introduction and Tutorial: Players are introduced to the game's concept, story, and mechanics through an interactive tutorial. They learn about the protagonist's mission to save the island using math as a magical power and become familiar with the basic controls and gameplay elements.

Exploration and Quests: Players begin their adventure by exploring the island and interacting with NPCs to receive quests or missions. These quests guide the player through the game, providing objectives and challenges to overcome. Players have the freedom to explore different areas, discover hidden secrets, and uncover the island's history.

Village Management: In the village area, players engage in city management gameplay. They rebuild and upgrade buildings, gather resources, and manage the island's economy, this involves constructing new structures.

Deck Building and Card Acquisition: Players focus on building and enhancing their deck of math-based cards. They acquire new cards by completing quests, defeating enemies, or purchasing them from shops. Strategic card selection is crucial as it determines the player's abilities and attacks during battles.

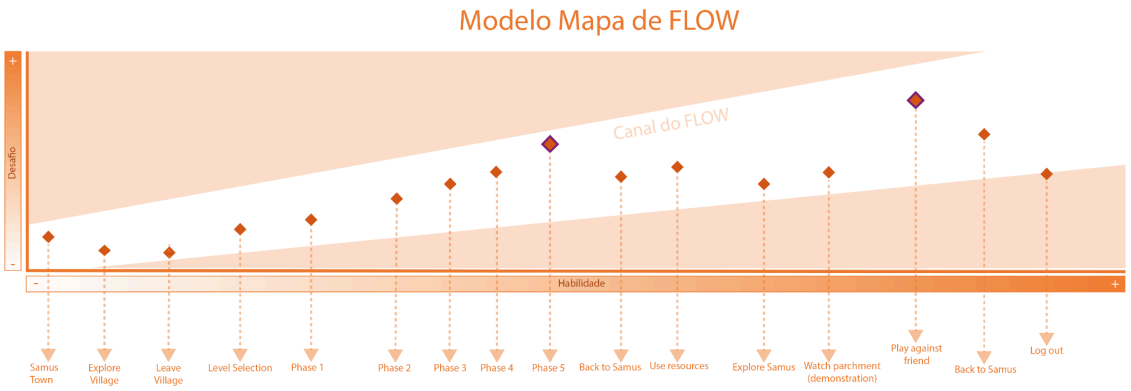
Math Battles: Players engage in turn-based battles against various enemies, including monsters and bosses. During battles, players use their deck of math cards to perform attacks, cast spells, or activate special abilities. Correctly solving math problems associated with the cards results in successful attacks, while mistakes may leave the player vulnerable to counterattacks.

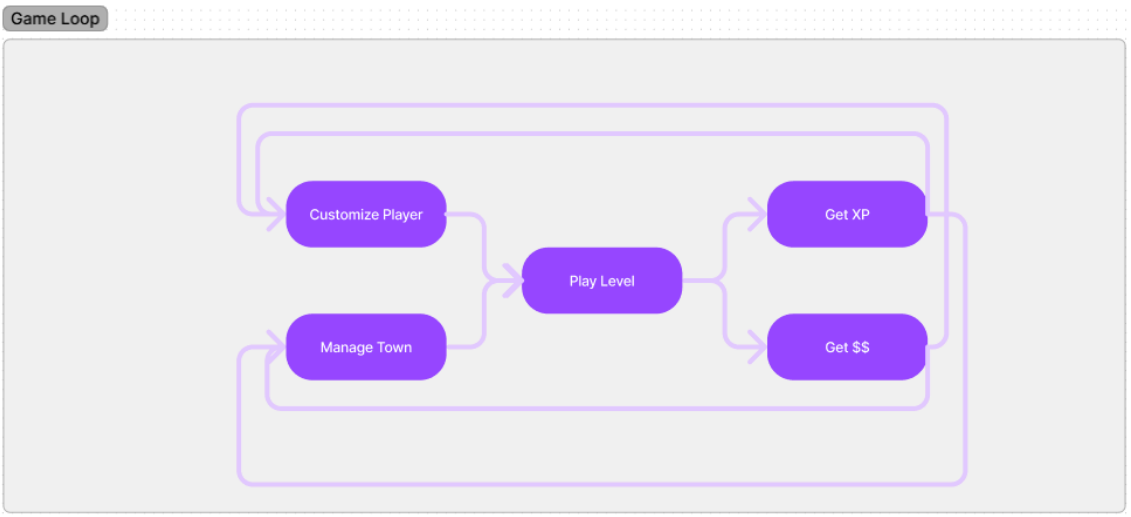
Progression and Upgrades: Successful completion of battles and quests rewards players with experience points, coins, and other resources. They can level up their character, unlock new abilities, upgrade their cards, and acquire more powerful weapons or equipment. This progression enhances the player's combat capabilities and overall performance.

Customization and Social Interaction: Players have the opportunity to customize their character's appearance, as well as the island's layout and their own house. They can interact with NPCs, engage in conversations, trade resources, and form relationships with other characters. Social interaction may involve cooperative missions with friends or competitive challenges against other players.

Challenges and Achievements: Throughout the game, players face challenging encounters, including mini-boss battles and special events. Overcoming these challenges grants rewards and unlocks further progression. Players can also strive to complete achievements, earning medals and recognition for their accomplishments.

Increasing Difficulty and New Content: As players advance through the game, the difficulty level gradually increases. New math concepts, complex problems, and more formidable enemies are introduced to provide a continuous challenge. The game also periodically introduces new content, such as additional islands, quests, and card sets, to keep the gameplay fresh and engaging.





DAILY REWARDS

In Math Masters, players are rewarded for their daily commitment and progress through a daily rewards system. Each day a player logs into the game, they are greeted with a Daily Reward Calendar. The calendar features a series of consecutive days, and for each day the player logs in, they receive increasingly valuable rewards. For example, on the first day, players may receive in-game currency or a helpful item, and as they continue to log in consecutively, the rewards become more enticing, such as rare cards, special outfits for their avatar, or exclusive resources.

Daily Reward Calendar

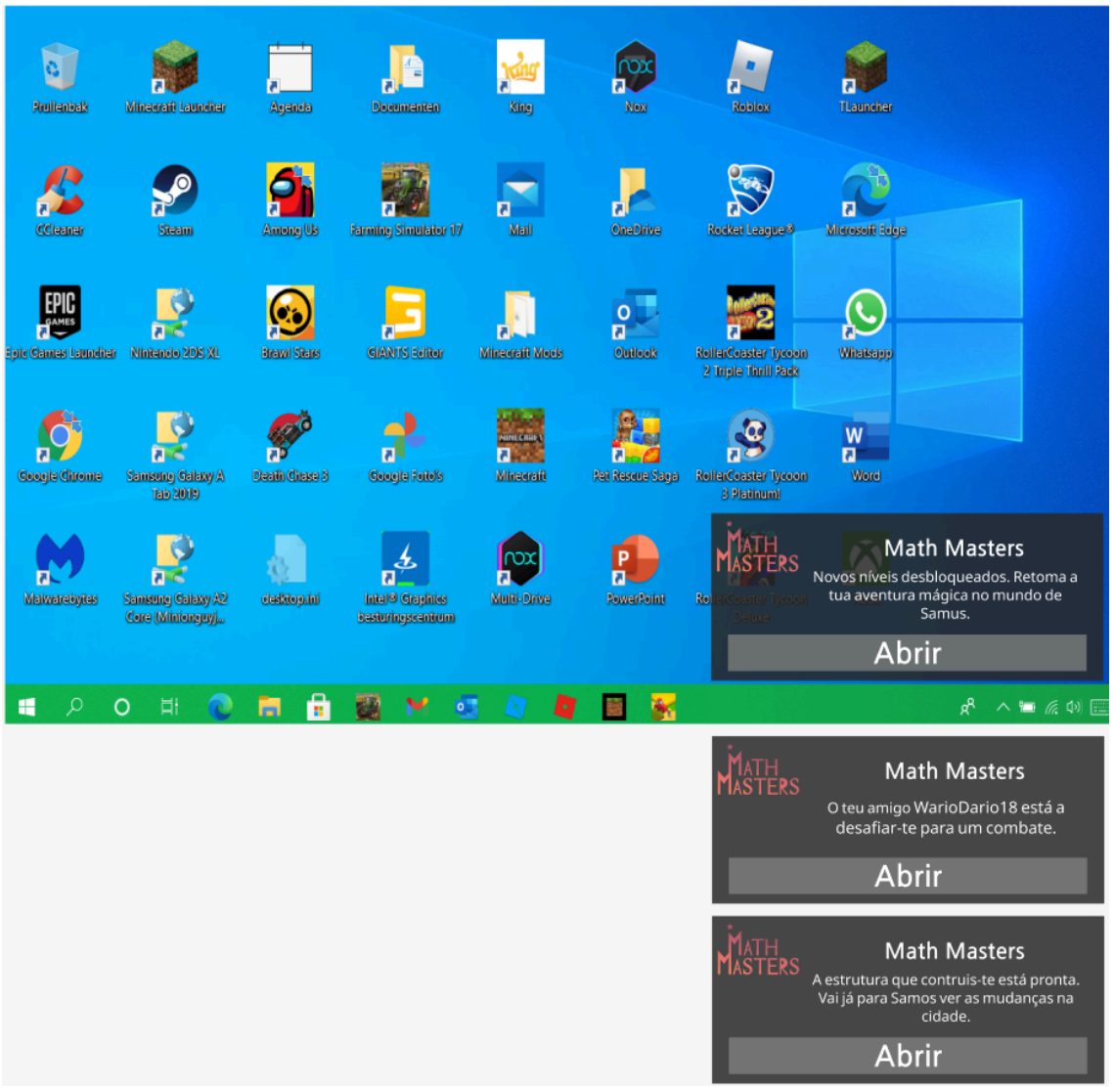
MISSIONS

In Math Masters, the mission system offers a diverse range of challenges and quests for players. Missions are presented through the Quest Board, missions are tailored to reinforce specific mathematical concepts and skills. These missions range in complexity, catering to players of different proficiency levels and allowing them to choose tasks aligned with their learning needs.
As players complete missions, they earn rewards such as experience points, in-game currency, and valuable items that aid in their progress.

Quest Board

NOTIFICATIONS

The notifications system in Math Masters plays a crucial role in keeping players informed, engaged, and motivated throughout their gaming experience. Players receive timely and relevant notifications, such as reminders for daily rewards, upcoming special events, and time-sensitive missions.
The system also provides personalized notifications based on individual progress, offering tips and suggestions to help players improve their math skills and overcome challenges.



Some notification options

MECHANICS

- Exploration
- Quests and Missions
- City Management
- Deck Building
- Turn-Based Battles
- Math Problem Solving
- Character Progression
- Resource Management
- Customization
- Social Interaction

Exploration
Players can freely explore the town, interact with NPCs and .

Quests and Missions
Players receive quests and missions from NPCs, guiding them through the game's storyline and providing objectives to accomplish.

City Management
Players manage and rebuild the island's structures, including constructing new buildings, upgrading existing ones, and maintaining resources for the island's development.

Deck Building
Players collect and manage a deck of math-based cards representing various abilities, spells, and attacks. They strategically select and customize their deck to optimize their combat effectiveness.

Turn-Based Battles
Battles are fought in a turn-based format, where players and enemies take turns executing actions. Players use their math cards to perform attacks, defend, cast spells and utilize special abilities.

Math Problem Solving
To perform attacks and cast spells during battles, players must solve math problems associated with their chosen cards. Correct answers result in successful actions, while incorrect answers may lead to consequences or missed opportunities.

Character Progression
Players earn experience points by completing quests and defeating enemies, allowing them to level up their character. Leveling up unlocks new abilities, increases stats, and enhances the player's combat capabilities.

Resource Management

Players gather resources, such as coins and materials, to support the island's development and upgrade buildings. Effective resource management is essential for progress and success in the game.

Customization
Players can customize their avatar's appearance, as well as the layout and design of their house and the island itself. This allows for personalization and a sense of ownership in the game world.

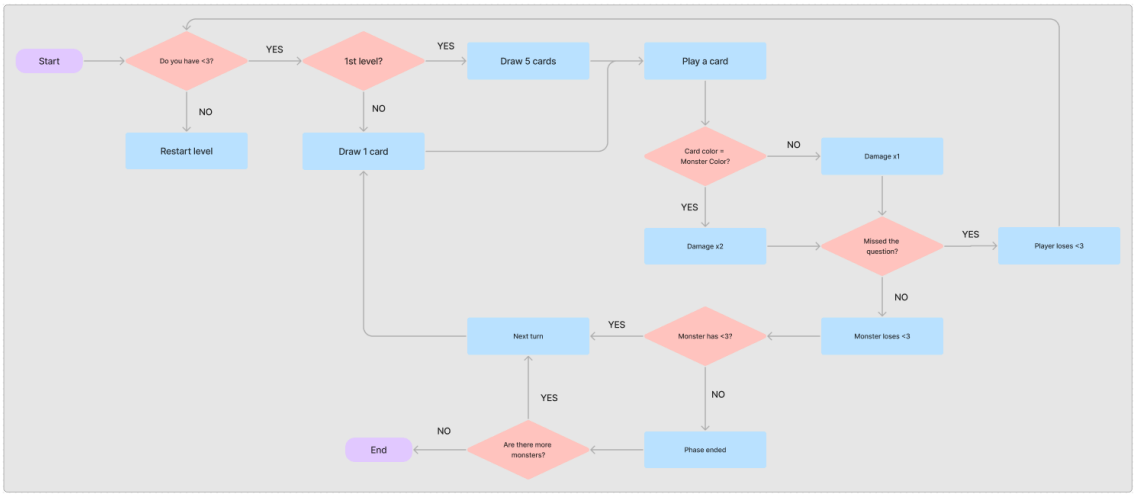
Social Interaction
Players can interact with NPCs, engage in conversations, and form relationships with characters in the game. They may also have opportunities for cooperative missions with friends or competitive challenges against other players.

MOVEMENT

In Math Masters, players navigate the game world using a point-and-click mechanism. They can freely explore the village, interact with NPCs, and discover hidden secrets. The movement is intuitive, allowing players to click on desired locations to move their character. Linear progression may apply in certain areas, but the village serves as a hub for unrestricted exploration. A pathfinding system ensures smooth movement around obstacles. Fast travel is available for efficient navigation between locations. Overall, the movement mechanics offer a seamless and immersive experience in Math Masters.

COMBAT

In Math Masters, combat is a turn-based experience where players use a deck of math-based cards to attack enemies. Each card represents a mathematical operation and requires players to solve a math problem to unleash its effect. The accuracy and speed of their answers determine the success of their attacks. As players progress, they acquire new cards and encounter special abilities, adding strategic depth to the combat system. Overall, combat in Math Masters combines math problem-solving with engaging battles.



Battle Flow

Level	HP	Attack	Bonus	Exp	Diff		f(x)=(x-1+300*2^(x-1/7)/4)
1	2	1		0			
2	3	1		83	83		
3	3	1		174	91		
4	4	1		276	102		
5	4	1	Card	388	112		
6	5	2		512	124		

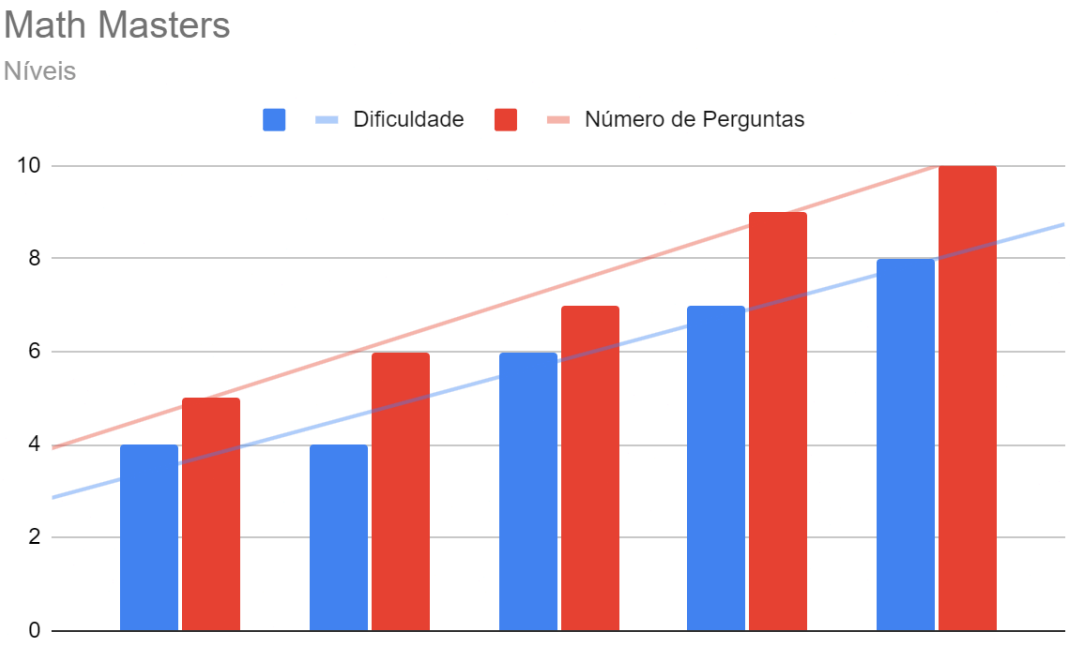
Player progression

	HP	Tier	Difficulty	Exp	Money
Red Slime	1	1	1	20	12
Spike Slime	2	1	1	26	18
Monster Chest	3	1,2	2	34	22

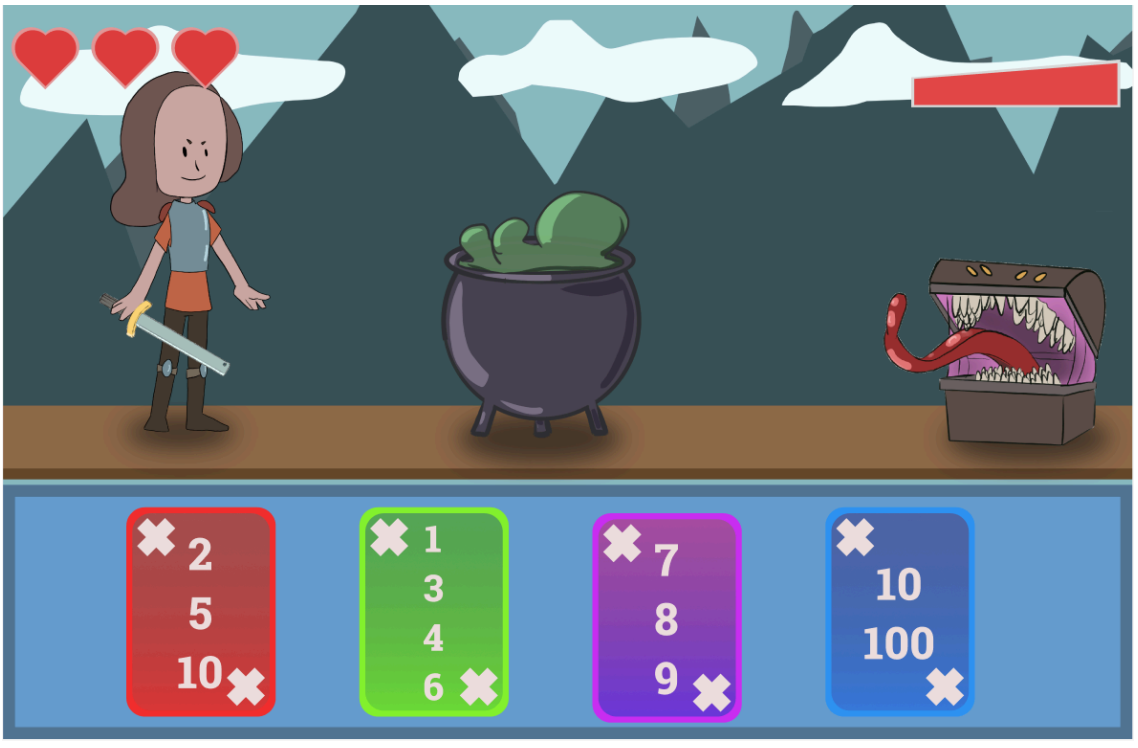
Beholder	2	2,3	2	38	24
Horned Bug	4	2,3	3	42	30
Mini Lich	5	3,4	4	50	47

Monsters

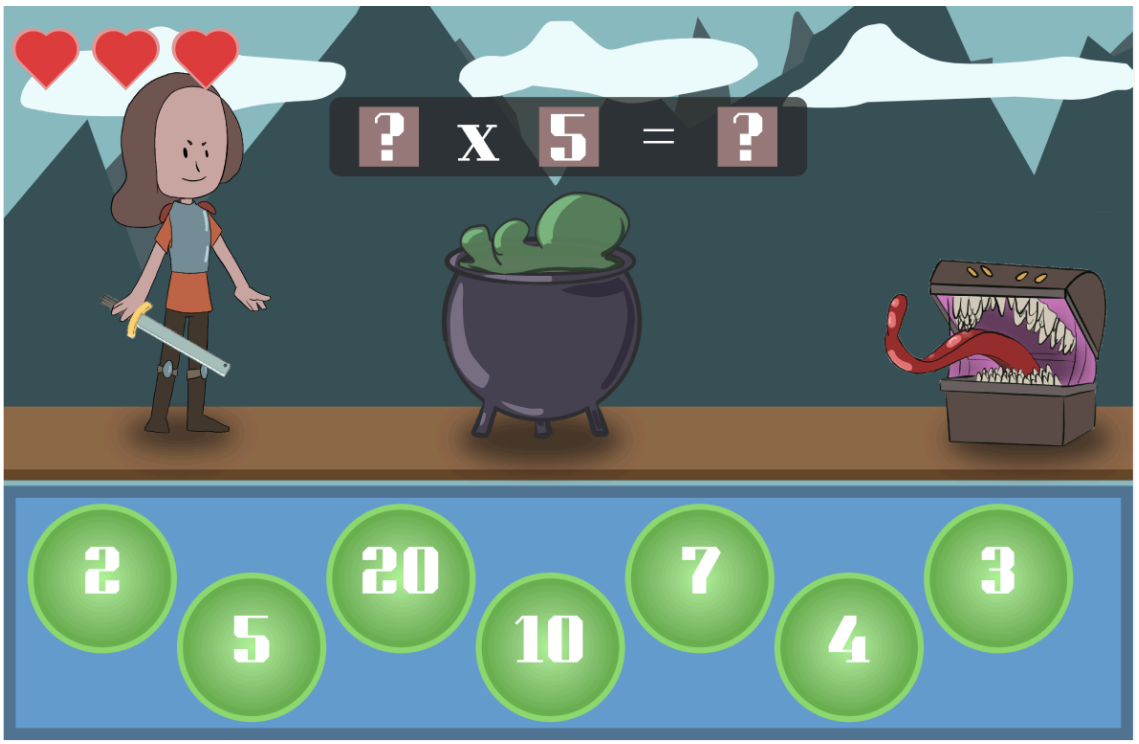
Level	Stage 1		Stage 2		Stage 3		Stage 4		...	Level Difficulty	Numer of Questions
1	Red Slime	1	Red Slime	1	Spike Slime	1	Red Slime	1		4	5
2	Red Slime	1	Spike Slime	1	Monster Chest	2				4	6
3	Red Slime	1	Monster Chest	2	Red Slime	1	Beholder	2		6	7
4	Red Slime	1	Red Slime	1	Monster Chest	2	Horned Bug	3		7	9
5	Red Slime	1	Spike Slime	1	Beholder	2	Mini Lich	4		8	10
											37



Levels Progression



Choose card/exercise



Question and magic balls to answer

ECONOMY

Within the game, players earn currency, typically coins, by completing quests, defeating enemies, or achieving milestones. These coins serve as the primary medium of exchange and are used to purchase items, upgrade buildings, and acquire new cards or equipment.

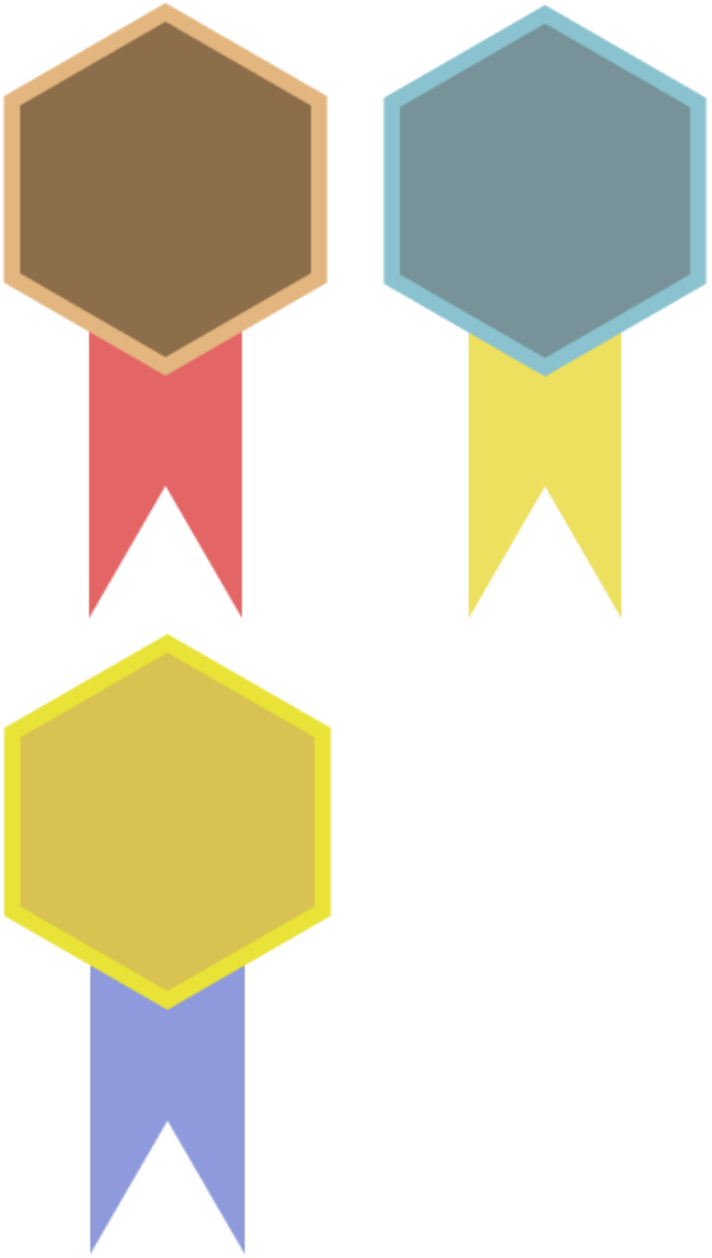
Resource gathering is an integral part of the game's economy. Players can explore the island, complete missions, or participate in mini-games to gather resources. These resources, such as materials, are essential for constructing buildings, upgrading structures, or crafting items.

A significant aspect of the economy revolves around village development. Players can utilize their resources and currency to rebuild and expand the village. Constructing and upgrading buildings, such as the guild, blacksmith, or fields, provide various benefits and unlock new features. However, upgrading buildings may require specific resources and coins, requiring players to strategize their resource allocation.

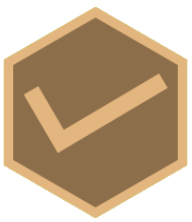
Shops and vendors play a role in the game economy as well. Players can visit these establishments within the game world to purchase items, equipment, or cards. These purchases can enhance their abilities in combat, provide bonuses, or unlock new features. Prices for items may vary, necessitating players to manage their finances wisely and make informed purchasing decisions.

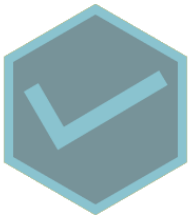
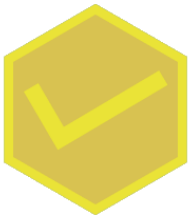
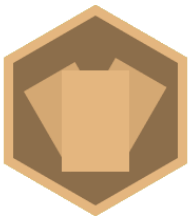
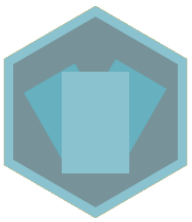
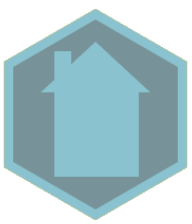
BADGES

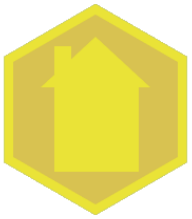
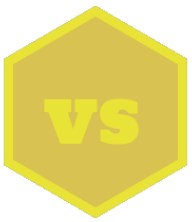
Players are rewarded with badges for accomplishing significant milestones and noteworthy achievements during gameplay. These badges serve as symbols of their progress and accomplishments, stored in their personal profile as a virtual trophy case. By earning and collecting badges, players can track their achievements and showcase their success in the game.



Badge Title	Icon	Description	Type	Effect

Mestre Matemático (I)		Achieved by correctly answering 50 math problems.	Bronze	100 XP
Mestre Matemático (II)		Achieved by correctly answering 200 math problems.	Silver	250 XP
Mestre Matemático (III)		Achieved by correctly answering 500 math problems.	Gold	500 XP
Estrela da Cooperação (I)		Earned by successfully completing a co-op quest with a classmate or friend.	Bronze	100 XP
Estrela da Cooperação (II)		Earned by successfully completing 10 co-op quests with a classmate or friend.	Silver	250 XP
Estrela da Cooperação (III)		Earned by successfully completing 30 co-op quests with a classmate or friend.	Gold	500 XP
Herói Invencível (I)		Earned by completing a level without losing any lives.	Bronze	100 XP

Herói Invencível (II)		Earned by completing 10 levels without losing any lives.	Silver	250 XP
Herói Invencível (III)		Earned by completing 30 levels without losing any lives.	Gold	500 XP
Campeão das Cartas (I)		Achieved by collecting 10 cards in the game.	Bronze	100 XP
Campeão das Cartas (II)		Achieved by collecting 20 cards in the game.	Silver	250 XP
Campeão das Cartas (III)		Achieved by collecting 30 cards in the game.	Gold	500 XP
Arquiteto Habilidoso (I)		Earned by rebuilding the guild.	Bronze	100 XP
Arquiteto Habilidoso (II)		Earned by building 3 buildings in the village, transforming it into a thriving and welcoming place.	Silver	250 XP

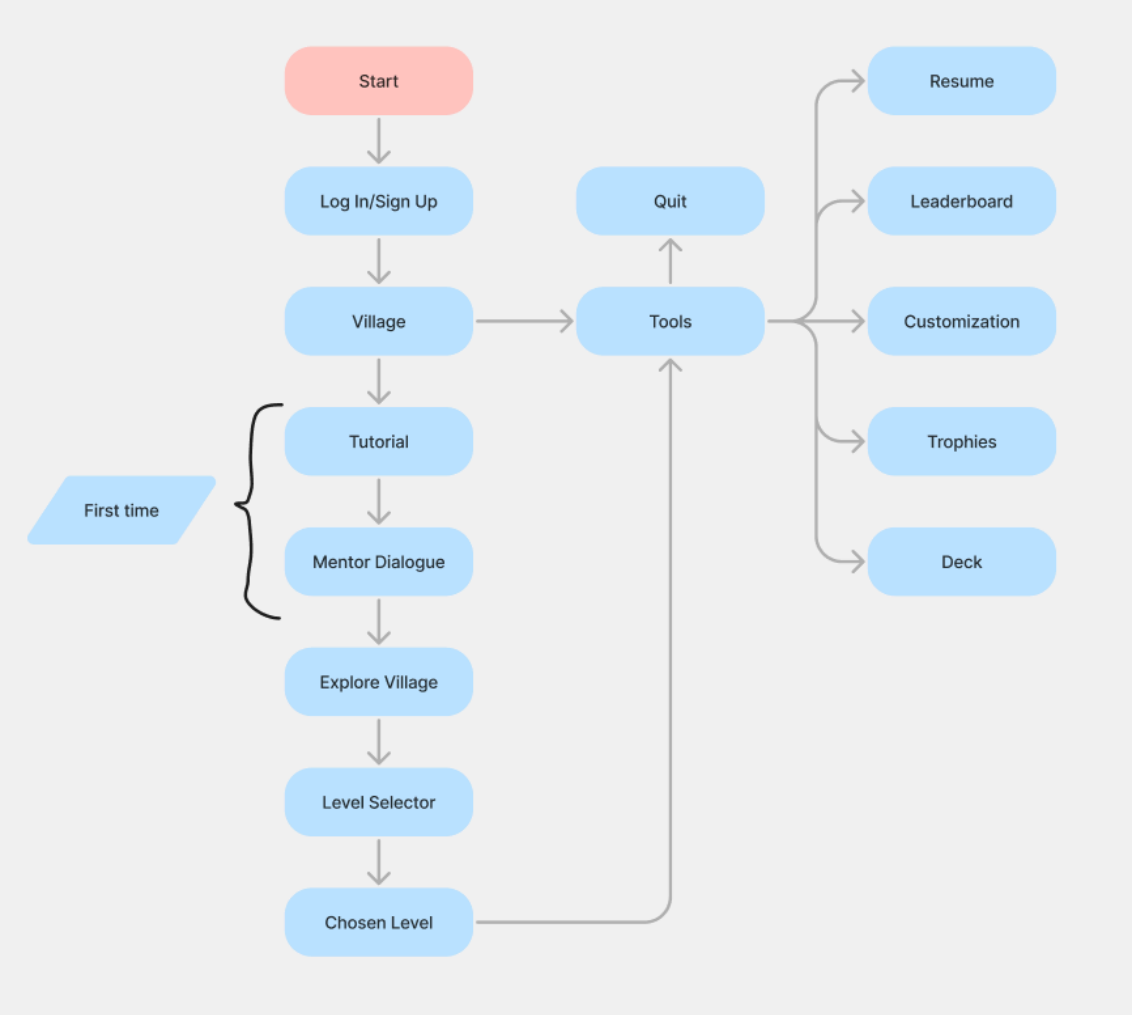
Arquiteto Habilidoso (III)		Earned by building and fully customizing every building in the village, transforming it into a thriving and welcoming place.	Gold	500 XP
Lenda dos Duelos (I)		Achieved by winning 1 duel against other players in challenges.	Bronze	100 XP
Lenda dos Duelos (II)		Achieved by winning 20 duels against other players in challenges.	Silver	250 XP
Lenda dos Duelos (III)		Achieved by winning 50 duels against other players in challenges.	Gold	500 XP

CITY MANAGEMENT

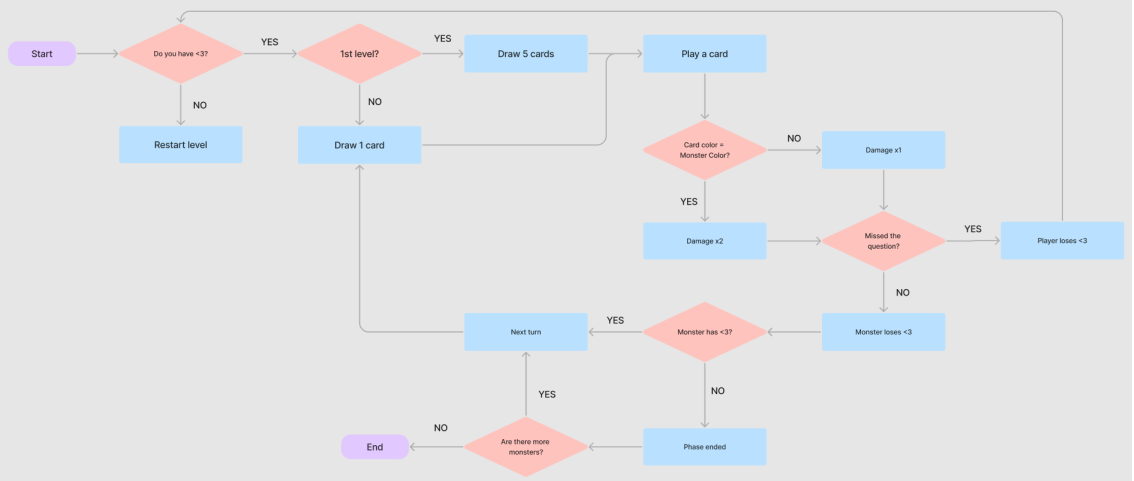
In the city management, players are responsible for the growth and prosperity of Samos. They must manage resources, make strategic decisions, and allocate them wisely to various aspects of the town's development. This includes constructing new buildings, upgrading existing infrastructure, and managing the town's economy. By effectively managing resources and making smart choices, players can attract more residents, taken for monsters, enhance the town's facilities, and unlock more content.

Building	Description	Materials
Guild	A central hub where players can join study groups, collaborate with other students, and unlock cooperative missions for additional rewards.	tbd
Library	Expand your knowledge by visiting the Library, where you can access a wide range of educational resources, books, and study materials to aid in your learning journey.	tbd
Market	Enhance your arsenal by visiting the Market, where you can upgrade weapons and armor to increase your combat effectiveness.	tbd
Cereal Field	Cultivate your own crops in the Cereal Field, providing a sustainable source of food for the town and earning resources in return.	tbd
Player House	In the player's house, customize your living space with furniture, decorations, and personal touches, creating a cozy and personalized sanctuary. You can also change styles here.	tbd

SCREEN FLOW


Start
Log In/Sign Up
Village
Tutorial
First time
Mentor Dialogue
Explore Village
Level Selector
Chosen Level
Quit
Tools
Resume
Leaderboard
Customization
Trophies
Deck

USER FLOW


Start
Do you have <3?
YES
1st level?
YES
Draw 5 cards
Play a card
NO
Restart level
NO
Draw 1 card
Card color = Monster Color?
NO
Damage x1
YES
Damage x2
Missed the question?
YES
Player loses <3
NO
Monster loses <3
Monster has <3?
YES
Next turn
NO
Phase ended
YES
Are there more monsters?
NO
End

SAVING AND LOADING

In the game, the saving process is designed to provide convenience and ensure that players can easily pick up where they left off. The game automatically saves the player's progress when transitioning between locations, ensuring that their accomplishments are preserved. Additionally, players have the option to manually save their game in the village or map level selection screen, allowing them to save their progress at any time. However, it's important to note that saving cannot be done during battles or stages. The game utilizes a single save slot per player, simplifying the saving process and avoiding any complexities associated with managing multiple save files. All saved data is stored securely online on the game's server, ensuring that players can access their progress from any device. With a straightforward and reliable saving system, players can focus on their adventure and explore the game's world without worry.

STORY, SETTING, & CHARACTER

Math Masters takes players on an immersive journey through the captivating Numeria Archipelago. This vibrant setting is comprised of diverse islands, each offering its own unique challenges and themes, from lush forests to ancient ruins. As players explore the archipelago, they will encounter a fascinating cast of characters, including a determined hero driven to save their island from the clutches of an evil villain and their relentless army of monsters. Guided by a wise mentor, Cavendish, players will embark on quests, interact with NPCs, and uncover the secrets of this enchanting realm. With the ability to customize their own avatar, players can truly immerse themselves in the captivating world of Math Masters.

STORY & NARRATIVE

In the Numeria Archipelago, a once-thriving island paradise, darkness has befallen the land. The evil villain, known as the Enigma, has unleashed a horde of monsters that terrorize the inhabitants and drain the island of its magic. As the hero of the island, it is your mission to embark on a daring adventure to save your home from this malevolent force.

Guided by your wise mentor, Cavendish, you must harness the power of mathematics to overcome challenges and defeat the Enigma's minions. Armed with a deck of magical cards, each representing a mathematical operation, you engage in turn-based battles against the monsters. Solving mathematical equations correctly unleashes powerful attacks, while mistakes weaken your abilities and put you at risk.

As you journey through the Numeria Archipelago, you explore its diverse islands, each presenting unique puzzles and obstacles, you must rely on your mathematical skills to progress.

Along the way, you encounter intriguing characters, both friend and foe, who provide clues, quests and valuable insights into the secrets of the Enigma's power. The island's inhabitants, once vibrant and joyous, now seek hope and restoration. By completing missions, rebuilding the island's structures, and solving mathematical challenges, you not only restore the island's magic but also inspire its people to regain their confidence and fight against the Enigma's darkness.

As the stakes rise, you face mini-bosses guarding the Enigma's lair on each island. Only by conquering them can you access the final battle against the Enigma himself. Your mathematical prowess, strategic thinking, and courage will be put to the ultimate test as you confront the villain in an epic showdown to save the Numeria Archipelago and restore peace and harmony to your cherished home.

CUT SCENES

In this game, the storytelling is primarily convered through audio, text and images, as there are no traditional cut scenes. The NPCs, particularly the mentor character, play a significant role in guiding the player's journey and providing information. Through dialogue boxes accompanied by expressive character portraits or images, players engage in meaningful interactions with the NPCs. The texts are accompanied by voices to make the players engaged once they are very young and don't like to read.

GAME WORLD

The game world of "Math Masters" is a vibrant and enchanting archipelago inspired by the beauty of Greek landscapes. From lush green forests to crystal-clear beaches and ancient ruins, each location within the archipelago offers a unique setting for the player's journey. The world is crafted in a charming low-poly art style, creating a visually appealing and inviting environment. As players traverse the islands, they will encounter NPCs, engage in educational challenges, and witness the transformation of the once-damaged landscapes into thriving communities. The game world of "Math Masters" is not only a captivating backdrop for the player's mathematical adventures but also a testament to the power of learning and perseverance in restoring beauty and harmony to the world.

The game is divided into three main parts, each offering unique experiences. The vibrant village serves as a bustling hub, where players can interact with NPCs, customize their surroundings, and manage resources. The level selection allows for exploration across the archipelago, with diverse islands to conquer. Finally, engaging in turn-based battles, players use their math skills to defeat enemies by playing cards. With a captivating world to explore, a lively village to cultivate, and thrilling battles to conquer, "Math Masters" offers an immersive gameplay experience that combines strategic thinking, customization, and mathematical learning.

CHARACTERS

PLAYABLE CHARACTERS

The players assume the role of a courageous hero on a mission to save their island from a nefarious villain and their monstrous minions. The hero wields the power of mathematics and embodies resilience, intelligence, and a passion for learning.

NON-PLAYABLE CHARACTERS

Enigma
The enemy in "Math Masters" is a formidable villain corrupted by dark magic and he commands an army of monsters. With their cunning and determination, the enemy seeks to hinder the hero's progress and prevent the restoration of knowledge and harmony on the island.

Cavendish

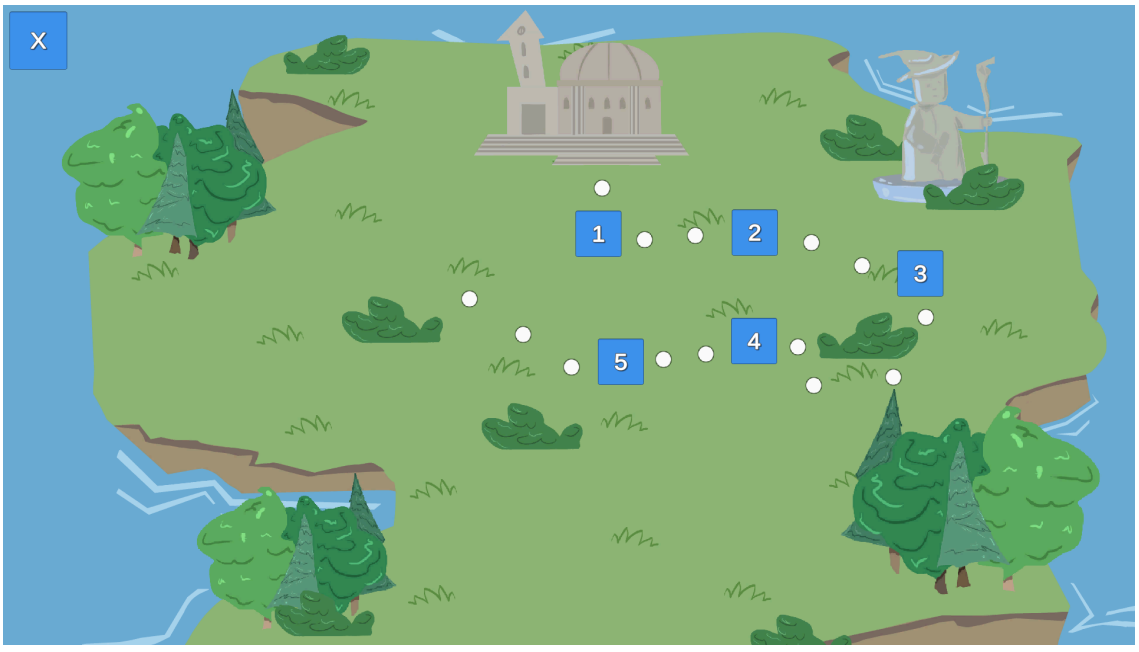
The hero's mentor in "Math Masters" is a wise and experienced guide who possesses profound knowledge of mathematics. With unwavering support and encouragement, the mentor instills confidence in the hero and empowers them to unlock their full potential as a mathemagician.

LEVELS

The game consists of multiple levels that offer engaging challenges and exciting gameplay for players. Each level is carefully designed to provide a progressive learning experience while keeping the gameplay enjoyable and rewarding.

LEVELS

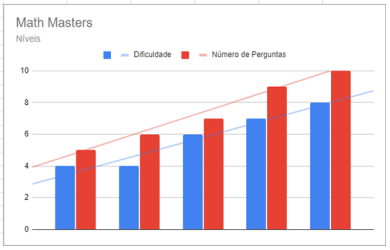
In the town, players can engage in various activities such as interacting with NPCs, visiting shops to purchase items and upgrades, customizing their avatar's appearance and house, and managing resources to rebuild and improve the island.



The level selector allows players to choose from a variety of levels, each with its own unique challenges and objectives. Players can navigate through an interactive map, selecting and unlocking levels as they progress. Only two levels are unlocked each day.

In combat, players engage in turn-based battles using their mathematical skills as magical abilities. They must solve math problems to unleash powerful attacks and defeat enemies, combining strategy and problem-solving in exciting and dynamic battles. Each level has three to six phases.

Level	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Level Difficulty	Numer of Questions
1	Red Slime 1	Red Slime 1	Spike Slime 1	Red Slime 1		4	5
2	Red Slime 1	Spike Slime 1	Monster Chest 2			4	6
3	Red Slime 1	Monster Chest 2	Red Slime 1	Beholder 2		6	7
4	Red Slime 1	Red Slime 1	Monster Chest 2	Horned Bug 3		7	9
5	Red Slime 1	Spike Slime 1	Beholder 2	Mini Lich 4		8	10
							37



The game features a gradual difficulty progression, with increasingly complex mathematical challenges, ensuring continuous and engaging learning for the players. Additionally, the difficulty adapts to the player's performance, offering more challenging exercises for those who consistently answer correctly and providing a smoother pace for those who need more practice.

INTERFACE

The game interface presents a clean and intuitive design that ensures players can easily navigate and interact with the game. The interface elements are strategically placed for optimal visibility and accessibility, allowing players to focus on the gameplay without distractions. The main menu provides a central hub where players can access various game modes, settings, and progress tracking features.

CONTROL SYSTEM

In the game, players have a straightforward and intuitive movement system. They can navigate and interact with the game world using the mouse as the primary input device. By simply left-clicking, players can move their character or select objects, providing a seamless and responsive control scheme. Additionally, players can use the scroll wheel to zoom in and out, allowing them to adjust their view and get a better perspective of the surroundings. This movement system promotes accessibility and ease of use, enabling players to explore the game environment and engage with various elements effortlessly.

AUDIO, MUSIC, AND SOUND EFFECTS

The game utilizes a range of high-quality sound effects, music, and audio assets sourced from the Unity Asset Store to enhance the overall immersive experience. Carefully selected sound effects accompany various actions and events in the game, adding depth and realism to the gameplay. From the satisfying sounds of card shuffling and combat impacts to the delightful chimes of level-ups and achievements, the sound effects enrich the player's engagement with the game mechanics.

HELP SYSTEM

To provide additional support and guidance to students, the game features interactive scrolls that contain educational videos specifically designed to assist them in solving questions and problems. These scrolls serve as valuable resources, offering step-by-step explanations and demonstrations of various mathematical concepts and problem-solving techniques.

The scrolls in the game are designed to align closely with the students' progress in the classroom. They are unlocked based on the teacher's marking of a subject as learned during class sessions. As the teacher covers various topics and verifies students' understanding, they have the authority to mark specific subjects as learned within the game.

ARTIFICIAL INTELLIGENCE

The game's AI mechanics are relatively simple, they contribute to an engaging and personalized educational journey, empowering students to develop their mathematical skills in an interactive and enjoyable way.

ENEMY AI

The game's difficulty adjusts dynamically based on the player's performance, presenting more challenging questions for those who excel and easier ones for those who require additional support. This adaptive system encourages continuous engagement and progress by striking a balance between providing a suitable level of challenge and ensuring a positive learning experience.

FRIENDLY AI

In terms of non-player characters (NPCs), their behavior is limited to basic interactions within the game's town environment. They serve to create a sense of immersion and atmosphere rather than engaging in complex AI-driven interactions.

TECHNICAL

TARGET HARDWARE

The game is specifically designed to be compatible with the PC hardware provided to every child by the school, ensuring accessibility and equal opportunities for all students.

DEVELOPMENT HARDWARE & SOFTWARE

Hardware

- Computer
- Ipad

Software

- Unity
- Visual Studio Code
- Blender
- Photoshop
- Procreate
- Github
- Audacity
- Google Doc
- Google Sheets
- Google Drive
- ChatGPT

NETWORK REQUIREMENTS

The game requires an internet connection for two primary purposes: saving game progress and managing student data. The school ensures that every student is equipped with a router, allowing them to access the game's online features even if they don't have internet connectivity at home.

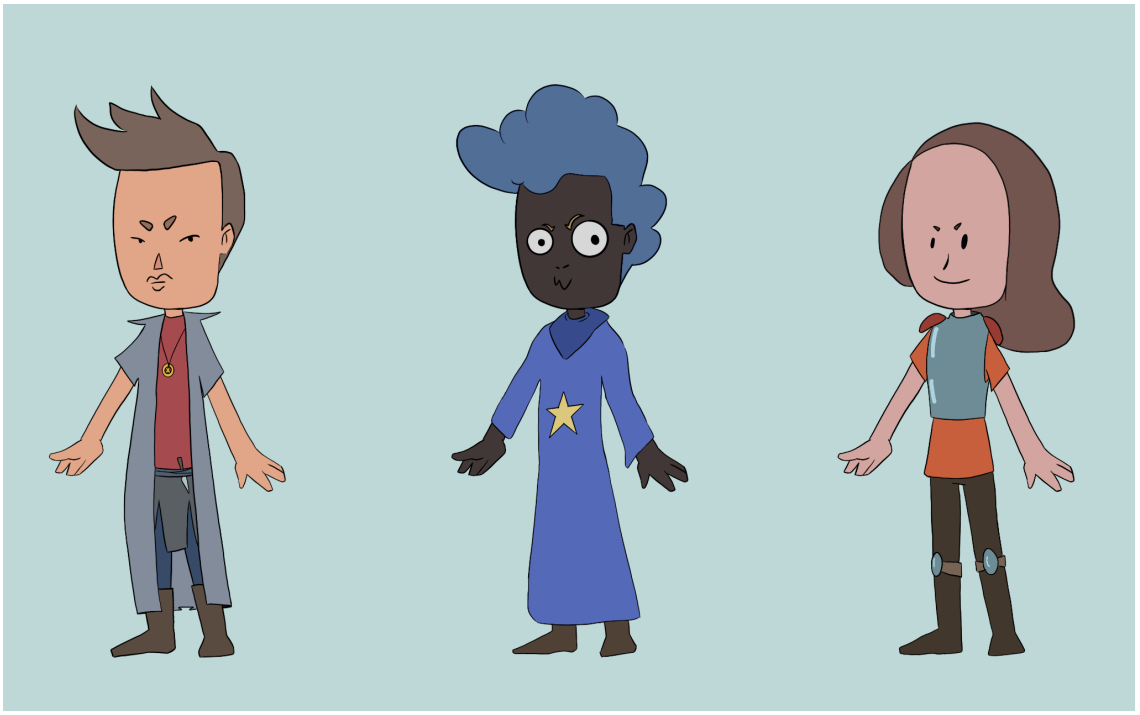
GAME ART

The art style of "Math Masters" is characterized by its vibrant and colorful visuals. Inspired by the Greek aesthetic, the game features a low-poly art style with cartoony elements, creating a visually appealing and playful atmosphere. The environments, including the island and the village, are beautifully designed with attention to detail, showcasing the creativity and imagination of the game world.

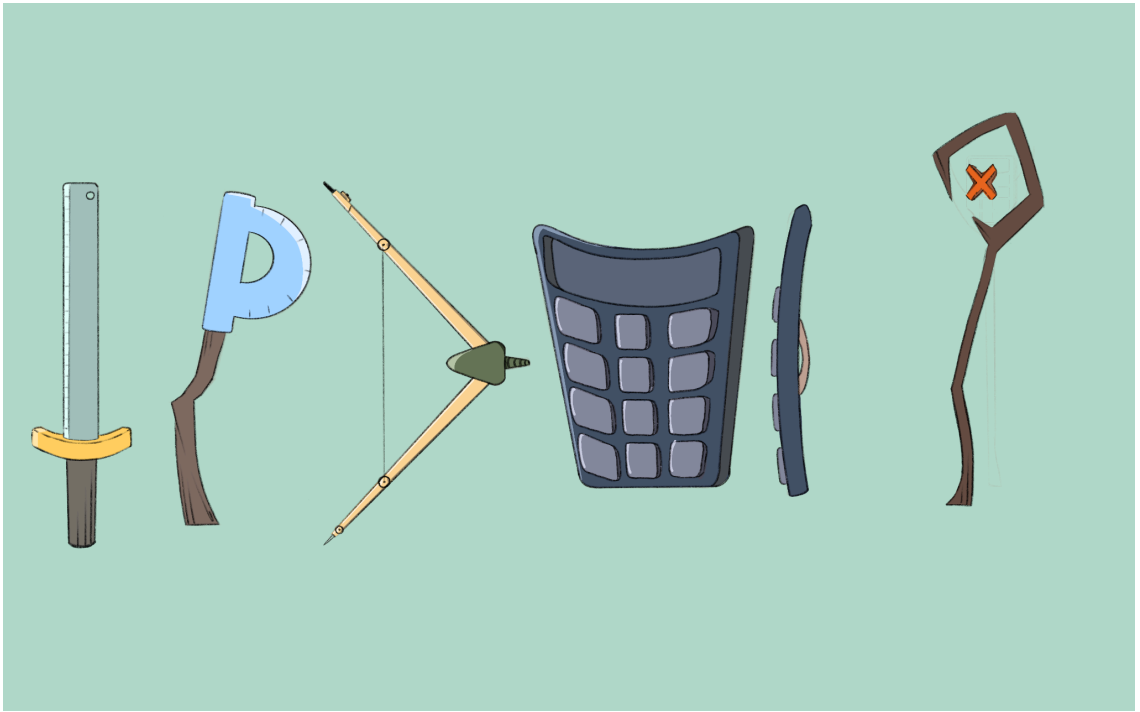
The characters, both the hero and the NPCs, are brought to life with smooth and lively animations, enhancing the overall charm of the game. Each character has a distinct design, reflecting their personalities and roles within the story. The special effects during combat, level-ups, and victories add excitement and visual flair to the gameplay, immersing players in the magical world of math.

CONCEPT ART

Hero



Weapons



Enemies