Adventure and roleplaying architectures for advanced digital learning systems

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Adventure and Roleplaying Architectures for Advanced Digital Learning Systems

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ABSTRACT

This White Paper introduces four innovations that span fundamental research, accredited by the Portuguese National Agency for Innovation (ANI) as R&D, and have previously been published in multiple scientific journals and presented in distinguished conferences:

1. Adventure-based learning architecture.
2. Contextualized visualization and interaction of Scientific and Mathematical Contents.
3. Advanced technological systems for digital adventure and roleplaying learning experiences.
4. Liber Domus – An educational roleplaying and adventures digital game for 6th grade mathematics and natural sciences learning.

Following a brief discussion of the educational theory and vision for the development process, these innovations will be described and detailed, giving an additional overview of the game design and game development interactions and processes. Additional evaluations and measurements of these innovations will be added to this document as they become available.

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MOTIVATION FOR

The research project was initiated during the COVID-19 pandemic which forced educators to question the structure and suitability of traditional e-learning tools to develop active and pro-active students, bringing back the reflection about the need to reinvent education through hyper sensorial and gamified strategies. At the same time, existing educational tools keep neglecting the development of soft skills and the basic principles for global and sustainable development of a young student.

This need was exacerbated by the negative impact related to the pandemic itself, with schools and teachers reporting record learning losses both in mathematics and reading subjects, as well as extremely low motivation and focus time.

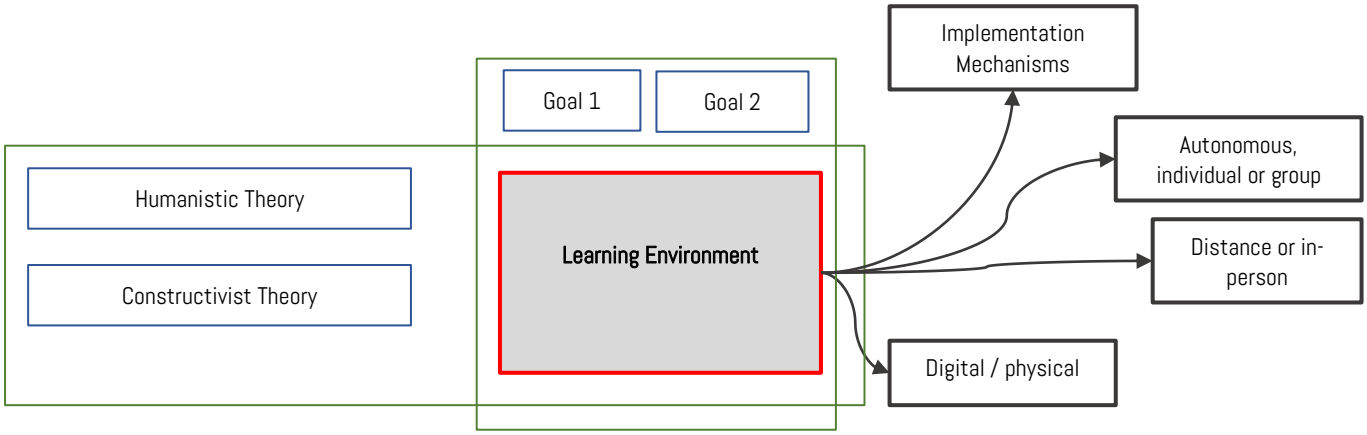
In that context, we sought to demonstrate the possible use of digital games as learning environments in which the player/learner could navigate, interact, and visualize educational contents blended with gameplay in a way that would support learning (and teaching) of different disciplinary subjects. Our main questions were:

- Is it possible for a game to act as an e-learning tool?
- What type of educational support is such a game able to provide to students? Introductory, advanced, complete?
- How can a game be structured to accommodate the educational objectives set?
- What type of game mechanisms and gameplay functionalities are required to assure that students get a complete and fun learning experience?

EDUCATIONAL PERSPECTIVE

Before developing any type of solution, the educational background and theory were analysed, having settled on a practical and digital application of the humanistic theory of learning (Johnson, 2014) as well as the constructivist theory (Wadsworth, 1996) with two parallel goals:

1. For students to reach, inside a learning environment, high levels of knowledge and advanced taxonomies of educational goals, increasing knowledge retention rates.
2. Alter the posture of the student towards knowledge acquisition tasks such as studying and instead build a positive and motivated attitude in any type of learning.



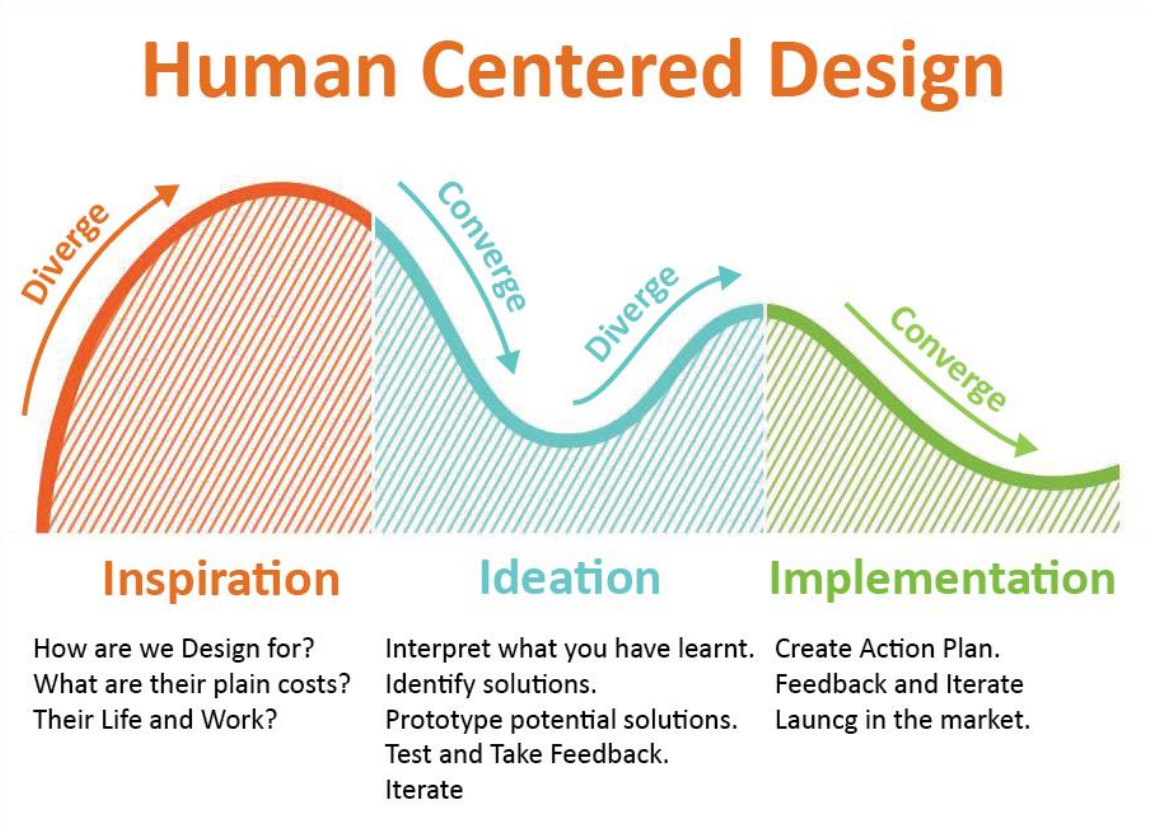
HUMANISTIC THEORY AND HUMAN-FOCUSED DESIGN (HFD)

The humanistic theory in learning and teaching is the concept of centring the student in the learning experience, directly opposing the traditional model of knowledge transmission by an expert. Instead, it neglects results and focuses on impactful, experiential, and process-based knowledge acquisition (Tangney, 2014). Currently it's considered the state-of-the-art educational theory by UNESCO (UNESCO, 2020). The main principles are:

- Student choice – choice is key, encouraging and giving autonomy to students to choose their degree of focus and dedication in each subject.

- Self-motivation – The more and more immersive the intrinsic motivation factors, the more inspired and effective are the students in the learning process.
- Self-assessment – The student should, in any way possible, get constructive feedback and opportunities to try again during assessment moments (if existing), with the pace being defined by the student.
- Safe learning environment – Students should feel physically, mentally, and emotionally safe to focus on learning.
- Interconnect emotion and knowledge – The student's emotional connection to the acquired knowledge allows the enhancement of focus and knowledge retention.

For that reason, it's considered best practice the development of any information system with human interaction to follow a humanized or human-focused design (Venable et al. 2011).

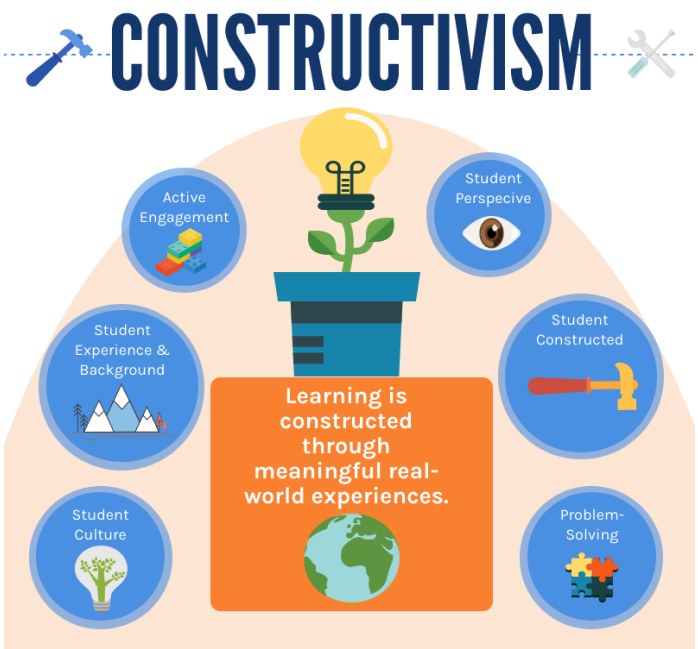


1. **Inspiration** - In education, that means we need to assure we are producing the right type of solutions and educational mechanisms for the target audience, understanding what challenges, struggles and desires students face in each school year. It is about not building what we think is important for students but what they actually want, putting ourselves in their shoes. That way, when we build educational solutions, we are making sure these are real-life connected, grounded in their realities and they will be empathic and, therefore, more engaged and motivated.
2. **Ideation** - Each game mechanism and learning moment must be worked under the learning outcomes from the first phase and continuous iterations should be attempted with students, gathering as much feedback as possible.
3. **Implementation** - We put this dynamic in practice by developing in five stages: prototype, MVP, alpha, beta, and final versions. This means that, technically, our iteration with students will never end, as we will gather all positive and negative feedback for future versions of the game and other games to be developed.

CONSTRUCTIVISM

There are a lot of good characteristics that make digital games such an important tool in today's education. But one that is particularly relevant is the ability to construct knowledge.

Constructivism, a theory that originated in epistemology, focus on learning through the construction of knowledge and bases it on the experiences of the learner.



This assumes that students take an active role in the learning process and that students will acquire knowledge through active engagement with the world, such as through experiments or real-world problem solving.

Learning is also seen as a social activity, something that is done through interactions, rather than abstract concepts.

EDUCATIONAL OBJECTIVES TAXONOMIES

This classification structure determines, in each educational moment, what is expected or desired that the student learns. This structure facilitates the identification and design of educational solutions that are adequate and non-redundant or reductive (Krathwohl, 2002).

(Krathwohl, 2002)

The more taxonomies, and the higher the order, are targeted in any given study moment, the more effective the learning session and the more lasting and impactful the knowledge acquired.

Educational tools should seek to reach, in any given moment, that the student reaches specific learning taxonomies such as the analysis of problems, creating differentiation between subjects, deconstructing, criticizing, evaluating, verifying, and more important, creating, planning, and developing hypothesis (Anderson & Krahwohl, 2001).

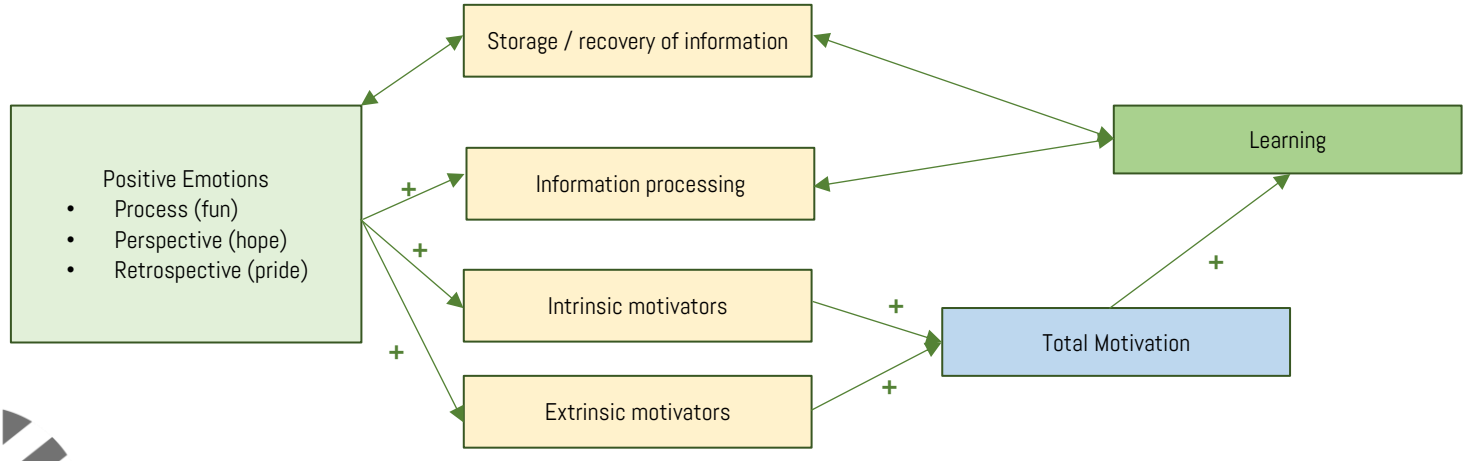
lower order thinking skills → higher order thinking skills					
remember	**understand**	**apply**	**analyze**	**evaluate**	**create**
recognizing • identifying recalling • retrieving	interpreting • clarifying • paraphrasing • representing • translating exemplifying • illustrating • instantiating classifying • categorizing • subsuming summarizing • abstracting • generalizing inferring • concluding • extrapolating • interpolating • predicting comparing • contrasting • mapping • matching explaining • constructing models	executing • carrying out implementing • using	differentiating • discriminating • distinguishing • focusing • selecting organizing • finding coherence • integrating • outlining • parsing • structuring attributing • deconstructing	checking • coordinating • detecting • monitoring • testing critiquing • judging	generating • hypothesizing planning • designing producing • constructing

(Anderson & Krahwohl, 2001)

However, inside a traditional classroom, several authors point to the impossibility of putting educational models that can reach these taxonomies due to overextending curricula, overcrowded classrooms, lack of teacher training, and insufficient tools.

Naturally, one of the most prolific areas of education has been the creation of tools, both physical and digital, to support this so desired evolution of learning.

ATTITUDE TOWARDS LEARNING



- The growth in usage of digital games and technology-enabled gamified tools in education is directly connected with the persistent search to increase motivational levels and create positive attitudes towards knowledge acquisition by students.
- Several relationships have been identified between positive emotions and high levels of motivation with school success and reaching exceptional outcomes. Anxiety, fear, and lack of motivation, on the other hand, are directly linked to failure and poor results, which might lead to premature school dropout (Pekrun, 1992).
- Additionally, research suggests that a positive attitude towards learning and high levels of intrinsic motivation led to a strong probability of higher knowledge retention rates, memory, and curiosity, up to 68% above normal (Duan et al., 2020).

TECHNOLOGY IN EDUCATION

Resorting to technology-supported or technology-based approaches, in the current educational context, is desirable, due to the extraordinary period of technological change we're facing. But at the same time raises the question of

- **What is the most desirable way we're going to teach and how are the students going to learn in a post-globalized and post-pandemic world?**

What we do know is that:

- Schools became less desirable and considered a closed and conservative place, without the ability to stimulate access to hyper-sensorial sources of knowledge (Vieira & Restivo, 2014).
- The student is becoming an ever more active agent in their own educational process using technologies. These must facilitate students' ability to analyse information, solve problems, develop a critical mind and initiative, and communication and critical cultural consciousness (European Council, 2016).

- The new e-learning model is motivating students and teachers alike to use web 2.0 or 3.0 tools and/or platforms, helping them promote XXI century skills (Cruz, 2019).
- And, although this presents the ideal moment for a new hybrid model for education, accelerated not only by online education but also by the integration of technologies as a fundamental part of schools, current existing tools do not present the desired characteristics (Fuentes, 2020).

GAMIFICATION AND GAME-BASED LEARNING

GAMIFICATION

School's reconfiguration must take place by using new approaches, based on an experiential focus and gamification pedagogy (Cruz, 2019), and favouring holistic competencies development, specific learning styles, and competitive and cooperative practices. This implies the use of didactic practices such as gamification which is defined as follows.

Gamification

"Technique that the teacher uses in the design of a learning activity (be it analogue or digital) introducing elements of the game (badges, time limit, scores, dice, etc.) and their thinking (challenges, competition, etc.), in order to enrich that learning experience, direct and/or modify the behaviour of the students in the classroom" (Foncubierta & Rodriguez, 2015).

With this approach, the teacher has the opportunity to utilize game elements, such as specific mechanics, motivation, and problem-solving characteristics, in the creation of didactic activities so that those can be more attractive in the eyes of their students (cf. Kapp, 2012).

However, **the teacher must apply a Human Focused Design (HFD) to the process of recreating educational activities**, with a particular focus on feelings optimization, motivation, and empowerment of students (Oliveira & Cruz, 2018).

GAME-BASED LEARNING (GBL) AND IMPACTFUL GAMIFICATION

Where traditional and gamified digital learning tools fail, other solutions have emerged over the years to complement and to add to the learning experience by offering a more engaging and motivating experience (Nunes, 2021).

Game-Based Learning

The use of games, which can be commercial, adapted, transformed, or built and that have defined learning outcomes and (sometimes) create educational contexts for the purpose of learning and development. It is, generally speaking, a design process of games for learning that involves balancing the need to cover the subject matter with the desire to prioritize game play (Plass et al. 2015).

Several different games, structures, and game mechanisms can be used which will impact game play and also the ability of transmitting, interpreting, explaining, understanding, and retaining information by the student using it.

It is generally accepted that a commercial game can be used for learning purposes (e.g. Civilization series) but the subjects will be introductory and sometimes even misleading in simplification. Said commercial game can be adapted (modded, programmed, updated, etc.) to correct mistakes or improve on content, however, there are some limitations (inability to change game mechanisms and systems) that still limit its use.

Building a game for game-based learning will improve on the ability to use specific variables and mechanisms unavailable otherwise, but the learning outcome is very dependent on: the game play style chosen (rpg, fps, strategy, grand-strategy, tps, platform, adventure/puzzle, etc.), on the game mechanisms included, the degree of contextualization and the structure of the game (how much it depends on narrative, how evolved are the characters, how much non-educational content is included, how open-ended and free roaming it allows players to be, etc.) (Nunes, 2021).

As mentioned, different games produce different outcomes with a significant number of variables to keep track of that can impact the user experience and educational outcomes. Several attempts made to build game-based learning experiences have resulted in weak or worse educational results due to its misuse.

Chou, 2016

The superficial development of a game, or the simple usage of a game structure and experience in the form of mechanisms such as points, leader board, badges, among others, should not be attempted**. In fact, using these mechanisms must be applied in a significant way and with the intention of motivating and creating impactful and fun experiences for the students.**

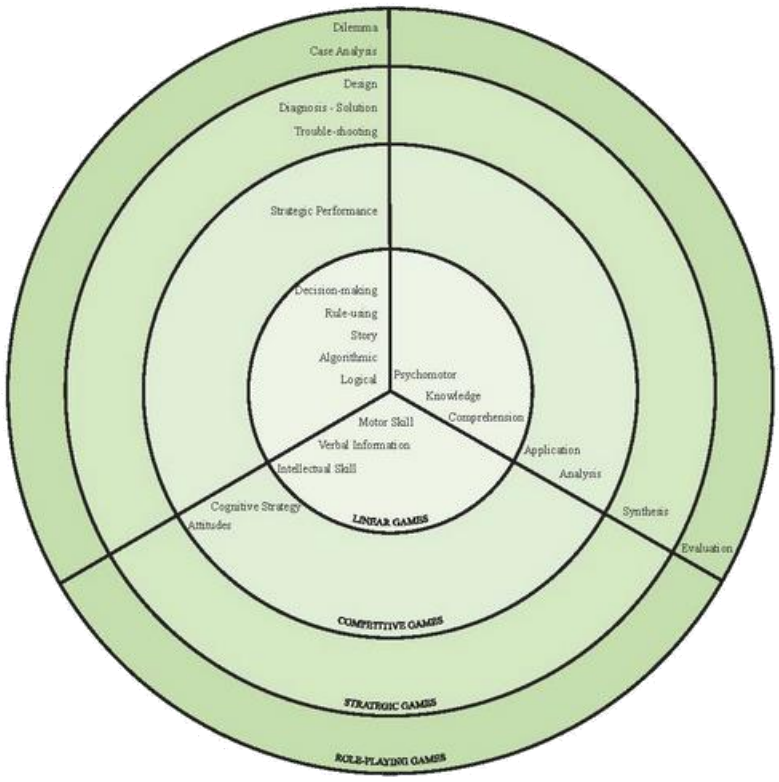
Nunes, 2021

- Approaches such as Kahoot!, Mentimeter, Duolingo, ABC Mouse, BrainPOP, among others, seek the development of such an approach, but resort unnecessarily to these non-related mechanisms, with no bridges between gameplay and content and with no attempt to use HDF in their architecture, substantially decreasing any potential gain from it's usage.
- Other solutions such as Adventure Academy, Legends of Learning and PowerZ allow for social and/or game-like experiences in fantasy worlds, demonstrating some approximation to student's motivations towards interaction and gameplay. However, HFD is still very limited and there are almost-to-none learning mechanisms incorporated and no attempt to provide educational information and learning in-line with formal learning curricula. **This not only reduces potential intrinsic motivation levels as the ability to reach relevant taxonomies**.

ROLEPLAYING GAMES AND ADVENTURE-BASED LEARNING

Lawless & Schrader (2010) analysed different educational tools based in games and through its evaluation a comparison of different achievable taxonomies was structured. They concluded that **roleplaying games present the highest probability of, structurally, reaching higher-order taxonomies**.

In these games, built using worldbuilding techniques, the player creates unique personalities, which possess skills that can be improved on. During gameplay, **the player roleplays as a character involved in adventures, or quests, through interaction, help, and support of characters or objects** such as diaries, letters, personal items, consumables, etc.



(Lawless & Schrader, 2010)

The conclusion of such adventures allows the player to improve their relationship with the characters and the surrounding world and narrative and receive rewards such as skill improvement, currency (which can then be used for the player to buy items in stores), unique items, equipment, etc.

Worldbuilding

"The art/task/craft of designing and representing an internally consistent and realistic setting for use in fiction, video or tabletop role playing games, movies, comics, etc." – in *Worldbuilding for Writers, Gamers, and Other Creators* by Matthew Wayne Selznick

"The act of creating an imaginary world." – *The Complete Art of Worldbuilding* by Randy Ellefson. Although a simple definition, Randy Ellefson details that building an imaginary world may include an enormous number of elements, ranging from multiple worlds and stars, continents, all, and any natural geographic elements that compose them, cultures, mythology, species and races, fauna and flora, characters, political, social and economic entities and relationships, relationships, objects, magical elements and technology, which may span multiple centuries.
Therefore, to introduce worldbuilding into the process of game design implies that all elements that are presented, and to some extent, some that the player might never discover or read about, are connected, logical (when compared to the rest of the world "rules") and make it credible, even if not real or possible.

It also enables the player to move further into the more complex narrative and active plots, assuring **there are additional motivations to proceed playing and exploring even if the previous quest was deemed boring** or "grindy".

The closer the player is to reach the end of the game, the closer they are to reach the end of the storyline inside the ending that is fitting to the character they created and the type of play they developed inside the game.

RPG are highly complex, which creates the possibility to involve the student in large and diverse educational experiences, including information manipulation, written and verbal information, decision-making, exploration, moral and ethical choices, creativity, and naturally, knowledge comprehension.

Storytelling in Education

"Storytelling is the vivid description of ideas, beliefs, personal experiences, and life-lessons through stories or narratives that evoke powerful emotions and insights." (Zaro & Salaberri, 1995)

Storytelling is an important tool in teaching and in learning and has been used, in multiple different ways for thousands of years. Studies have shown significant benefits in its use, from:

Development of listening skills.

Acquisition of new vocabulary.

Development of literary competence (ability to understand and enjoy literature).

Increase in communication skills (as listener and as a storyteller), especially if there's interaction between the two and/or if the student can determine and chose the path the story will take and their actions/reactions in it.

Increase in motivation, leading to the student's increase in interest regarding anything story related, which can lead to crucial positive consequences in their learning processes.

Stimulation and development of imagination – Stories are, even if simply told, interactive. The listener is actively imagining the visual replication of the story and imagining details and contexts, recreating scenes and characters, which encourages creativity and inventiveness.

The investment each player puts into the game, motivated by the complex gameplay, translates into more study and learning time inside the game world and all its elements, reaching a

learning metacognition which is not only valuable but virtually impossible to obtain any other way (Yee, 2006).

A very common complaint regarding GBL has been the continuous development of solutions whose objectives and structure are contrary to best practices, and it is considered urgent to revisit this practice and develop games with real educational value (Royle, 2008).

Currently there are no roleplaying and adventures games that have been developed in specifically designed architecture, systems, and mechanisms to accommodate educational objectives and outcomes.

ADVENTURE-BASED LEARNING ARCHITECTURE

PROBLEM IDENTIFIED

- Multiple issues arise from having basic education students learn autonomously. Specifically, these seem to struggle with motivation and effort, which can be solved using satisfactory digital resources such as 3D adventure and roleplaying games (Nunes, 2021).
- Learning through educational games is usually centred in introductory themes and support specific subjects and currently do not meet that criterion.
- At the time of this project, there were no educational games or equivalent that could display any sort of architecture meeting that criterion, neither digital nor physical.

Questions and Uncertainties

- Can we identify a complex and variable structure, despite non-existing pre-conceived sets of rules and definitions, that can accommodate necessary knowledge transmission while maintaining a complex narrative to create an educational adventure and roleplaying game?
- How will this educational framework to be designed will distinguish from traditional classroom and autonomous learning? Will it compromise educational goals and essential learning objectives?
- How certain are we that we can reach the higher order taxonomies using such a framework?
- By using narratives, and emotional and humanized elements such as characters, will the adventures have the necessary intrinsic value to reach high short and long-term motivation levels? Will these non-educational moments lead to unbalancing of the game in all or specific areas of gameplay?

STATE OF THE ART

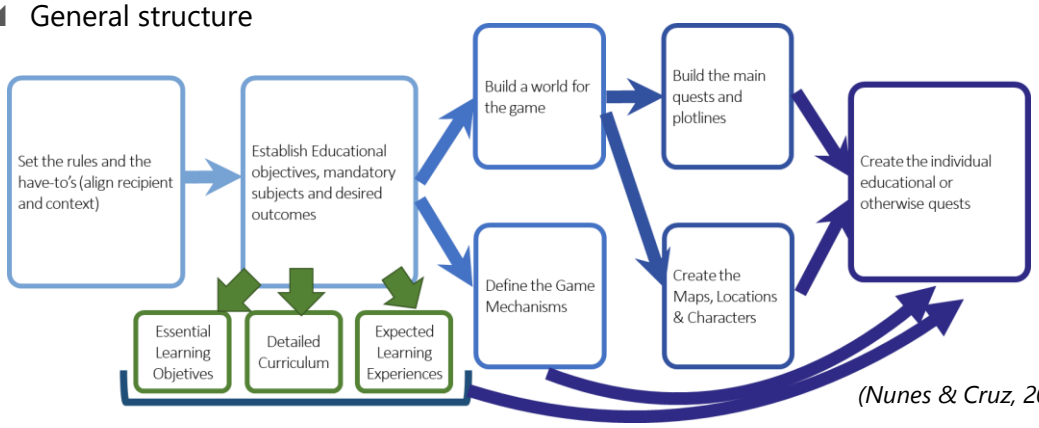
1. Adventure-based learning experiences, dependent on the teacher's methodologies and specific content, without real educational value.
2. Educational adventure games based on social models of gamified iterations with no narrative and with no connection between the narrative and educational themes.
3. Classroom experiences with adventures in physical form without significant previous structurization.
4. Research suggests there might exist the possibility of a digital roleplaying game, based on adventures, to produce the relevant and adequate outcomes.

Traditional learning (Classroom)	Adventure-based learning (Classroom)
• Teaching dependent on method, tools, students and teachers attitude and dynamics created. • Students dynamics and questions depend on motivation levels, attitude towards learning and social relationships created. • Assessment based on tests, homework and projects with immediate and delayed non-individualized feedback, no rewards and variable penalties. • Focus on transmission, memorization and repetition.	• Teaching depends on the student's attitude and the dynamic created by the teacher. • Student's dynamics and questions centred in the game and not in the student. Questions are means not an ends. • Individualized, immediate assessment, focused on continuous improvement. Variable rewards. Negative outcomes are limited. • Focus on how students learn each subject.

Traditional learning (autonomous)	Adventure-based learning (Classroom)
• Efficiency is dependent on focus level, autonomy, motivation and attitude of student as well as the presence of distracting factors. • Delayed feedback. • Tools with little to no dynamics. • Supported by tutoring, e-learning (gamified or traditional).	• Tool promotes focus, autonomy, motivation and positive attitudes in students as well as introducing controlled, distraction/relaxing moments and factors. • Automatic and immediate feedback. • Humanized support for learning. • Dynamic and variable tool.

SOLUTION DESIGN

- General structure



(Nunes & Cruz, 2021)

Each game's set of rules and have-to's are established and are directly linked to the student's age and the subject's theme. For instance, if the game is related to physics and chemistry in 9th grade, then the game will have themes and storylines related to scientific adventures and locations, such as a sci-fi scenario. At the same time, as the students will be around 15 years-old, the game structure will encourage complex autonomous

exploration and not too complex plots and stories and make heavy use of emotional content to which they can relate to. Naturally, there will also be specific rules such as actions, violence, and language barriers that directly or indirectly conflict with the educational purposes.

Table 2. Not allowed or strongly discouraged RPG elements to include in educational games.

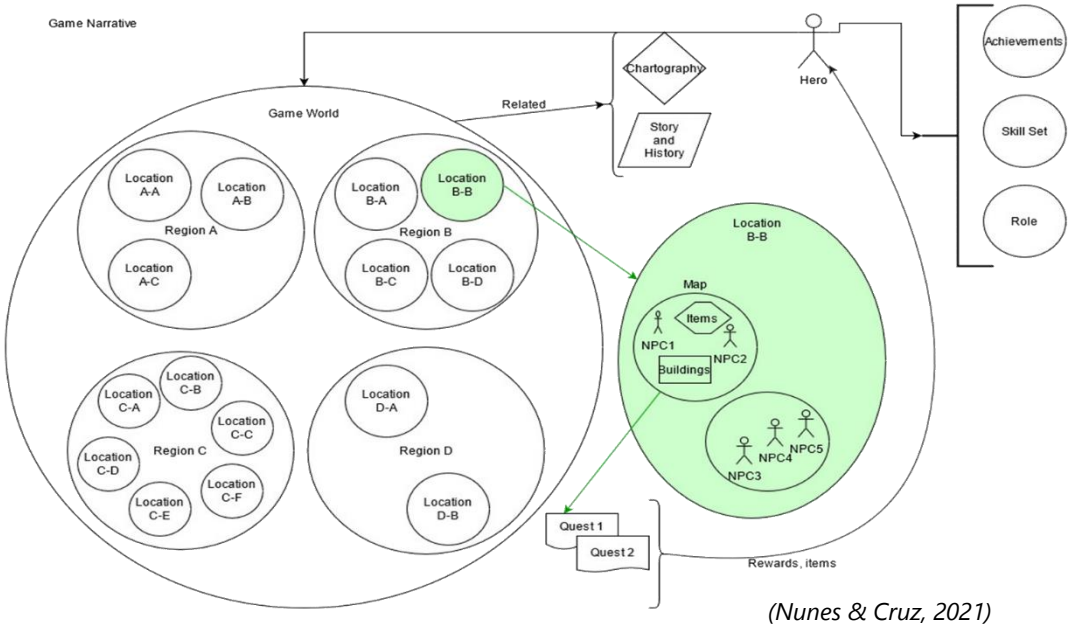
Mechanisms	Battle & battle equipment Destruction of property / Vandalism Stealing Abuse of in-game currency mechanism Cheating Loot and loot boxes Psychological manipulation of character or NPC
Gameplay and Narrative	Violence (execution or graphic), except directly related to curricular contents Violence (graphic mention or dialogue, from player or NPC) Nudity (any form) Sexual content (any form, including implicit or indirect), except directly related to curricular contents Lying (through dialogue) Racism or intolerance towards an NPC (through dialogue) Direct or indirect use of luck/chance to alter outcomes without explicit use of probabilities in age-appropriate settings Excessive use of magic and fantastic elements

(Nunes, 2022)

Educational objectives are determined and detailed, regardless of the main subject of focus (e.g. Math 6th grade), regarding the:

- Essential Learning Objectives, connected with the government's body guides and instructions.
- Detailed curriculum according to official curricular documents such as manuals approved for the subject.
- Expected Learning Experiences, related to the ideal outcomes that are expected from a student and include soft skills and personal development goals.

Based on that information, the game world is built as well as the game mechanisms. Both are developed at the same time with the previously determined educational goals, subjects, and outcomes to assure complete contextualization and integration.



(Nunes & Cruz, 2021)

The picture above illustrates an example of game world creation, which determines how many locations exist, which characters, items, and other interactable objects in it, how the player is introduced into the whole world and individualized interactions and so on.

From that moment, individual quests are created. Below can be seen an example of the individual structure of adventures.

- Individualized structurization of adventures

Aventura #3 – "Jogos do Fórum" Bancada Vermelha		
	Mecanismo de jogo	"Jogo de Troncos & Anéis"
	Descrição	O jogador é convidado pela Hypatia de Veteris Ruma, um dos "Mestres de Matemática" a participar num minijogo em que o jogador lançou um anel num tronco, situado dentro de um ângulo e distância específicos de acordo com um conjunto aleatório de perguntas.
	Condições vencedoras	Obtenha 5 respostas corretamente de sete tentativas possíveis (terceira resposta errada causa derrota). Obrigatório: 2 pontos de energia para jogar. Recompensas: 3 maçãs + 1 item especial
	Duração esperada	15-30 minutos
	Objetivos de Aprendizagem	Funcionamento do jogo (interação, navegação, narrativa) **Objetivos essenciais de aprendizagem:** **Matemática Complementar 5º ano** Geometria e medida Ponto 3
	Ensino Essencial (matemática & ciência PT Currículo)	Nível introdutório: Capítulo 5 - Parte 1
	Taxonomia de Bloom	Lembre-se (reconhecer, recordar); Compreender (exemplificando, classificando, inferindo, comparando); Aplicar (execução); Análise (diferenciação); Avaliar (verificação);
	Procedimento de Avaliação & Texto de Realização	A avaliação baseia-se em 5 respostas corretas de 7 (min 70%). A repetição é possível. Sem diferenciação entre 100% e 70%. "O Mestre Hypatia queria testar o nosso objetivo. Fazendo contas e tivemos que acertar nos troncos posicionados em certos ângulos. O sucesso foi nosso!
	Estado	Implementado

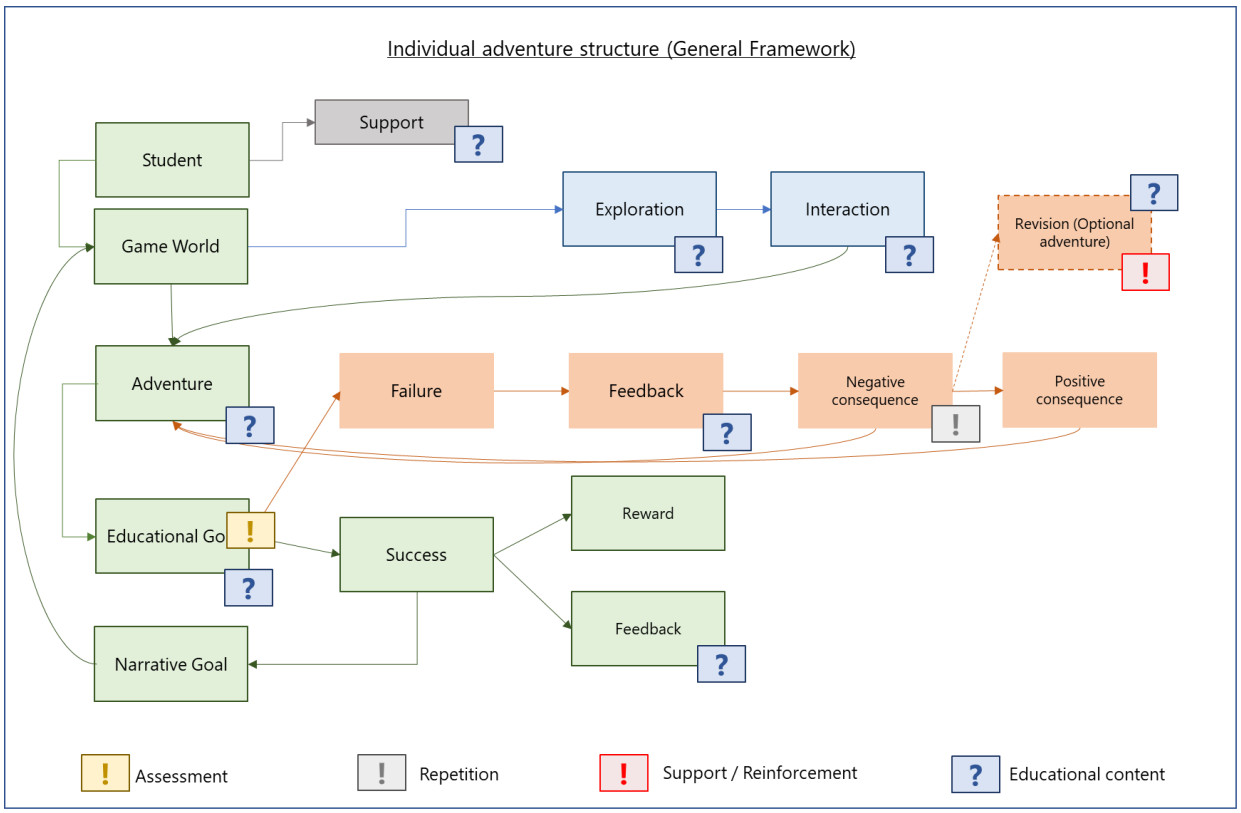
(Nunes, 2022)

Each adventure is designed through its own simplified game design document. These documents inform of gameplay characteristics such as quest text, characters that participate, game mechanisms to enable/build/disable, locations to use/build, and additional information.

However, it has two main objectives, one non-educational and one educational. Winning conditions for each are determined as well as

individualized feedback provided by the characters or game systems, support systems, etc. Educationally, each adventure is also structured:

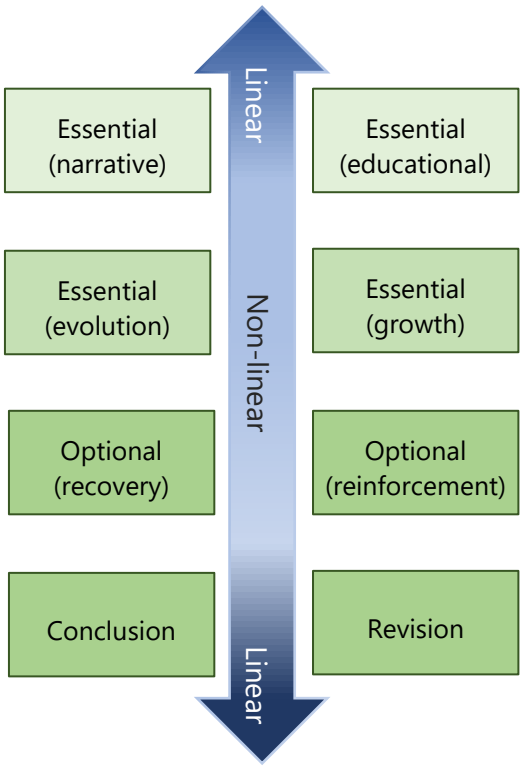
- Duration: time spent in each quest, which is calculated by testing and reflects the appropriate time of "studying".
- Individual educational goals that are targeted.
- Educational curriculum: To assure all curricular objectives are targeted, these are identified as introductory, main, and reinforcement.
- Evaluation procedure: How the student/player will be assessed regarding the outcome of the educational objective.
- Bloom's Taxonomies: Which taxonomies we are reaching with each adventure.
- A complete flowchart of a general framework that is used for all adventure design and development.



- Adventure design

From the start of design, the question regarding the development of a game or any sort of educational experience based in adventures led to the questions:

- What happens if the player needs to reinforce specific contents?
- Can the player choose their adventure path? How do we assure complete knowledge acquisition while allowing for this type of flexibility?
- What solution can exist if the player is "stuck" in a quest, without sufficient knowledge or proficiency to advance, despite all support systems?



It was determined that there should be linear to non-linear adventure progression. Students start the game going through the tutorial stage (linear), then progress into introductory quests (mostly linear), then reach the main content to be learned (mostly non-linear), with the support of reinforcement quests and recovery quests (completely non-linear) until the revision period (linear).

ARTEFACT DEVELOPMENT

Two artefacts were developed. One physical and one digital.

- Physical artefact – Age of Society

The adventure-based learning architecture was implemented in a 3rd grade classroom, for the teaching of Mathematics and Natural Sciences with a total of 19 children.

The game was played during four different moments for one month and the students were integrated into groups.

(Gavaia et al., 2021)

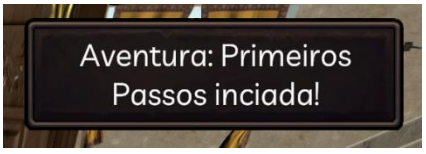
The game consisted of several moments of roleplaying, inside a custom-built world and custom-built adventures that integrated the educational contents according to the framework defined.

(Gavaia et al., 2021)

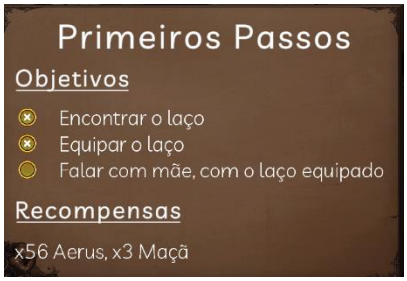
- Digital artefact – Liber Domus – adventure

1 - Quest giver

2 - Quest dialogue

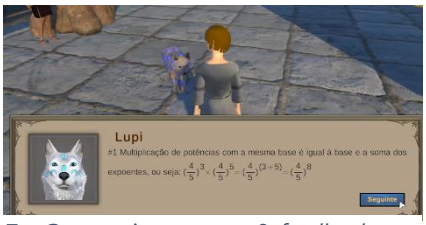


3 - Quest notification

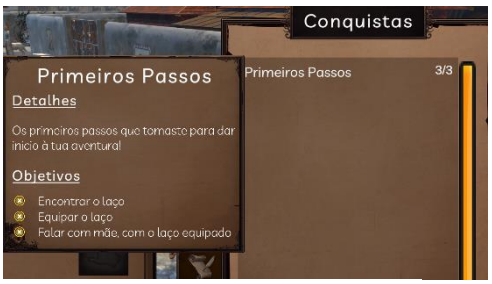


4 – Quest objectives & rewards

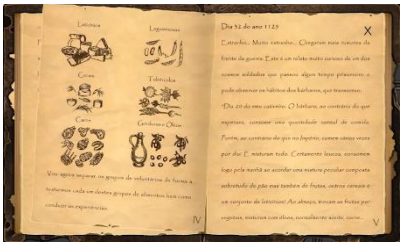
5 – Objective conclusion



7 – Companion support & feedback



6 – Adventure conclusion



8 – Educational content

9 – Educational support during gameplay

10 – Negative consequence mechanism

PILOT, DEMONSTRATION, AND EVALUATION

- Both architectures were tested in pilot programs, as seen below.
- Results are consistent with the humanistic and constructivist theories, introducing humanized and positive feedback and individualized learning experiences.
- Game mechanisms are compatible with higher-order taxonomic objectives.
- The structure is compatible with physical and digital applications.
- Blend between ludic and learning moments integrated into narratives and adventures.
- Can be used in autonomous learning or classroom, in one or more subject, with dimensions spanning from one curricular theme to a full year-long curriculum.

Age of Society

- 19 3rd grade students in one Primary School in the Oporto area, Portugal
- 4 different gameplay sessions
- Mathematics and Natural Science curricula

"The integration of the video game in the classroom stimulates pedagogical and evaluation changes in the learning process. However, it requires a transdisciplinary plan based on learning by challenge in a collaborative way and technical and pedagogical plan to integrate digital resources."

Liber Domus (classroom)

- 30 6th graders in Oporto area, Portugal.
- Classroom environment – 10 different groups
- Qualitative study with semi-structured interviews

"Digital role-play games can contribute to an increase in motivation and the development of collaboration, critical thinking and creativity skills, which in turn improve the behaviour and the involvement of the pupils at learning maths in a very active way. (…) Pupils value these sort of approaches (…)"

Liber Domus (e-learning)

- +400 5th and 6th graders in Oporto, Gaia, Lisbon and Amadora areas, Portugal
- Autonomous learning from home environment – 10 different schools
- Quantitative study through questionnaires (comparing with existing e-learning tools)
- 100% of students felt more motivated (level 6-8, of which 61% felt much more motivated (level 9-10); 81% felt they learned faster (level 6-8) of which 65% felt they learned much faster (level 9-10). 97% graded the game the tool more fun to use (level 9-10).

CONTEXTUALIZED VISUALIZATION AND INTERACTION OF SCIENTIFIC AND MATHEMATICAL CONTENTS

PROBLEM IDENTIFIED

1. Digital teaching using a gamified approach only presents superior outcomes compared to traditional learning and teaching, regarding comprehension and retention, when the game mechanisms are acceptable. This is not the case in the vast majority of gamified or game-based learning solutions (Nolan & McBride, 2014).
2. Gamified solutions, including GBL, present weak or non-existent links between the narrative (if it exists at all) and the educational content (Gunter et al., 2008).
3. The degree of variation between contents inside an annual curriculum is significant, which prevents repetition (which is not desirable - Van Eck, 2006) and makes the whole development process complex and slow, which brings into question the ability to integrate those mechanisms inside a logical and intertwined system.

- How can students visualize and interact, in a gamified or game-like fashion, with educational content while keeping the contextualization of the narrative and at the same time reaching the essential learning objectives?
- How can we maximize the gamified moment (a.k.a. the educational mechanism) so that we can obtain different taxonomies?
- How can we blend different moments and knowledge to reach different taxonomies and learning contexts?
- **Main objective: To create digital mechanisms that can be integrated into an individual learning and teaching game for science and mathematics, in 2D and/or 3D. These should be compatible with full support and feedback integration and flexibility regarding the different subjects.**

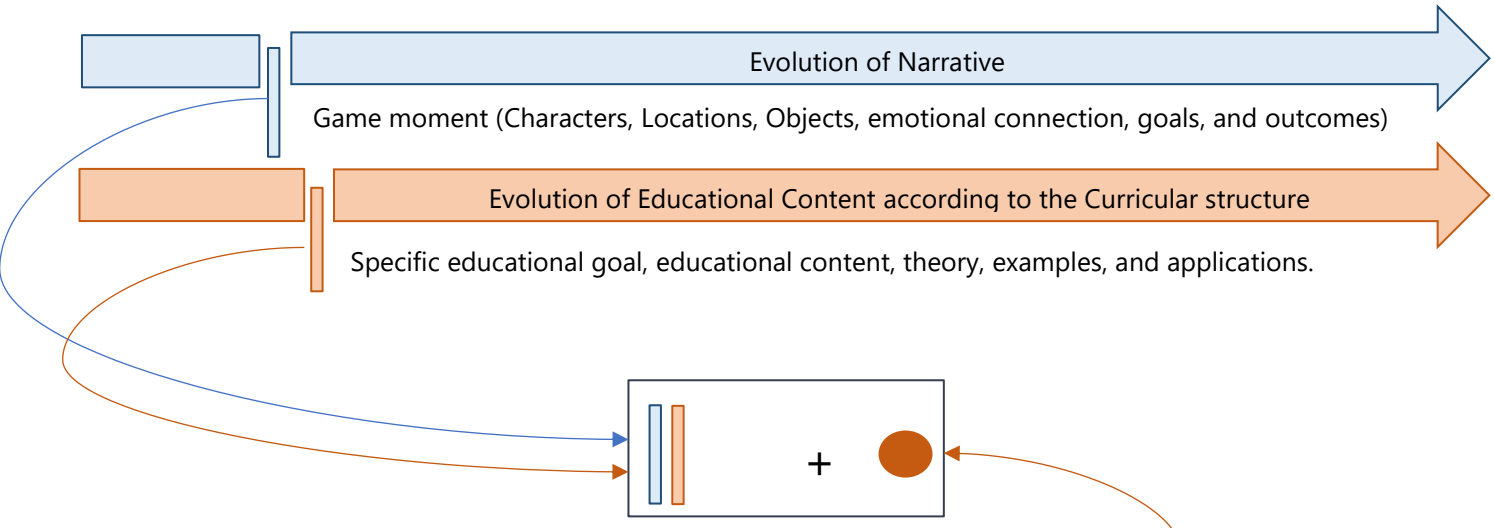
STATE OF THE ART

Royle, 2008

- To maximize learning, designers must use different ways of presenting the same information.
- Game mechanisms must relate to the authentic content (narrative, plots, stories, motivations).
- The game must use authentic content in a believable scenario.
- The game support systems (help, tips and information) should be intrinsic and extrinsic to the game.
- Players should customize their character and determine their rhythm and direction/shape of their progress.

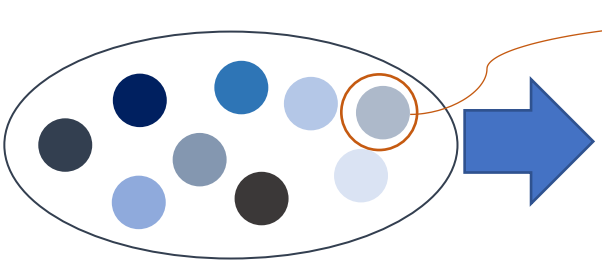
SOLUTION DESIGN

1. We began by creating a comprehensive inventory of representations, structures, shapes, both physical and digital, existing, or designed for classroom or autonomous environments, for a specific curricular objective or equivalent.
2. We then recreated each pedagogical practice and typified it according to guidance for a target audience and structured it digitally.
3. Additionally, we analysed alternative solutions and compared them through different perspectives, educational goals, narrative typologies, and game moments, non-educational objectives, dynamics, timings, educational and non-educational outcomes, among others.



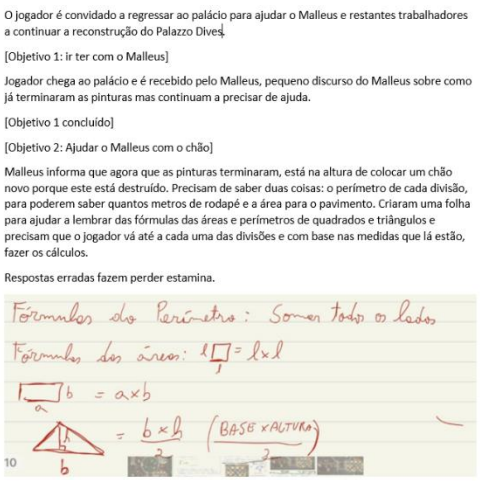
Inventory of teaching methods which:

- fit the target audience
- fits existing content
- can be implemented digitally.



Selection, contextualization, and non-educational content creation

ARTEFACT DEVELOPMENT



O jogador é convidado a regressar ao palácio para ajudar o Malleus e restantes trabalhadores a continuar a reconstrução do Palazzo Dives.

[Objetivo 1: ir ter com o Malleus]

Jogador chega ao palácio e é recebido pelo Malleus, pequeno discurso do Malleus sobre como já terminaram as pinturas mas continuam a precisar de ajuda.

[Objetivo 1 concluído]

[Objetivo 2: Ajudar o Malleus com o chão]

Malleus informa que agora que as pinturas terminaram, está na altura de colocar um chão novo porque este está destruído. Precisam de saber duas coisas: o perímetro de cada divisão, para poderem saber quantos metros de rodapé e a área para o pavimento. Criaram uma folha para ajudar a lembrar das fórmulas das áreas e perímetros de quadrados e triângulos e precisam que o jogador vá até a cada uma das divisões e com base nas medidas que lá estão, fazer os cálculos.

Respostas erradas fazem perder estamina.

Fórmulas do Perímetro: Somar todos os lados

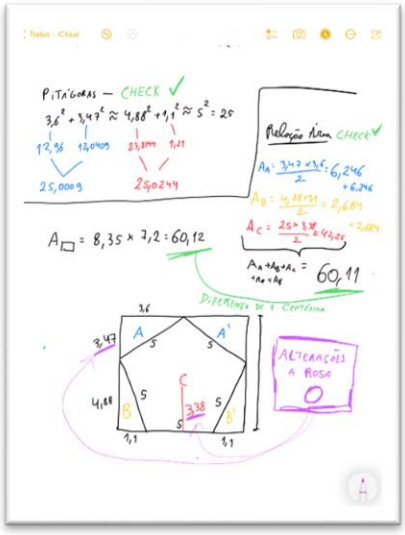
Fórmulas das áreas:

$= a \times b$

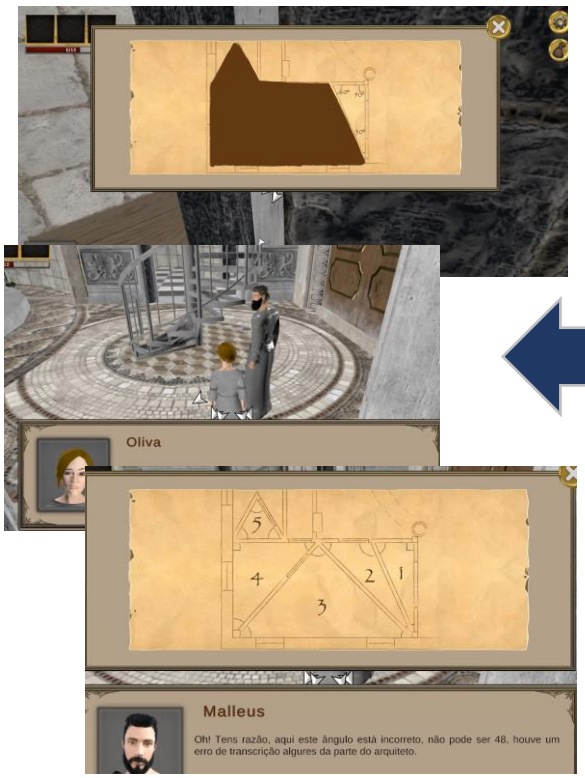
$= \frac{b \times h}{2}$ (BASE x ALTURA)

10

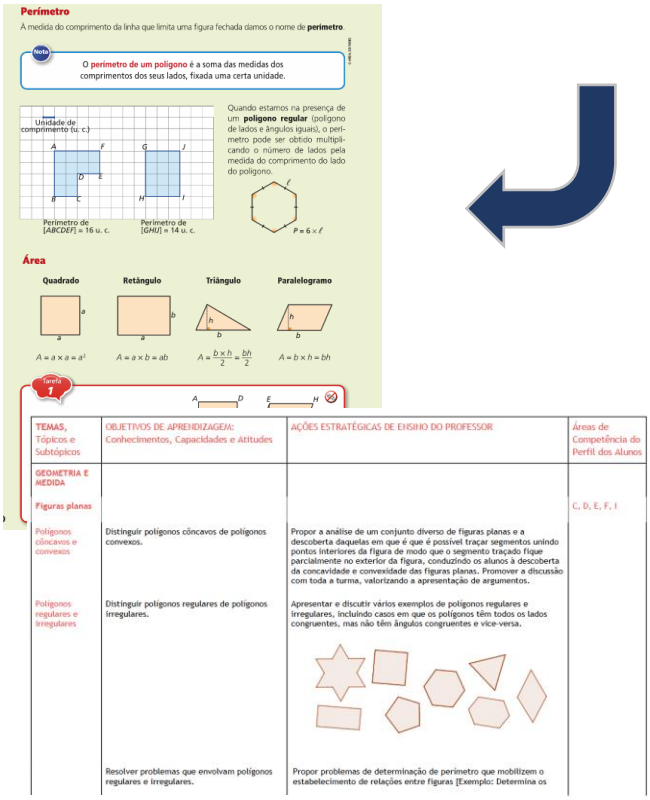
1 – Artefact design and structure



2 - Objective identification and organization



4 – Artefact development & implementation



3 – Curricular analysis and defining educational goals

PILOT, DEMONSTRATION, AND EVALUATION

The entirety of the contextualized educational mechanisms was integrated into the digital game Liber Domus. In total:

- More than 57 educational objectives and the total amount of essential learning goals for mathematics and science in 6th grade were implemented through game mechanisms.
- 16 completely new and innovative mechanisms were developed, including 10 with 3D capabilities, and of which, more than 40 different variations were produced.
- 26 adapted and contextualized mechanisms were produced, including more than 70 variations, including the 3D adaptation of 20 mechanisms.
- 6 contextualized existing mechanisms.

Outcomes

- New learning mechanisms for classroom teaching, classroom learning and autonomous learning, which can be contextualized into new scenarios and narratives, and which can be implemented in a group or individual context, with or without the support of the teacher.
- Visualization and interaction mechanisms for mathematics and science content that can be flexibly used between the 3rd to 6th grades and are compatible to internal or external adaptation.
- Flexible programming which allows for web, windows, iOS, OsX and Android implementation.

ADVANCED TECHNOLOGICAL SYSTEMS FOR DIGITAL ADVENTURE AND ROLEPLAYING LEARNING EXPERIENCES

PROBLEM IDENTIFIED

1. The development of educational games is slow and complex. There's a clear gap between developers and educators and an inherent struggle to understand each one's role. This degree of complexity leads to insufficient or unexpected/undesirable educational outcomes (Hartt et al., 2020).
2. There's a clear need for optimization of the game design and game development processes when it comes to educational purposes, despite software advances, which results in very low efficacy (Hirumi & Stapleton, 2008).
3. The traditional development of educational content and gamified educational mechanisms does not allow for the required integration level for an educational adventure game, resulting in low immersion and low motivation levels (Kiili, 2005).

- How can we create comprehensive systems for pedagogic agents?
- Is it possible to integrate all pedagogic required systems, including support, without changing the core architecture of the game?
- Can we integrate into the development phase educational and non-educational content? (example: Rewards in the form of game lore and an educational book in the inventory)
- **How can we build digital systems that enable the development of educational adventure games, based on best practices and that allow a facilitated production with educational contents and mechanisms integrated?**

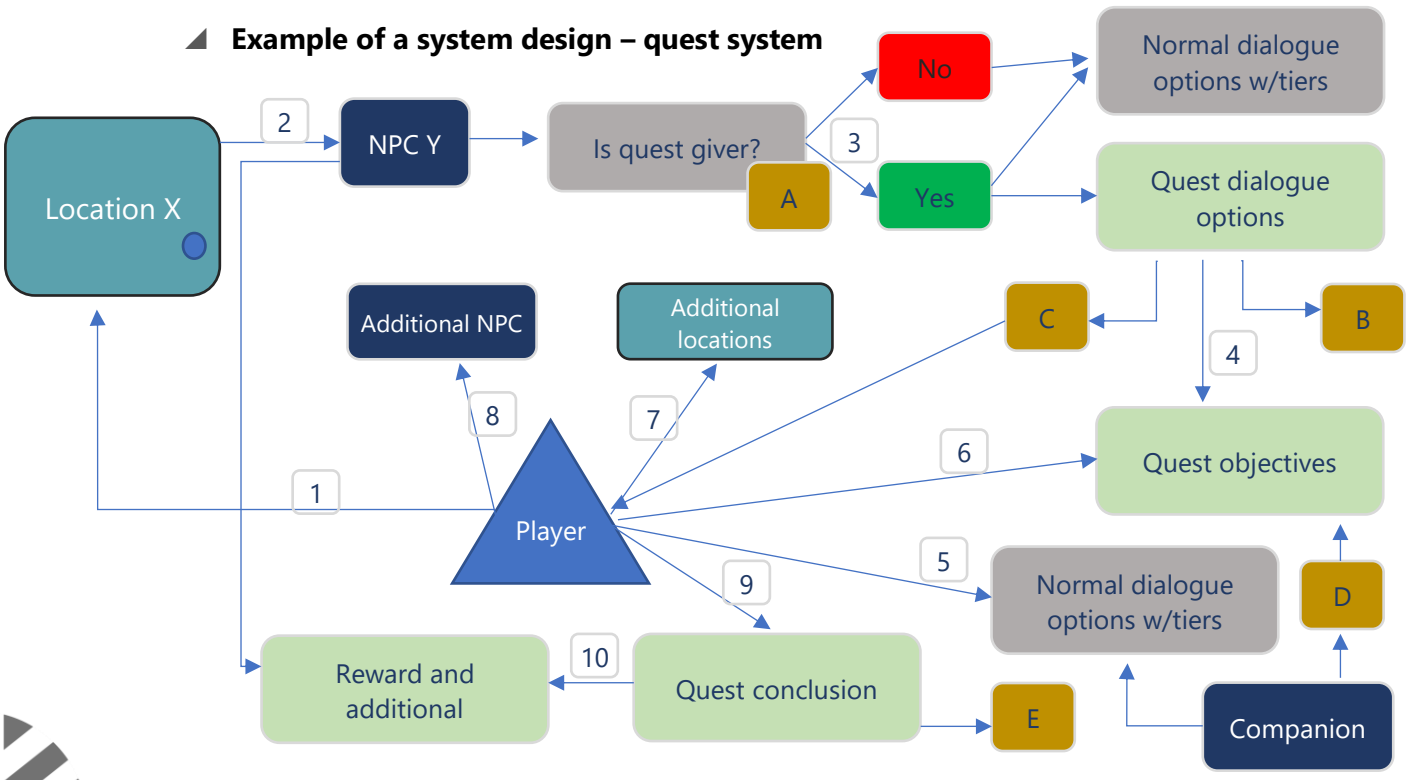
STATE OF THE ART

Kiili, 2005; Hirumi & Stapleton, 2008; Nunes & Cruz, 2021; Nunes et al., 2022

- An educational adventure game should have all the required systems as a traditional roleplaying and adventure game, apart from non-acceptable content.
- Pedagogy must be integrated into the educational game architecture.
- The game must be adapted to allow full learning and full educational support of one or more subjects.
- Repetition, comprehension, and reinforcement must be promoted.
- Content creation should be facilitated as so the pedagogic agents can comprehend and collaborate in the development process.
- Systems developed must display the required flexibility to adapt to different educational content without the need to produce new.

SOLUTION DESIGN

Example of a system design – quest system



Description of a regular quest system:

The player travels to a location **(1)**, and interacts with a character/NPC **(2)*.** Under determined conditions (the player has a certain item / has completed a previous required quest / has a specific level / has a certain stat level / has a certain equipment / no conditions), the NPC will give out a quest, which the player is required to accept or may decline to do so **(3)**. Dialogue options vary according to each choice as well as other elements (e.g., if the player successfully completed a quest for a personal enemy of the quest giver, then the quest giver may reply a specific answer "you helped my enemies and therefore I will require assistance but only because I have no one else to turn to.").

The player then receives the quest objectives and may or may not interact with the companion (if it exists) for additional help, information, support, items, etc. **(5)**. Then each objective is concluded (6) by interacting in different locations **(7)** (if required, some quests might not request this) and/or different NPC **(8)** (if required, again, some quests might not request this). By completing all quest objectives the player then travels back to the quest giver and completes the quest **(9)**, receiving the rewards** and any additional information that might be useful for the player.

* Sometimes quests can be given out by interacting with certain objects or simply reaching said location, but for the sake of simplification, we will only present the example of interaction with NPC.

** Rewards can take the shape of: currency, items (permanent, degradable, special or consumable), equipment (useful or cosmetic), experience for levelling up, experience for stats improvement, lore, new quests, among other options).

Educational Adaptations:

A → Quest giver can provide educational introductory information while providing quest details and, if introduced through backstory and lore, it can help the connection between educational and non-educational content.

B → There is, inside the dialogue options and the quest information, educational details that can be given, such as tips, diagrams, and other information to support the educational success. According to performance from the player, the feedback given is immediate and provides additional support, motivational dialogue or even additional tools.

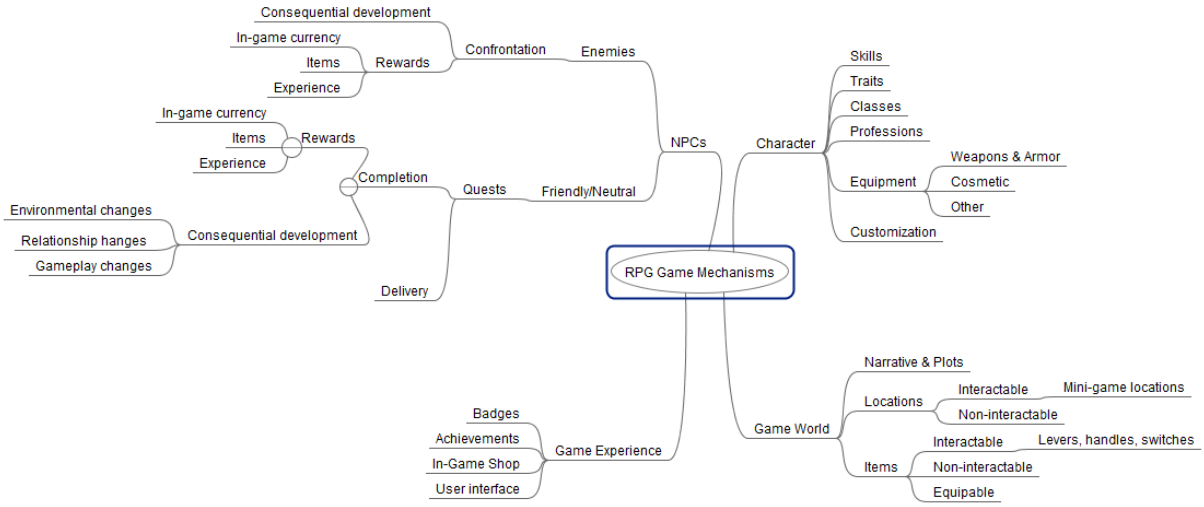
C → The player can additionally be given information during the execution of objectives, such as a question mark with full educational information, as well as inventory items such as a book which contains details, simply contextualized or fully integrated into the narrative, to support learning.

D → The companion has the function, inside the normal dialogue options which usually accompany information regarding the quest, to provide additional tips, indications on how to complete the quest or specific objectives.

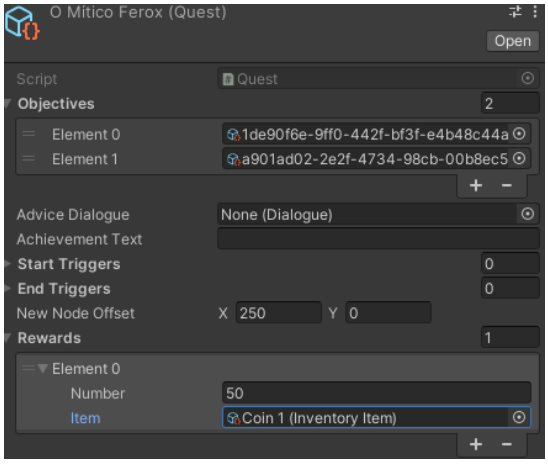
E →The quest completion may also provide the player with additional educational information for a consequential quest or as a reward to the player (e.g. a tip book to learn functions).

Every system design follows the same logic, as long as it's accommodated inside the game architecture. As we can see in the diagram below, not all systems are desired for educational purposes, being omitted from gameplay.

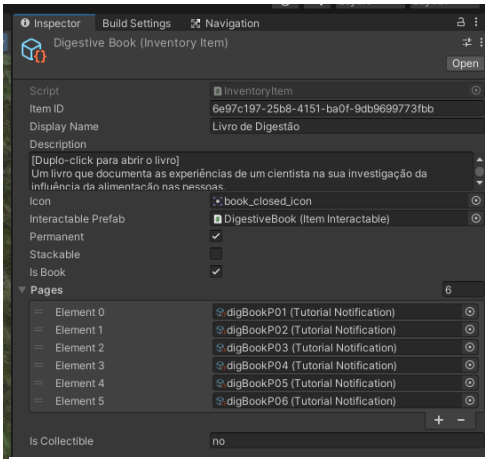
- **Although those aren't mentioned directly in this section, UI adaptations are also done to accommodate the educational nature of the game to assure full contextualization.**



ARTEFACT DEVELOPMENT

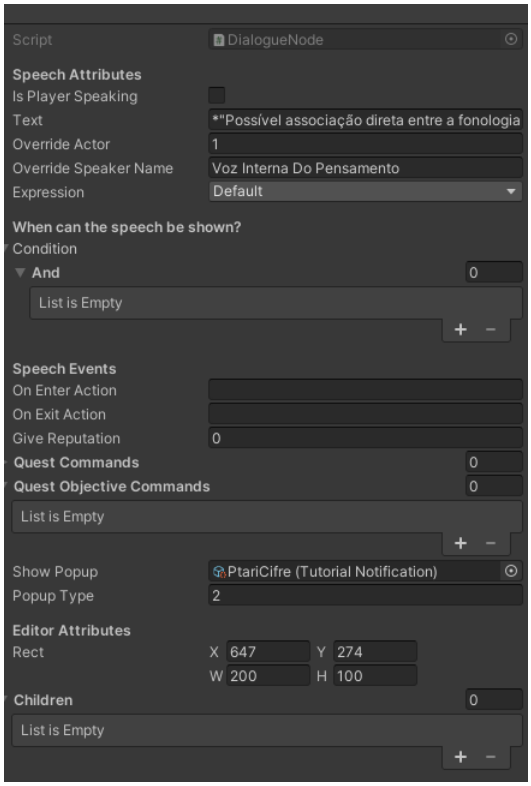


1 – Quest system implementation

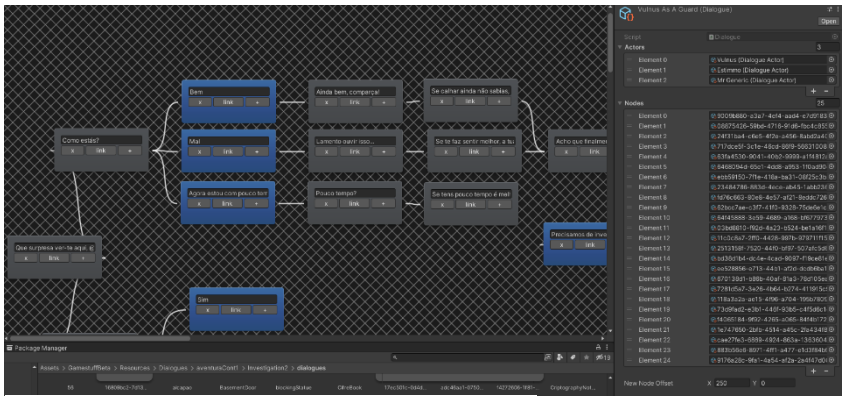


2 – Character interaction system

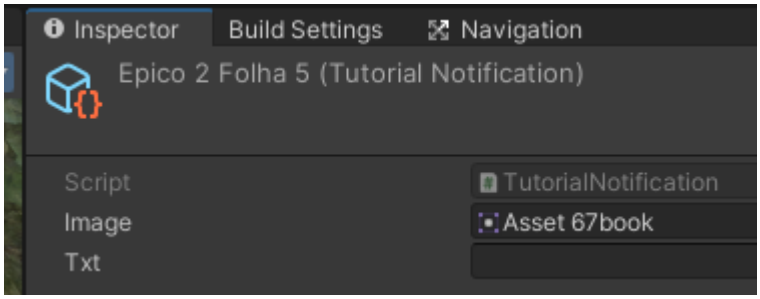
Continuing the example of the quest system above, each system is programmed to easily produce new or adapt existing quests and implement those inside the game, with the main concern being guaranteeing the narrative and existing backstories, and plots keep their logic and timeline unbroken.



3 – Educational Support System #1



4 – Dialogue System



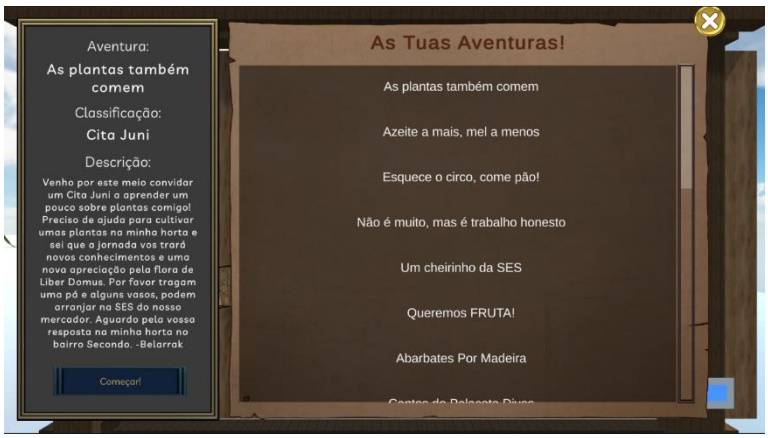
5 – Educational Support System #2

PILOT, DEMONSTRATION, AND EVALUATION

Several main systems were developed into a prototype alongside 4 initial quests, completed in June 2021 and tested in 4 different school districts between July and September 2021.

The outcome was presented in two different reports for internships for the Degree of TSIW (ESMAD – IPP -Porto). Implementation was a success and further systems were developed to a total of 16, which include:

- Dialogue and dynamic NPC interaction system
- Quest system
- Companion
- Financial and currency system (including shops)
- Dynamic inventory and items system
- Statistics and stats
- Notifications (soft & hard, intrusive and non-intrusive)
- Map and navigation system
- Character equipment
- Character creation
- Crafting and repairing items
- Book and adventure support (integrated into the mechanisms)
- Free-roaming adventure choice through quest-board



Example of Quest System with free-roaming options

LIBER DOMUS

PROBLEM IDENTIFIED

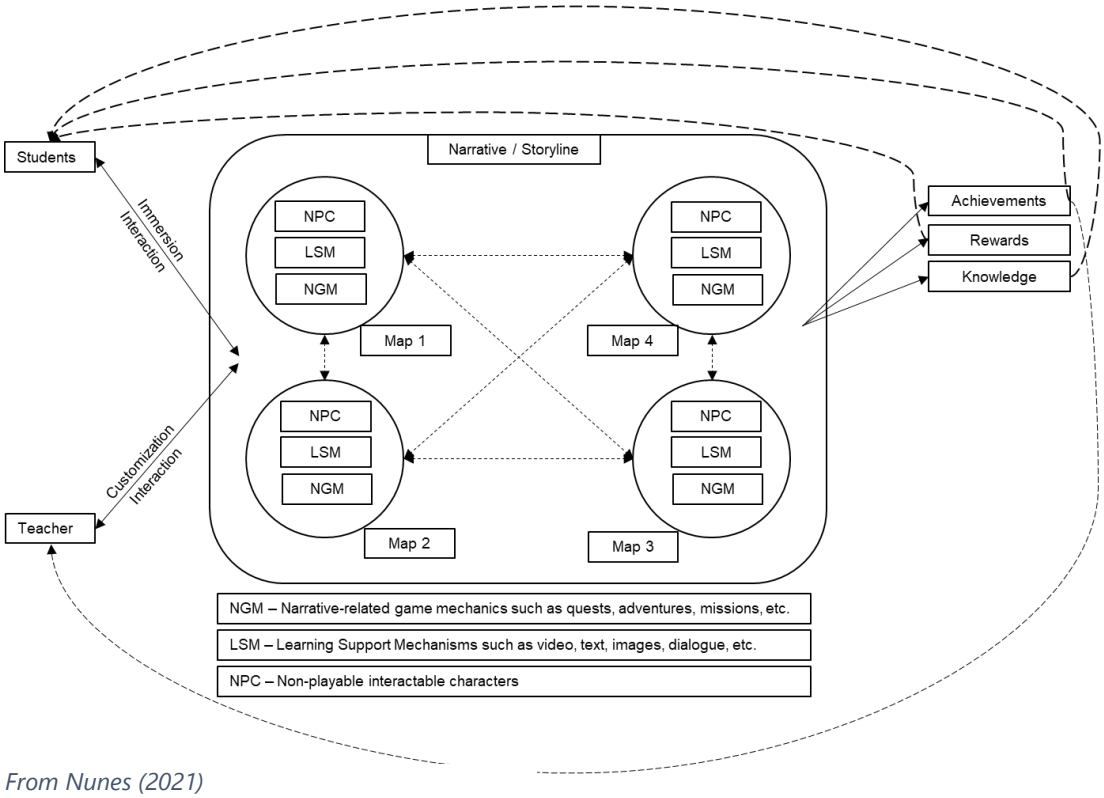
1. The educational game development based on roleplaying/adventure structure, in 3D and for any degree or subject inside the formal educational system and complete educational support has never been attempted previously (Nunes, 2021).
2. Using 3D tools inside the classroom that can truly support formal teaching scenarios are not gamified.
3. There are no tools that integrate and contextualize learning nor focus specifically on improving motivation and learning/teaching capacity, with existing solutions presenting trade-offs between the two.
4. The full development of games that do not neglect gameplay and motivational mechanisms with the required educational support for a full understanding of any subject is deemed too expensive and time-consuming to be viable.
5. There are significant barriers to using digital games inside a classroom:
    a. Financial costs.
    b. Access to required hardware and compatibility between platforms.
    c. Standardization or generalized acceptance of a teaching methodology.
    d. Technological skills of teachers.
    e. Game efficiency in comparison to traditional resources.
    f. Teacher/student motivations, attitudes, and beliefs regarding the game capacity.
6. Additionally, there are also barriers to using digital games in autonomous learning:
    a. Financial costs.
    b. Access to required hardware and platform compatibility.
    c. Motivations, attitudes, and beliefs from students/parents regarding the game capacity.

- **How can we build a 3D adventure/roleplaying game that can support full-scale year-long learning, aligned with the formal educational and pedagogical goals for mathematics and science 6th grade?**

STATE OF THE ART

The state of the art was extensively explored in the previous innovations and is intrinsically connected to it and therefore will not be detailed here.

SOLUTION DESIGN



From Nunes (2021)

The game was developed following a significant 3 month period of worldbuilding and narrative writing, alongside game design elements and instructional design to assure a complete connection between all elements of the game, non-educative (narrative and gameplay related) a

Examples of concept art for narrative building

We followed the RETAIN model, Level 3, meaning the game design successfully attempted a design of a digital world in which learners "imagined" lives could be played out through characters and a variety of themes.

Table 4 RETAIN rubric

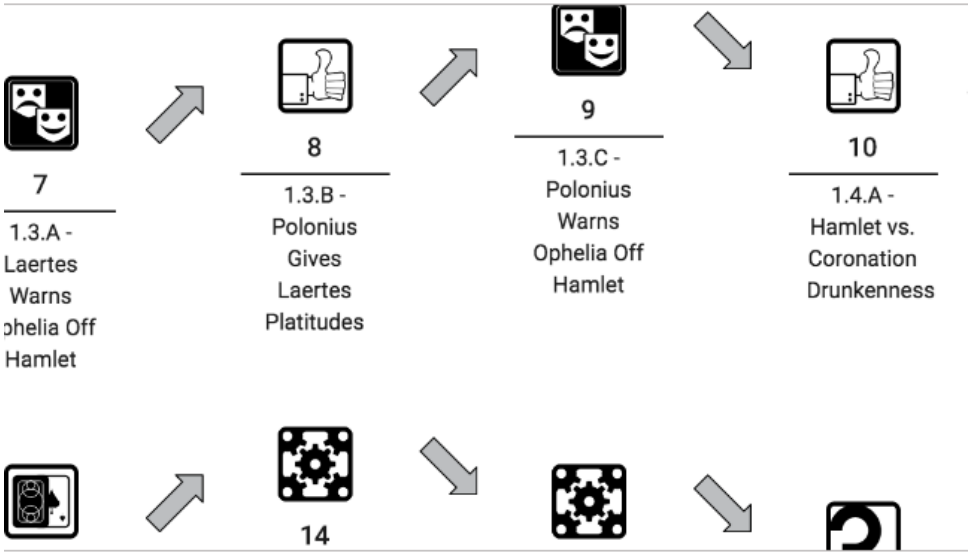
	Level 0	Level 1	Level 2	Level 3
Relevance	The story/fantasy creates little stimulus for learning and is in a format that is of little interest to the players/ learners nor does it utilize advanced organizers. The player/learner does not know the state of the game or the required learning content based on the choices presented.	The story/fantasy is age/content appropriate or it has a limited educational focus and little progression. The pedagogic elements are somewhat defined but occasionally players/learners are allowed by the embedded fantasy to become engaged in inappropriate content or contexts.	In addition to overcoming limitations and/or adding to Level 1 features, the following are also present: Specific didactic content is targeted and learning objectives are clearly defined. Creates interest in what is to be learned and a natural stimulus and desire to learn more.	In addition to overcoming limitations and/or adding to Level 1 & 2 features, the following are also present: Is relevant to players'/learners' lives, (real or imagined) and/ or the world around them using characters and themes familiar to them. Matches the players/learners to their appropriate developmental level by providing adequate cognitive challenges.
Embedding	The "teachable" moments disrupt the players/learner's gameplay, that is, flow of the game. Has no interactive focus/hook either on the emotional, psychological, physical, or intellectual level.	Didactic elements are both present but are not cohesively integrated—one or the other is added as an afterthought to the first. Content to be learned is exogenous to the fantasy context of the game.	In addition to overcoming limitations and/or adding to Level 1 features, the following are also present: Allows for extended experiences with problems and contexts specific to the curriculum. Intellectual challenges are presented to players/learners of sufficient level to keep them interested in completing the game.	In addition to overcoming limitations and/or adding to Level 1 & 2 features, the following are also present: Involves the players/learners both mentally and emotionally in such a way that they are conditioned to accept change and invest in the belief. Educational content is fully endogenous to the fantasy context.

From Gunter et al. (2008)

Narrative, backstories, and plots were designed to assure not only mental but emotional connection between the player and the characters (including the main character, companion, and NPC).

All story-related and educational-based content was contextualized for 6th grade students (ages 10-11) according to their emotional, social, and personal expected growth levels and themes to which they would feel connected to.

Emotional development and connection inside the game followed the Story Beats (see Robin D. Laws "Beating the Story" and "Hamlet's Hit Points") methodology.



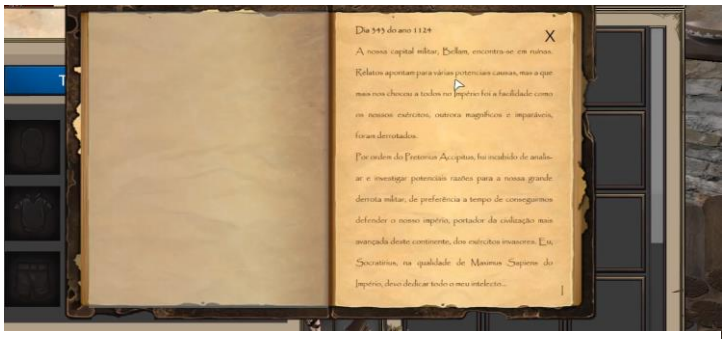
From Robyn D. Laws "Beating the Story"

ARTEFACT DEVELOPMENT

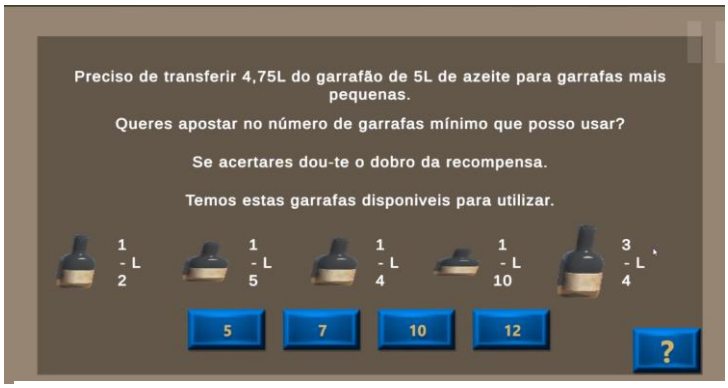
Artefact development took place between March-2021 and July-2022, with the following steps:

- Prototype Development – March-2021 until June-2021
- Prototype testing – July-2021 until September-2021
- Alpha version development – October-2021 until December-2021
- Alpha version testing – January-2022 until March-2022
- Beta version development – January-2022 until April-2022
- Beta version testing – April-2022 until June-2022
- Final version development – May-2022 until July-2022

Example – Quest related to data-analysis section of mathematical curriculum

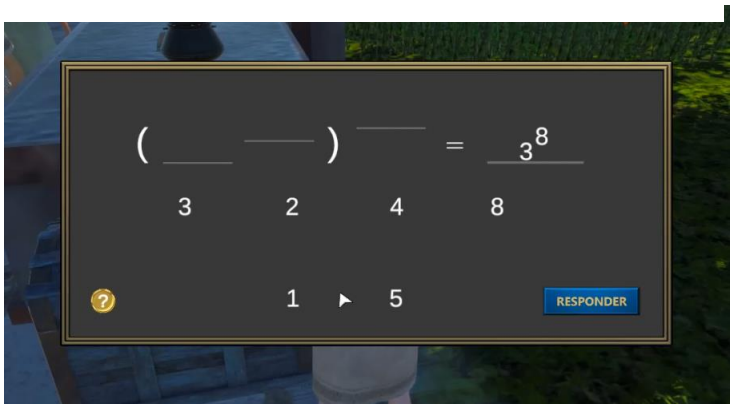


Example – One of many books written for the game lore & educational content



Example – Quest integrating both mathematical & scientific content

Example – Companion system



Example – Mathematical game mechanism to unlock reward chest

Example – Adventure development

PILOT, DEMONSTRATION, AND EVALUATION

The game was extensively piloted, and feedback and iterations were continuously obtained during the development stage (prototyping, alpha, and beta versions).

Currently the game is ready for market and results are being consolidated and scientifically expanded through the Schoolers & Scholars ongoing research project.

The game structure has presented itself to be:

- **Flexible** – allowing the introduction, replacement, and elimination of quests to adjust to curricular needs and modifications.
- **Adaptable** – Translations of the game are expected to take up to three months (1 translator) and curricular adaptations between 3 to 6 months (1 educator), demonstrating the system's and the game engine's ability to be introduced to any school curriculum and national educational programme.
- **Cost-efficient** – The entire process was developed with an average of 5 people working on it, which is considerably efficient compared to traditional e-learning development or game development teams.
- **Scalable** – The game span three additional educational tools:
    - **Teacher's Version** – A specific game version that keeps the contextualization but removes time spent during adventures and uses replayable and randomized mechanisms, allowing for the game mechanisms to be used inside the time and classroom constraints.
    - **Multiplayer Version** – For specific events such as Math Olympics, classroom competitions, and cooperation moments, and school-wide as well as national-wide events related to science and mathematics, using the same contextualization and open world scenarios as the original game.
- **Cross-platform** – The game was developed in a flexible engine, allowing it to be playable on a computer and tablet and across different devices with the same character and progress through cloud saving.

EXPECTED OUTCOMES

Each innovation has specific outcomes, existing and expected. In this section we will focus on expected outcomes that can be delivered by Kendir Studios or any other educational technology studio/company/research centre. This list serves to highlight the potential applications and impact we expect to reach, in the short or long term, but serve, by no means, as an exhaustive catalogue.

ADVENTURE-BASED LEARNING ARCHITECTURE

- The architecture proposed in this White Paper serves as an example of the use of elements such as roleplaying, roleplaying-related mechanisms, storytelling, and worldbuilding-related mechanisms in a formal classroom environment.
- These elements do not possess, on its own, enough educational importance to be implemented without educational content. However, the depth and number of educational moments, mechanisms and content used will be left to the objectives defined by the teacher.
- Nevertheless, it is important to signal the expected outcomes of each of these elements, either used inside a digital or physical game developed.
- Properly contextualized and intrinsically related with content, storytelling, alongside the use of dramatic tension, can improve the learning environment, improve desire to acquire knowledge (Gunter et al., 2008), affecting motivation, curiosity, and emotional attachment to the content (Malone and Lepper, 1987), which in turn improves knowledge-retention rates by helping form memories (Duan et al., 2020).
- Worldbuilding elements, from narrative-related, to visual content, and (if implemented) even audible elements such as specific environmental and action-related sounds and voices (including accents), and a particular care for narrative contextualization of all elements has been proven to improve immersion, increase engagement, and introduce to players ideas related to experimentation and speculation, crucial to improve critical thinking (Roine, 2016).

- Roleplaying elements, such as having students playing out a character (or several), which has different, flexible, evolutive, and customizable personality, skills, traits, strengths, and weaknesses tends to result in significantly higher immersion levels when connected to any type of activity. This means that it can create less friction between leisure and study moments, resulting in longer study periods, and higher concentration levels and knowledge absorption rates (Brom et al., 2016; Nunes, 2021).

CONTEXTUALIZED VISUALIZATION AND INTERACTION OF SCIENTIFIC AND MATHEMATICAL CONTENTS

We expect these mechanisms of interaction and visualization can be scalable, expandable and re-used in several other digital 3D applications for learning.
Each developed mechanism is, in our perspective, an additional tool to make digital environments not only a place for students and teachers to meet remotely, but also make full use of technology to better understand how anything works.
It is our understanding that without the contextualization of these mechanisms, any attempt to develop an educational digital environment will result in novelties without any real educational purpose and impact on students.
Additionally, it is also understood that the development of said mechanisms must always attempt to replicate reality in terms of physical structure and characteristics, and its normal behaviour in real life, including all types of interactions. Therefore, the use of pixelized, low-poly or otherwise simplified visual effects should be avoided, and if it cannot, should not, in any way, replace the accurate representation.

ADVANCED TECHNOLOGICAL SYSTEMS FOR DIGITAL ADVENTURE AND ROLEPLAYING LEARNING EXPERIENCES

The development of these systems will serve any future game development efforts by reducing the time-constraints and costs related to game development. All of the systems

developed can be re-used for several different applications, from gamified to non-gamified applications, new game-based solutions based or not on rpg/adventure structures as Liber Domus or otherwise.

We expect these systems to continue being updated and improved to facilitate back-end implementation of new games, game scenes, adventures, and game mechanisms with educational value, and therefore help bridge the gap between game development and educational instructional design.

As we continue research and development, we also plan to develop further systems to complement the different ways students can access and use educational support and content.

EDUCATIONAL ROLEPLAYING AND ADVENTURES DIGITAL GAMES FOR FORMAL LEARNING

We believe that Liber Domus is but a first step towards what we consider an evolution of the e-learning traditional (and gamified) e-learning system.

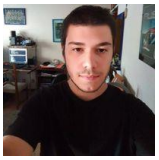
Both for learning and teaching, digital environments in the form of a game, which creates context, scenarios and are fully equipped to support teachers with tools and students with learning mechanisms, cannot be more perfect in the absence of correspondent physical solutions.

It is expected that this game is improved on by further games, both nationally and internationally. Indifferently from graphic improvements, story and educational content, developed in the way of adventures and roleplaying experiences for students will always possess the impact seen previously and it can be assumed that it will take learning outcomes, motivation and knowledge retention to levels never seen before.

THE TEAM

Eduardo Nunes
Lead Game & Story Designer
Project Coordinator

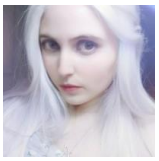
Bruno Gavaia
Instructional Designer



Heitor Silva
Senior Game Developer

Jamim Oliveira
Concept, 2D & 3D Artist

Luís Sampaio
Game Systems Developer



Luísa Mallet
3D & Animation Designer

Raquel Silva
Game Implementation Developer

Additional team members:
Pedro Ermida – Game Developer
André Sousa – Audio Designer
Leonor Cardoso – Game Developer
Fábio Resende – Senior Game Developer
Sérgio Rodrigues – Senior Game Developer

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THE COMPANY

Kendir Studios is an educational game and digital learning environments studio that spun from a research project initiated by iNED – Centre for Innovation in Education, a research centre in the School of Education from the Polytechnic Institute of Porto, Portugal. The main concern of the research project named Schoolers & Scholars was to answer, through state-of-the-art analysis, **how to fundamentally alter the architecture of remote learning for students** in the basic levels of the formal education system (ages 8 to 15) to improve outcomes and the learner-content relationship.

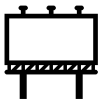
The main objective of the company is to, therefore, develop digital game-based educational content that is structured according to best practices determined and fundamental and experimental research developed. We can divide this main goal into three development focus areas:

Research & Development

- To create innovative solutions for educational contexts that solve educational problems by using virtual environments.
- Develop digital gamified mechanisms that allow for a full, stronger and quicker comprehension by students.
- To keep pushing the boundaries of best practices regarding gamification and game-based learning theory.

Knowledge

- Allow students to reach new learning methods unreachable through traditional teaching.
- To give teachers & schools practical, effective, and simple but efficient tools to support classroom teaching.
- Connect students and teachers from different geographies through virtual worlds.
- Use Big Data to continuously improve our understanding of how the student learns.



Focus & Motivation

- Create gradually and progressively more complex and advanced digital worlds that allow students and teachers to explore *de facto* worlds, breaking any existing barriers to learning, iteration, and immersion.
- Expand all possible scenarios for exploration, comprehension and usage of narratives, including giving students the possibility to create their own.

PUBLICATIONS

1. Gavaia, B., Ribeiro, C., Quadro-Flores, P., Nunes, E. (2021), Age of Society – Building a game to/while learn(ing), Simpósio de Engenharia Informática - Link

2. Nunes, E., Cruz, M. (2021), Game-Based Learning: a Push for Introducing a C(classroom)-MORG, Advances in Intelligent Systems and Computing, 2021 - Link

3. Nunes, E. (2021), Games based learning environments: A review of potential steps forward for virtual learning, Sensos-e, Vol. VIII, nº1 - Link

4. Nunes, E., Cruz, M. (2021), Schoolers & Scholars: A project focusing on RPG in Elementary Education, Proceedings of the 15th European Conference on Games Based Learning, 2021- Link

5. Nunes, E., Gavaia, B., Rodrigues, R., Sampaio, L., Silva, R. (to be published Summer 2022 issue no 53), Liber Domus – Development of a Prototype RPG for 6th Grade Mathematics and Science Learning, Interaction Design & Architecture(s) – **Awaiting publishing | Doc**

6. Cruz, M., Medeiros, P., Nunes, E., Role-play Game Applied to Maths Teaching: Representations of Students about a Digital Role-Play Gaming Platform, iCERi 2022 – 15th Annual Conference of Education, Research and Innovation– **Awaiting publishing | Doc**

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EDUARDO NUNES is the project coordinator, lead game designer, and lead writer and worldbuilder behind Liber Domus, the world's first educational adventures and roleplaying 3D game.

Graduated in Economics and Masters in Management, the first years were focused on all aspects of business management, but with time, focused more and more on research topics related to gamification, educational theory, game-based learning, digital games and game design.

He also develops research through inED – ESE – IPP, having published several articles and been invited to lecture on multiple occasions.

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