INTELI - INSTITUTO DE TECNOLOGIA E LIDERANÇA
SOFTWARE ENGINEERING

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MODULE 2 - PUBLIC REPORT
INTERACTIVE VIRTUAL ENVIRONMENT FOR SECONDARY SCHOOLS: APPLYING VIRTUAL REALITY TO THE TEACHING-LEARNING PROCESS

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SUMMARY

1 INTRODUCTION

Over the past ten weeks, the final course project "Interactive Virtual Environments for High School: Applying Virtual Reality to the Teaching-Learning Process" has made significant progress in the practical validation of the Godot engine for XR (Extended Reality) experiences, as well as in the conception and implementation of two educational experiences in Virtual Reality (VR), aimed at teaching Chemistry and Programming Logic.

The core objective of this module was to assess the technical and pedagogical feasibility of the Godot engine in developing immersive educational content, exploring its features, architecture, and XR plugin ecosystem. As a result, the Quimera VR experience was initiated, simulating a virtual Chemistry lab with interactive reactions, along with MindCode, a narrative game divided into phases for teaching basic computational logic and algorithms.

The actions developed do not represent a finalized product but rather a continuous process of prototyping and validation. The work was divided into development cycles (Sprints), allowing for the gradual evolution of functionalities and the systematic documentation of technical and pedagogical decisions. The main results are presented below, organized by thematic axis.

2 CONTEXT AND OBJECTIVE

The current stage of this Final Undergraduate Project (TCC) corresponds to the second phase of development, focusing on the exploration and validation of technological tools applicable to immersive educational experiences. This module, covering a period of ten weeks, had as its primary objective the technical and pedagogical investigation of the Godot Engine as a development platform for virtual reality (VR), as well as the prototyping of two distinct educational experiences—one in the field of Chemistry and the other in Programming Logic.

The central motivation behind this line of research lies in the urgent demand for educational strategies that are more engaging, effective, and aligned with the expectations of the digital generation. Virtual reality presents itself as a powerful pedagogical tool capable of transforming the student experience, making abstract concepts more tangible and promoting deep, experiential learning.

Within this context, the Godot Engine was selected as a candidate for implementing immersive educational solutions due to its open-source nature, modular architecture, and increasing support for XR (Extended Reality) features. The investigation aimed to assess the feasibility, advantages, and limitations of using Godot in the construction of pedagogically robust and technically functional VR applications.

Thus, the main objective of this phase was twofold: firstly, to technically validate the Godot engine for educational VR development—through documentation analysis, plugin testing, and deployment in VR devices—and secondly, to design and partially implement two VR-based learning environments. These environments, Quimera VR and Mindcode, were conceived not only as technological artifacts but as pedagogical experiments aligned with the Brazilian high school curriculum, aiming to enhance motivation and facilitate the assimilation of content in Chemistry and Programming, respectively.

The activities carried out in this phase are part of a broader continuous development process, where each cycle contributes incrementally to the construction of a modular, scalable, and pedagogically relevant platform. While the experiences presented are not yet finalized, they serve as concrete evidence of the project's progress and its alignment with contemporary educational innovation goals.

3 UNDERSTANDING THE FEASIBILITY OF USING GODOT

The selection of the Godot Engine as a tool for developing XR experiences is based on its open-source, accessible, and cross-platform nature, along with its growing adoption by academic and educational communities. Compared to established engines like Unity, Godot offers a smoother learning curve, thanks to its GDScript language (similar to Python) and its node-based architecture, which facilitates hierarchical scene development in 2D and 3D.

Although its XR support is relatively recent, version 4.x of Godot has significantly stabilized support for the OpenXR standard, increasing compatibility with various devices, such as Meta Quest, Pico, and Magic Leap 2 headsets. The engine allows for the integration of 2D interfaces into 3D environments through Viewport2D, a useful feature for building user interfaces in VR (HUDs and interactive menus), with laser pointer control and simulated buttons.

- The engine includes a plugin ecosystem, with the main ones being:
- OpenXR Plugin (official): provides the base for XR device compatibility;
- Godot XR Tools (community): toolkit with ready-to-use features for interaction, locomotion, pointer, hand tracking, and animations;
- Godot Meta Toolkit (official): focused on exporting to Meta devices, including automatic configuration for HorizonOS;
- OpenXR Vendors Plugin: offers specific compatibility for devices such as Pico and Magic Leap.

Exporting to VR, especially for Meta Quest, requires Android environment setup (SDK, NDK, and templates), developer mode activation on the headset, and setting XR mode to OpenXR. Renderer adjustments (OpenGLES2), framerate limitation, and techniques such as foveated rendering are recommended to optimize performance.

Despite limitations in mobile AR (ARCore/ARKit), the community has explored VR passthrough for mixed reality experiences. Thus, Godot stands out as a lightweight, free, and flexible alternative for educational XR prototypes, with the caveat that it requires attention to version compatibility and has still-expanding documentation.

4 QUIMERA VR — EDUCATIONAL CHEMISTRY GAME

The first experience developed was Quimera VR, a Chemistry lab in virtual reality, focused on simulating safe and visually instructive chemical reactions. The environment was modeled in 3D with a bench, glassware, reagents, equipment (scale, Bunsen burner, test tubes), and plausible lighting to maximize realism and presence.

Each reagent is an interactive object (RigidBody3D) with GDScript scripts controlling simulated reactions — such as the mixture of potassium permanganate with glycerin, triggering an ignition animation and heat release. Interactions follow collision and proximity logic, using Area3D nodes and signal detection to initiate chemical processes, with visual feedback (particles, sparks, color change) and textual feedback (instructions in clear Portuguese).

The initial menu is a floating 2D panel rendered with Viewport2D, containing buttons such as "View Experiments" and "Help." The laser pointer, configured by XR Tools, allows intuitive selection via controller trigger button. Manual interactions follow the XR Origin standard (with XRCamera and XRController), allowing users to grab, release, and manipulate objects with realistic hand-closing animations.

Pedagogical validation of the experience will be conducted by a Chemistry professional graduated from USP, who will assess whether the represented molecules and reactions meet scientific standards and align with high school curricula. This evaluation aims to ensure the conceptual accuracy and didactic value of the experience, especially regarding motivation and content retention, in line with previous studies in virtual laboratories.

5 MINDCODE — PROGRAMMING GAME NARRATIVE

The second experience under development is MindCode: The Time Machine, a narrative game in phases that teaches programming logic in VR. The game is divided into four phases, each set in a historical period and associated with a fundamental computing concept. The player solves logical puzzles by manipulating visual blocks representing operators and control structures.

Phase 1 – Ancient Greece: Basic Logical Operators:

Set in a classical temple, this phase introduces AND, OR, and NOT operators through mystical blocks and interactions with torches, mirrors, and doors. For example, a door opens only if two torches are simultaneously lit (AND). Elements use HingeJoint3D, OmniLight3D, AnimationPlayer, and scripts simulating logical operations.

Phase 2 – Middle Ages: Operator Composition:

In a medieval setting with castles and gears, the player must combine operators like XOR, in challenges involving gates, levers, and magical portals. Introducing logical compositions reinforces abstract reasoning. The narrative uses NPCs to contextualize challenges with visual clues and instructional dialogues.

Phase 3 – Industrial Revolution: Conditionals and Sequencing:

In this factory-themed phase, conditions (if/else) and logical sequencing are introduced via valves and sensors. The player configures circuits that control machines based on boolean conditions. GDScript scripts track signals and execute actions, such as releasing steam or activating conveyor belts, validating the use of conditionals in the environment.

Phase 4 – 1980s: Loops and Repetition:

In a retro setting inspired by arcades and 1980s computer labs, loops (for and while) are introduced. The player interacts with terminals and electronic panels, adjusting values to repeat actions and complete challenges, such as lighting up sequences or moving platforms.

Each phase presents specific sound and visual design, reinforcing the historical context and didactic content. The use of visual blocks, animations, and logic-based challenges promotes immersion, motivation, and the development of computational skills.

6 WEEKLY CLASSES ATTENDED

This section lists the mandatory classes attended every Tuesday during the analyzed period.

- April 29, 2025: CAREER TRACK- Hacking Cultures and Power Dynamics: Challenges with your peers
- May 06, 2025: CORPORATE TRACK - Project Management and Methodologies: Project, Program, and Portfolio Management
- May 13, 2025: CORPORATE TRACK - Innovation, Applied Research, and Digital Transformation: Emerging Tools and Technologies (AI and Blockchain).
- May 20, 2025: CORPORATE TRACK - Computer Science Job Market and Certifications: Relevant Certifications - Importance, preparation, and impact on your career.
- May 27, 2025: CORPORATE TRACK - Intellectual Property and Patents: Registration Processes - How to register patents, trademarks, and copyrights.
- Jun 03, 2025: CAREER TRACK - Hacking Cultures and Power Dynamics: Challenges with your boss.
- Jun 10, 2025: CAREER TRACK - Hacking Cultures and Power Dynamics: Challenges within your Organization.
- Jun 17, 2025: ENTREPRENEURIAL TRACK - Product Design: Techniques for validating product thesis through MVP (Minimum Viable Product)
- Jun 24, 2025: ACADEMIC TRACK - Structuring and Formatting Scientific Articles: Preparation for Publication - Final Review and Submission