Zenith Outdoor/Indoor Experience

May 2025 – April 2027 (24M)

Project 2024-1-CY01-KA220-ADU-000256958

D4.6 First Integrated Prototype

Authors	VIR
Abstract	The present deliverable provides a detailed functional overview of the First Integrated Prototype implemented for the ZOE project. Moving beyond initial architectural planning, this document evaluates the live staging platform and its operational features, which bridge outdoor Augmented Reality (AR) environments and indoor 3D virtual tours. It reviews the system's microservices-based cloud infrastructure, user role segmentation (Guest PIN-based access versus Registered persistent accounts), and the interactive 3D web-based environment featuring a first-person Walk Mode. Furthermore, this document details the platform's core mechanics, including automated georeferencing, a visual Action Sequence Chain Editor for multimedia Points of Interest (POIs), gamified item collection loops, and an API-driven global leaderboard system, verifying a stable cross-platform foundation for subsequent deployment phases. elements are prepared on the project platform and will be implemented as part of the user interaction task.

THE CONSORTIUM

No.	Abbreviation	Partner Name	Logo
1	**GEO**	Geoimaging ltd	
2	**AUTH**	Aristotle University of Thessaloniki	
3	**TUW**	Technische Universität Wien	
4	**VIR**	Virtual Solutions	

DISCLAIMER

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

CONTENTS

Contents

1. INTRODUCTION 4
2. SYSTEM ARCHITECTURE DESIGN 4
2.1 Guest User Instance 4
2.2 Registered Player Instance 5
3. APP WALKAROUND: CORE FEATURES & USER INTERACTION 6
3.1 Core Platform Base Experience Functions 7
3.2 Immersive 3D Web Environment 8
3.3 Scene Content Graph & Node Hierarchy (Left Panel) 8
3.4 Main 3D Real-Time Viewport Canvas (Central Window) 9
3.5 Automated Georeferencing Mapping (Left Sidebar) 9
3.6 Points of Interest (POIs) and Content Interaction 10
3.7 Visual Action Sequence Chain Editor 11
3.8 Gamification & Submodule Progress 12
3.9 Global Leaderboard System 13
4. INTEGRATION REQUIREMENTS & API PERFORMANCE 14
4.1 Description of Outdoor AR Integration 15
4.1.1 Current Capabilities of the TUW Guided AR Tour 15
4.1.2 Integration Architecture and Data Consistency 15
4.1.3 Gamification Alignment and Prototype 2 Development 16
5. SUMMARY AND CONCLUSIONS 16

GLOSSARY

GDPR	General Data Protection Regulation
API	Application Programming Interface
CMS	Content Management System
RBAC	Role-Based Access Control
UI	User Interface
POI	Point of Interest
WP	Work Package

1. INTRODUCTION

This deliverable presents a comprehensive overview of the implementation, functional capabilities, and live deployment of the First Integrated Prototype for the ZOE project. Moving from the theoretical frameworks established in prior architectural designs, this document transitions focus toward evaluating the live staging platform https://staging.project-zoe.eu/login. It outlines real-world application workflows, role-based user segmentations, and dynamic gamification mechanics designed to bridge outdoor Augmented Reality (AR) experiences with the indoor 3D virtual tour workspace. Ultimately, this report serves to validate the core system integrations necessary to deliver an immersive, cross-platform cultural tourism experience.

2. SYSTEM ARCHITECTURE DESIGN

The first prototype's microservices architecture and headless CMS are fully operational, supporting differentiated client data structures based on access rights. The platform segments users into two primary environments to manage access control and progress state tracking: (see Figure 1)

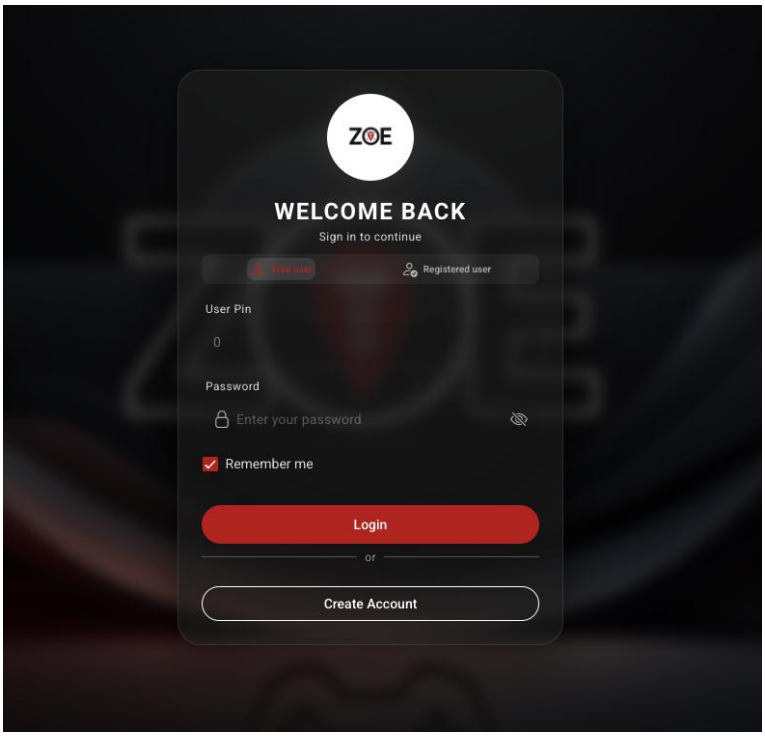

Figure 1: Login form for the Free User and registered User.

2.1 Guest User Instance

- **Behavior and Scope:** Acts as a PIN-based credential entry mechanism into the public platform layer. (see Figure 1)

- **Features Available:** Guest users can discover, load, and explore open-access cultural sites (e.g., the Karlskirche experience) using a unique PIN. They can engage with 3D models, interact with Points of Interest (POIs), and participate in basic gamification and item collection loops.

- **Data Constraints:** Game progress, level achievements, and accumulated scores are cached locally in the client state (using LocalStorage) and synchronized session-by-session to the backend database. Advanced base experience editing and publishing privileges are restricted until full registration.

2.2 Registered Player Instance

- **Behavior and Scope:** Connects the client to persistent cloud storage via the Headless CMS database.

- **Features Available:** Unlocks full access to both public and restricted "Non-Public Experiences." Progress tracking, personalized level history, and achievement updates are saved directly to the database user profile. (see Figure 3)

- **Data Privileges:** Enables persistent scoring across different devices (Mobile, Desktop). It links the user's specific performance directly to the global platform leaderboard ecosystem. (see Figure 2)

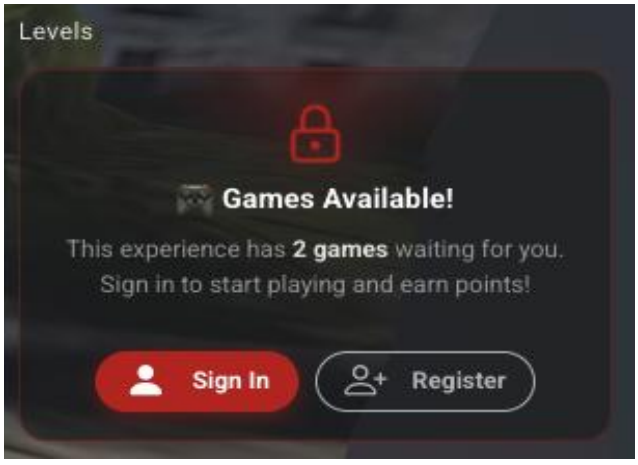

Figure 2: Box to login or register to have access to the gamification functionality.

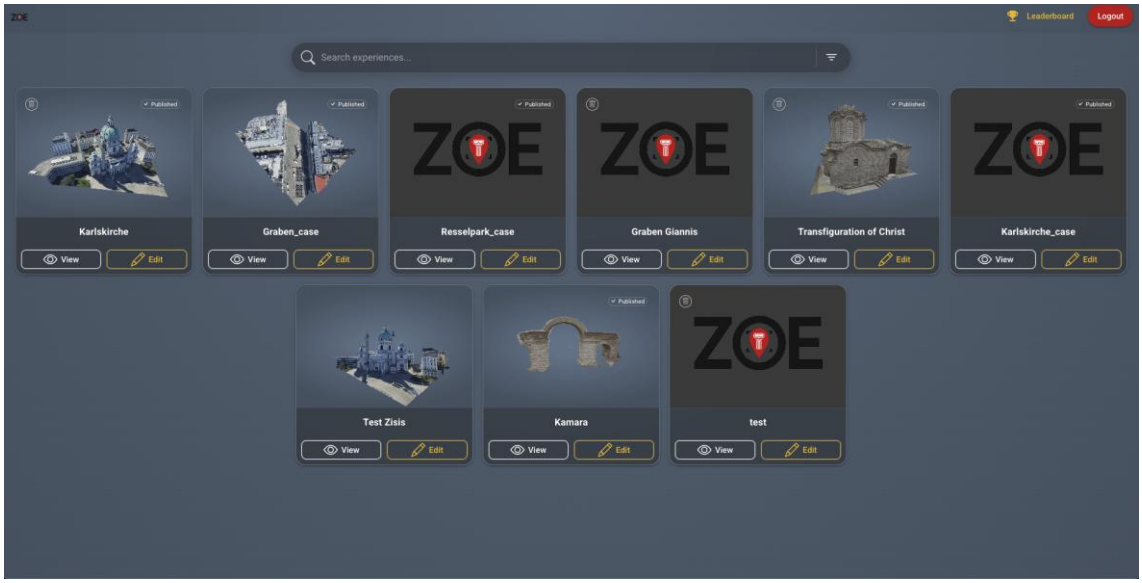

Figure 3: Full access to both public and restricted "Non-Public Experiences".

3. APP WALKAROUND: CORE FEATURES & USER INTERACTION

A thorough exploration of the live application reveals a fully functional web-based 3D environment integrated with a real-time responsive user interface. (see Figure 4)

Figure 4: Web-based 3D environment.

3.1 Core Platform Base Experience Functions

The ZOE platform establishes a standardized suite of foundational "Base Experience" functions. These baseline mechanics run under both user instances to ensure a stable core journey before layer-specific logic (like advanced gamification or restricted editing) is applied

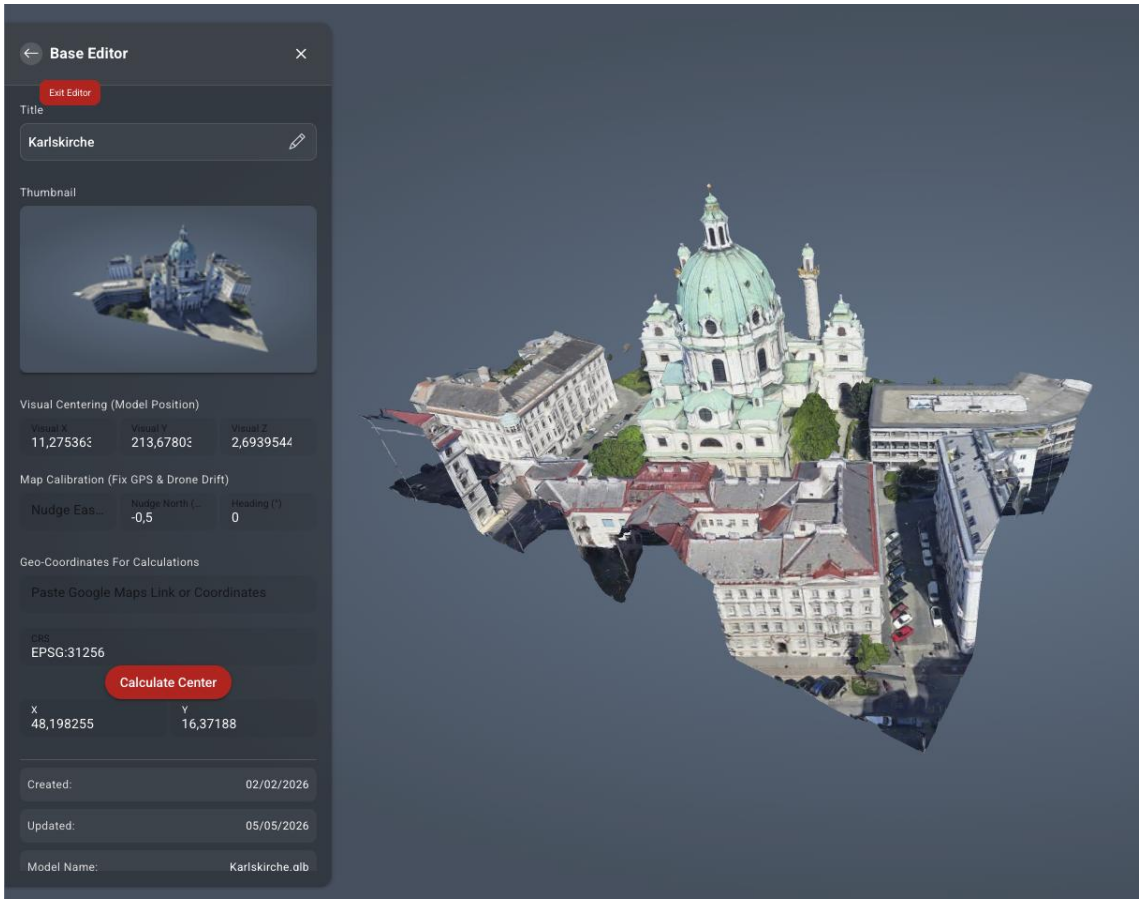

Figure 5: Cultural site Karlskirche (Base Experience).

- **Public Experience Directory:** The system automatically initializes by calling a custom API endpoint to catalog and display available interactive cultural sites (such as Karlskirche) on the main user dashboard. (see Figure 5)

- **Unified Schema Loading:** Every experience acts as an independent data entity containing pre-mapped points of interest, baseline level rules, and scene files that download progressively to minimize initial load times.

3.2 Immersive 3D Web Environment

Upon launching an experience, users are presented with a photorealistic 3D environment rendered via web graphics engines. (see Figure 6)

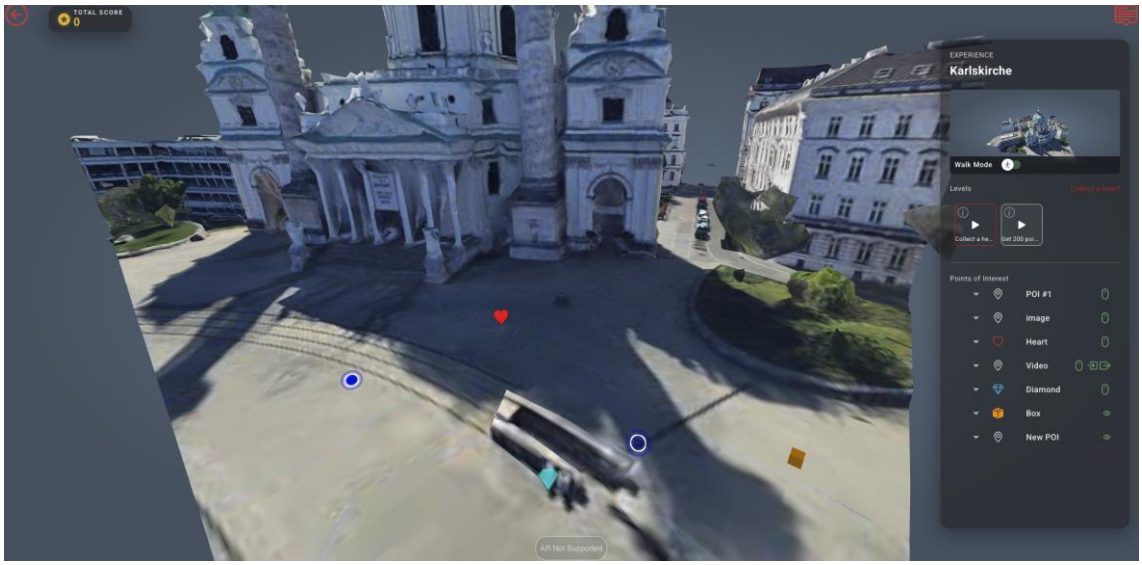

Figure 6: Photorealistic 3D environment rendered via web graphics engines.

- **Walk Mode Toggle:** A user interface switch changes the camera behavior from an overview/orbit perspective to a first-person Walk Mode. In Walk Mode, users navigate the plaza or interior spaces using on-screen navigation buttons or mouse-drag behaviors.
- **Cross-Platform Responsiveness:** The UI dynamically adjusts scaling and controller layouts for mobile touch screens versus desktop displays, validating the cross-platform architecture.

3.3 Scene Content Graph & Node Hierarchy (Left Panel)

- **Level Entity Registry:** Dynamically catalogs all current game nodes and interactive points allocated to the experience (see Figure 7)
- **Active Node Management:** Allows the experience creator to select, categorize, and prioritize components such as baseline level boundaries, game triggers, and item types (Hearts, Diamonds, Boxes) (see Figure 7)
- **Content State Toggles:** Provides visibility icons next to each element, sending immediate state parameters via backend protocols to test hiding or

showing objects before compiling the environment.

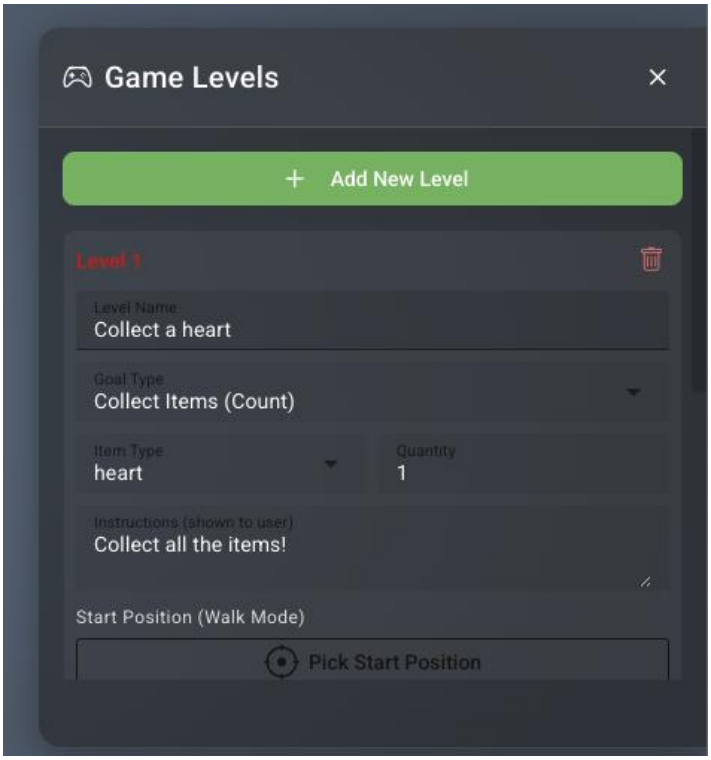

Figure 7: Scene Content Graph & Node Hierarchy (Left Panel) & Level Entity Registry & Active Node Management.

3.4 Main 3D Real-Time Viewport Canvas (Central Window)

- **WebGL Render Loop:** Implements real-time performance rendering to manipulate complex models, such as the Karlskirche environment, directly inside the browser window.
- **Transform Gizmos:** Provides standard drag functions that handle position, rotation, and scale, ensuring creators can orient newly imported assets intuitively without manual code insertion.

3.5 Automated Georeferencing Mapping (Left Sidebar)

- **Interactive Georeferencing and Map Calibration:** Allows creators to set spatial coordinates by pasting a Google Maps link or entering raw

coordinates (which are parsed into CRS and center coordinates). To correct for drone GPS drift or model misalignments, the system provides map calibration offsets (such as heading degrees, East/North nudges, and XYZ local translations) (see Figure 8)

- **Media URI Bindings:** Links interactive text fields, images, or streaming video URLs directly to localized Point of Interest (POI) nodes. This structural link ensures that clicking the point within the final mobile AR app (WP3) or 3D web app (WP4) correctly displays the assigned multimedia overlay.

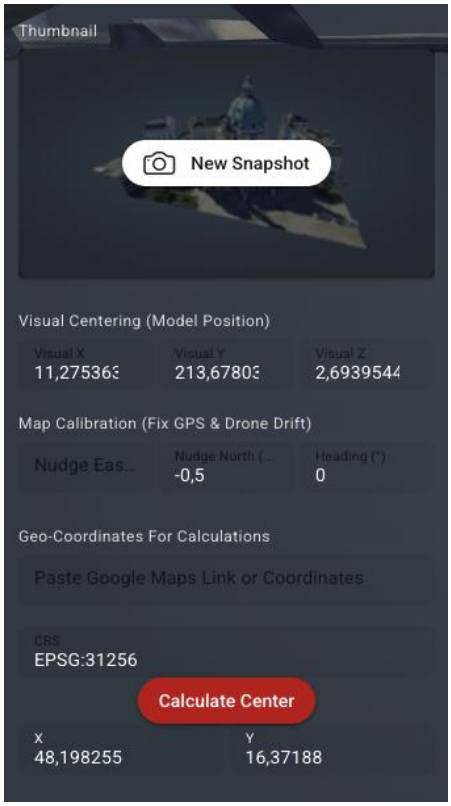

Figure 8: Set spatial coordinates by pasting a Google Maps link or entering raw coordinates.

3.6 Points of Interest (POIs) and Content Interaction

A persistent sidebar acts as a directory for localized site assets:

- **Interactive POI List:** Displays all markers bound to real-world geolocation parameters (e.g., POI #1, Image, Video, New POI). (see Figure 9)
- **Media Callouts:** Clicking a POI launches localized media playback windows

(such as guided text, audio, or embedded video arrays) directly over the 3D canvas.

- **State Visibility:** Toggles (eye icons) let content managers or users preview asset visibility statuses in real time.

Figure 9: The POI can display media files such as videos, documents etc.

3.7 Visual Action Sequence Chain Editor

Visual Action Sequence Chain Editor To enable rich interactivity without requiring manual coding, the platform integrates a visual Action Sequence Editor. Creators can chain multiple behavioral steps to run sequentially when a user interacts with a Point of Interest (POI) or enters a proximity boundary. The available action nodes in this builder include:

- **Set Visibility:** Toggles the visibility parameter of other POIs in the scene (hiding or revealing items dynamically).
- **Wait (Delay):** Pauses the execution flow for a specific number of seconds before triggering the next action.
- **Scale Model:** Dynamically scales the 3D model up or down using transition animations.
- **Rotate Model:** Triggers a smooth angular rotation of the asset around a chosen axis (X, Y, Z).
- **Play / Pause Video:** Plays an embedded video file on a 3D texture overlay or pauses it.

- **Play / Pause Audio:** Triggers localized voice guides or ambient sounds.
- **Focus POI:** Shifts the camera focus and centers the viewport on a specific coordinate node.
- **Is Clickable:** Enables or disables mouse/touch click interactions for target POIs.
- **Score:** Awards points (cultural, physical, intelligence) to the player's total score.
- **Walk To:** Forces the camera target to walk/translate to a specific target coordinate."

3.8 Gamification & Submodule Progress

The top and side HUD overlays display real-time variables managed by the backend microservices:

- **Total Score Tracker:** Dynamically Tallies cultural, physical, and intelligence points gathered through site interaction. (see Figure 10)

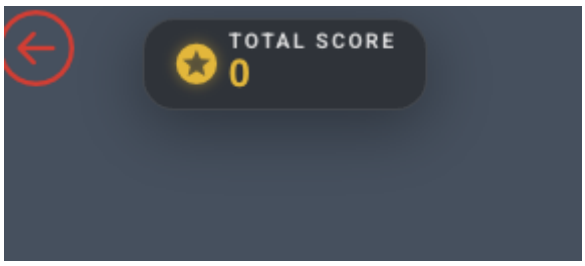

Figure 10: System to gather the total score based on the gamification functionality.

- **Item Collection Game:** Tracks floating interactive spatial items placed within the map (e.g., Collected (1 / 11) status tracking). Items are color-coded and themed according to objective categories (see Figure 11)

Figure 11: Tracks floating interactive spatial items placed within the map.

- **Level Completion HUD:** Displays current trial status (e.g., "Level 1: Not Completed" or timed challenges like "Level Completed: Time: 11.0s"), which feeds directly into user data arrays.

3.9 Global Leaderboard System

When accessing the Leaderboard interface, the application calls custom API endpoints to pull platform-wide statistics. (see Figure 12)

- **Real-time Ranking:** Displays global standings ranking players by Name, Experience, and Accumulated Score.
- **Data Verification:** Confirming actions from the registered profile updates standings dynamically across instances, confirming that communication via RESTful APIs and database sync works cleanly.

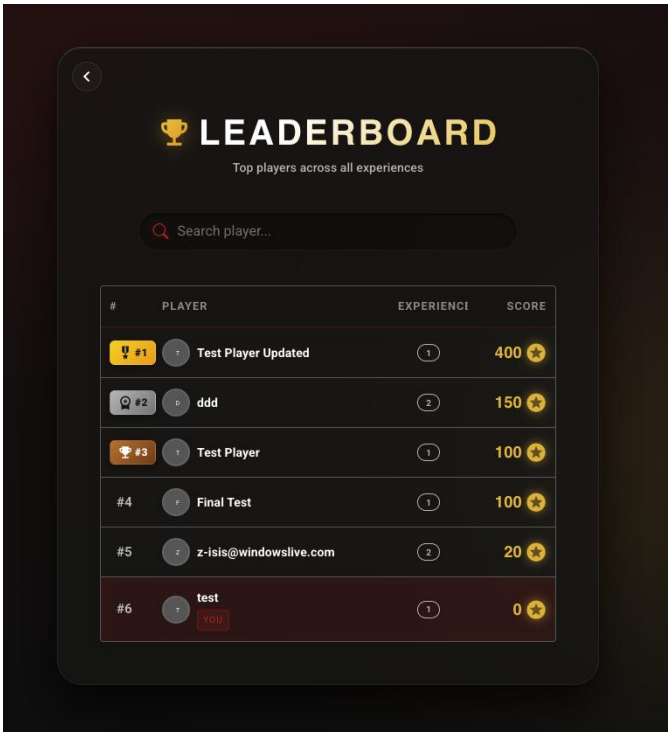

Figure 12: Leaderboard interface, Real-time Ranking.

4. INTEGRATION REQUIREMENTS & API PERFORMANCE

The first integrated prototype successfully unifies the data models required to keep experiences synchronized between devices and accounts:

Endpoint Feature	Action	Staging Verification Status
Secure Login	Authenticates users against the CMS database.	**Functional** (Verified via Guest & Registered setups)
Get Free/Non-Public Experiences	Segregates accessible world data fields based on role.	**Functional** (Restricts/permits access dynamically)
Asset Delivery (Load Assets)	Streams 3D meshes, panoramic tiles, and multimedia overlays.	**Functional** (High-fidelity models stream without crashing)
Game/POI GPS Sync	Translates absolute	**Functional**

	geographic coordinates into regional 3D vector space points.	**(Coordinates match between 3D space positions and maps)**

4.1 Description of Outdoor AR Integration

The First Integrated Prototype of the ZOE platform represents a significant milestone in merging outdoor Augmented Reality (AR) tour capabilities with the indoor 3D virtual environment. This integration leverages the guided AR tour prototype developed by TUW (documented in Deliverable D3.2) and the system architecture established by VIR (documented in Deliverable D4.1), creating a cohesive cross-platform experience that maintains data consistency and interaction parity across both environments.

4.1.1 Current Capabilities of the TUW Guided AR Tour

The outdoor AR component, implemented in Unity for VisionOS development (see D3.2), currently supports the loading of guided tours across three distinct sites per city (Vienna and Thessaloniki). Three primary use-case types have been established: interaction with large landmarks, proximity-based interaction with small monuments on a square, and interaction with facades around a town square. For Vienna, the use cases are: Karlskirche (a landmark church), Resselpark (2 small statues about famous inventors in a park), and Graben (a very historic street in the city). For Thessaloniki, the use cases are: Kamara (a ancient, excavated arch); Transfiguration of Christ (a small, ancient church surrounded by modern buildings); Makedonomahi (nine statues of men representing The Macedonian Struggle).

Core interaction mechanics include gaze-and-pinch selection, which extends the UI dialogue pattern from flat elements to georeferenced 3D objects, allowing users to look at a POI icon and confirm selection with a pinch gesture. Proximity-based interaction enables revealing content based on user distance from POIs, with configurable settings that accommodate users with limited mobility by making all content permanently accessible or enhancing engagement for others by revealing POIs progressively as they approach. The system supports multiple media types (text, audio, and image content) organized in a hierarchical level-of-detail structure where top-level POIs can reveal sub-POIs on demand. Proximity-based content scaling ensures appropriate visual presentation at varying distances, and a single application serves all use cases across both cities.

4.1.2 Integration Architecture and Data Consistency

The integration between outdoor AR and indoor 3D environments is founded on unified data models and shared geolocation standards established in the system architecture as outlined in D 4.1. Both environments utilize the same experience creation platform—the ZOE authoring tool developed by VIR—where experiences are configured, POIs are positioned, and media assets are uploaded before being stored in the project database. This shared authoring workflow ensures that content created for outdoor AR tours can

be seamlessly accessed and rendered in the indoor 3D environment, and vice versa. Custom API endpoints facilitate specialized operations essential for cross-platform functionality, including secure authentication, experience discovery, optimized content delivery, and accurate retrieval of geolocation data for AR devices.

4.1.3 Gamification Alignment and Prototype 2 Development

A dedicated gamification submodule has been integrated to increase user engagement, motivation, and interaction duration during cultural tours. For the outdoor AR tour, a subset of gamification mechanics relevant and plausible for outdoor environments has been agreed upon and will be fully implemented in Prototype 2. These elements include: searching for hidden POIs in a scene (implementing the Search and Discovery game), collecting georeferenced stars or objects in the scene (implementing the Item Collection game), displaying a progress bar of game status, and awarding points for specific kinds of interactions with AR objects.

For Prototype 2, VIR will implement proximity-based interaction mechanics in the indoor 3D environment, mirroring the outdoor AR functionality, while TUW will implement the agreed gamification elements in the outdoor AR tour. This division ensures that both environments converge toward features. Gaze-and-pinch interaction, currently the primary interaction method for outdoor AR on Apple Vision Pro, will be enabled for indoor AR to maintain interaction consistency.

This integrated approach verifies a stable cross-platform foundation for subsequent deployment phases, ensuring that the ZOE platform delivers a cohesive, scalable, and highly interactive user experience that bridges outdoor AR tours with indoor 3D virtual environments.

5. SUMMARY AND CONCLUSIONS

The First Integrated Prototype demonstrates a successful shift from initial architectural plans to a functioning, cross-platform cultural tourism platform. The user role management, interactive 3D navigation (Walk Mode), item collection gameplay loops, and API-driven leaderboard synchronization are fully up and running on the staging environment. This verified baseline ensures a stable foundation as the project moves toward its final deployment phases.