

Educational Location-Based Augmented Reality Applications For Indoor Spaces: Creating the Application “Exploring the Aquarium of Kastoria”.

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Alexandros Kleftodimos is an Assistant Professor at the Department of Communication and Digital Media, University of Western Macedonia, Greece. Dr Kleftodimos holds a PhD degree from the Department of Applied Informatics, of the University of Macedonia, Greece in the field of Educational Technologies. He also holds a BSc degree in Mathematics from the University of Aberdeen, UK and an MSc degree in Computer Science from the University of Wales in Aberystwyth. His research interests focus on the following fields: a) Educational Technologies and, more specifically VBL- Video Based Learning, Learning Analytics, Interactive Learning Environments, and b) Internet Technologies in Communication and Politics. Dr Kleftodimos teaches mainly courses related to Internet & Multimedia technologies in Communication. Dr Kleftodimos has also participated in several research and development projects with the Department of Communication and Digital Media and has worked for several years in the software industry as a developer and analyst of computer information systems.

Research Projects

Dr Alexandros Kleftodimos is a member of the Digital Media and Strategic Communication lab of the Communication and Digital Media Department (<https://dmsclab.uowm.gr/en/index/>).

The purpose of the lab is to conduct advanced research and implement development projects, as well as to cover research and educational needs at undergraduate and postgraduate level in the field of Digital Media and Communication. The lab's main goal is to connect academic research with entrepreneurship and society.

Current Funded Projects

Wine Live Label: Innovative Augmented Reality Applications in Wine Product Labeling
(https://dmsclab.uowm.gr/en/our-projects/wine_live_label/)

Serious Games and Interactive Treasure Hunt to Promote Mountain Trails in Western Macedonia
(https://dmsclab.uowm.gr/en/our-projects/serious_games/)

Location-based augmented reality (AR)

- Location-based Augmented Reality (AR) is a type of markerless AR technology where content is activated when a user reaches a specific location. This type of AR is currently used in many fields, such as tourism, recreational games, marketing, education, and initiatives that combine these purposes.
- Location-based AR applications typically rely on the mobile device's Global Positioning System (GPS) sensor to report the user's location. In indoor spaces, however, the GPS signals are either absent or weak, and tracking the users' position requires alternative methods.



Location-based AR for interior spaces

- While AR is widely used in education, location-based AR is limited and mainly concerns open spaces (e.g., city tours, cultural heritage sites, etc.).
- Location-based AR use cases for interior spaces (e.g., museums, aquariums etc.) where the GPS signal is either weak or totally absent are even fewer.

This paper aims

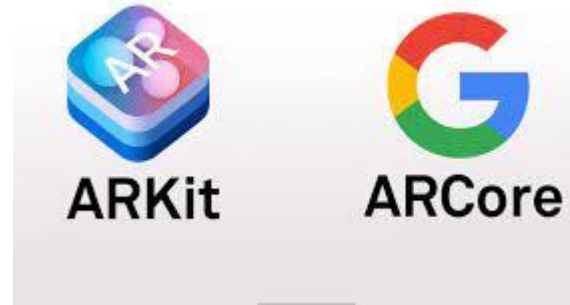
- to present an affordable process for developing location-based AR educational applications for indoor spaces (e.g., museums, schools, etc.). A process that can also be followed by educators without programming expertise.
- to present a location-based AR application for an aquarium, that was created by following this process. The application was created to educate school students and visitors about the fish and other freshwater organisms exhibited in the aquarium.
- To provide ideas and guidance for educators who are interested in creating similar applications.

Ways for developing location-based AR mobile applications for indoor spaces

Tracking Devices

- There are several solutions for tracking the users' position in indoor spaces such as museums (radio-based, optical, magnetic, and acoustic technologies).
- One hardware solution that is commonly supported by authoring software used for building location-based AR for indoor spaces is the iBeacon technology
- An iBeacon is a Bluetooth low-energy device that only sends a signal in a specific format
- The iOS and Android operating systems provide libraries for determining three proximity levels based on the signal strength of the iBeacon device. Multiple precision levels can indicate the user's position and support different application (or game) mechanics
- Many museums utilize this approach, and some examples are presented in the paper
- Beacons, however, come with a cost (around \$25), and in spaces such as museums with many exhibits, a large number of beacons may be needed

Software Tools



- Another concern when developing AR location-based applications is the software tools.
- There are solutions that require solid programming knowledge (e.g., ARCore, ARKit, WikiTude, and Vuforia) and solutions that require little or no programming experience (e.g., Taleblazer, ARIS, ActionBound, and Metaverse Studio). The latter are suitable for educators without programming experience.

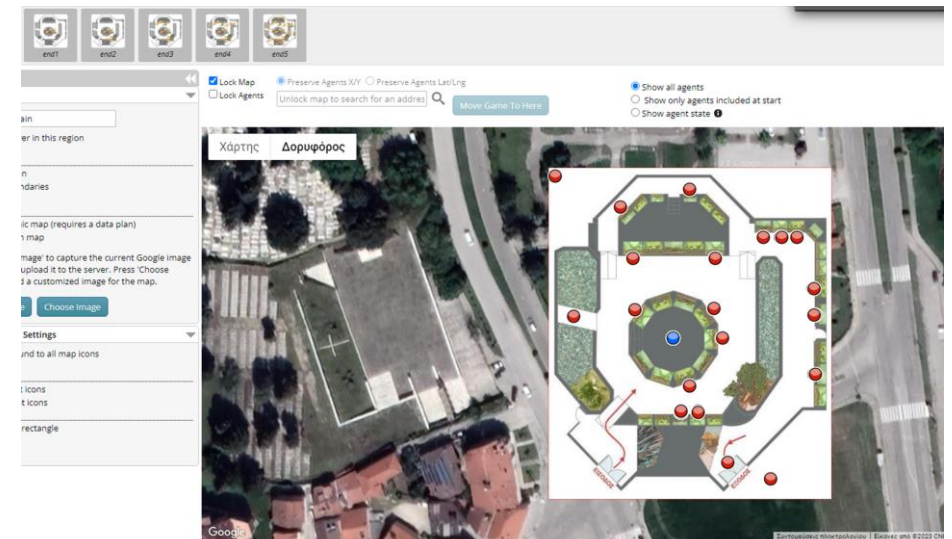
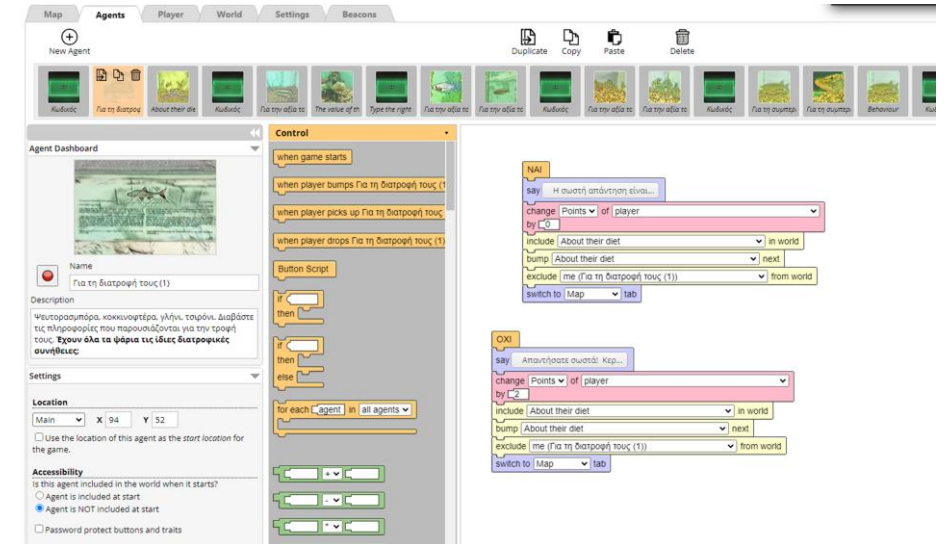


Taleblazer

The Taleblazer development environment relies on a visual block-based scripting language.

The basic elements of the Taleblazer environment are “Regions” and “Agents”.

- Regions are the physical areas on a map where the game takes place
- Agents are digital content associated with a GPS location and activated when a learner “bumps” into this location.



Using Taleblazer and password- protected agents for building location-based AR applications

- By using password-protected agents, an indoor location-based application can be created without position-tracking devices.
- Agents are placed on the custom map, and passwords are associated with these agents.
- The passwords must be placed close to the physical location (e.g., with signs, stickers, etc.)
- Digital content is activated only when the correct password is given. This way, it is guaranteed that the user is close to the right location.

The application “Exploring the Aquarium of Kastoria”

- The aquarium of Kastoria hosts fish and other freshwater organisms of Greece that are either indigenous, endemic, or foreign.
- The aquarium is visited every year by a large number of tourists as well as students who visit the aquarium as part of organized school trips.
- The application “Exploring the Aquarium of Kastoria” was created by the Center for Education for the Environment and Sustainability of Kastoria and the Digital Media and Strategic Communication lab of the Communication and Digital Media Department, University of Western Macedonia, Greece.
- The “Exploring the Aquarium of Kastoria” application is accessible to all aquarium visitors.

Application objectives

The application “Exploring the Aquarium of Kastoria” was designed with the following objectives in mind:

- To provide an alternative method that will mobilize the students' interest and strengthen their active participation during an educational program.
- To strengthen the experience of the educational activity through continuous observation and interaction with the real world (aquarium exhibits) and the digital elements of the AR mobile application.
- To evoke positive feelings usually present when students participate in games that encourage cooperation and are supported using their favorite means of entertainment and communication devices (smartphones and tablets).
- To utilize and further develop the students' digital literacy.
- To provide students with attractive means of obtaining knowledge about the fish exhibited in the aquarium.

Learning objectives

The application aims to inform users about the following aspects:

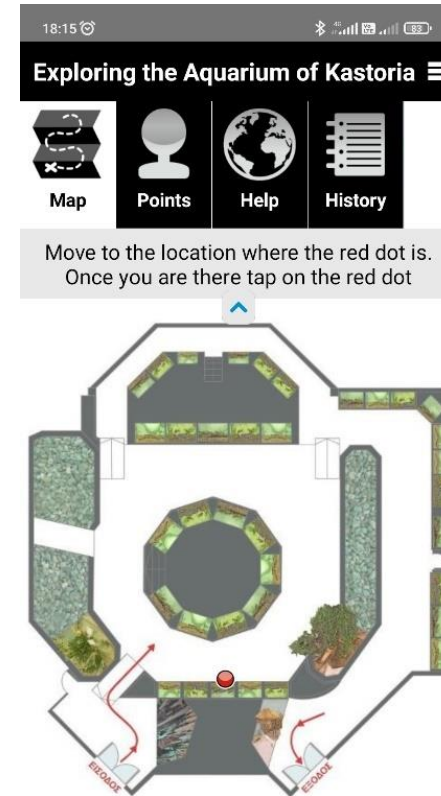
- What the fish eat
- Their value in environmental sustainability
- Their behaviour
- The polymorphism of their species
- Facts regarding the endemism and migration of fish
- The threats to their existence.

The procedure followed for developing the application

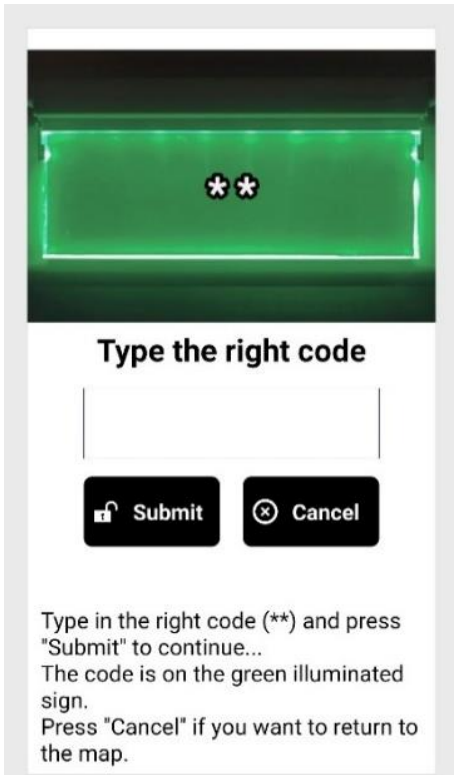
- The application has been developed using Taleblazer and password-protected agents.
- First, a custom map of the interior area of the aquarium was created using an image editing program.
- Then, Agents were inserted on the aquarium map. These agents are associated with several fish tanks (21 locations).
- The visitors are led to move in a seemingly random order inside the aquarium with the task to observe, think, answer questions regarding the fish, and collect points when these questions are answered correctly.
- The next location is always depicted with a red dot. Users must move to the red dot and type in the correct password to activate the digital content that is associated with the tank before them. The digital content is in the form of images, textual information, and multiple-choice questions. The textual information can also be received by sound.
- If questions are answered correctly, the user receives points.



The initial screen of the application



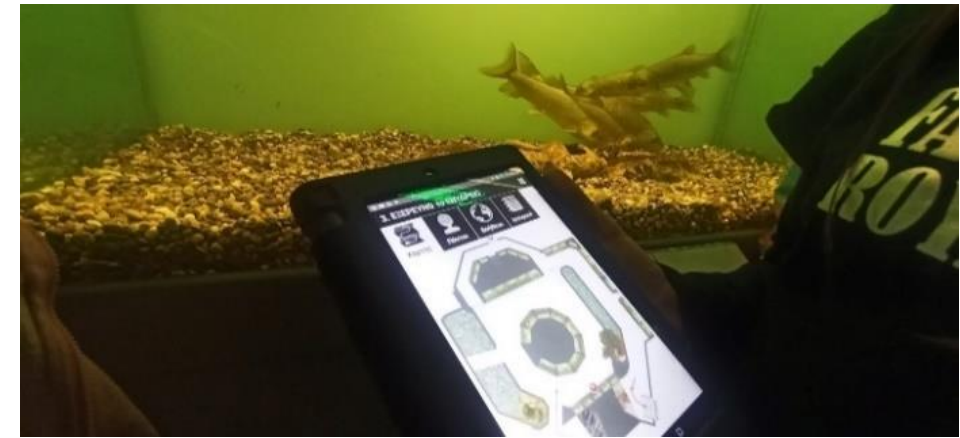
A custom map of the aquarium. The red dot depicts the next point (fish tank) to be visited



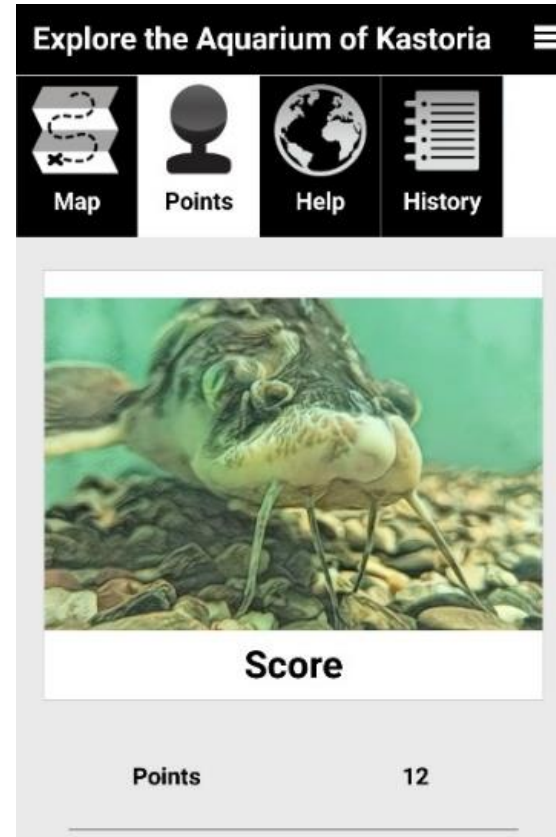
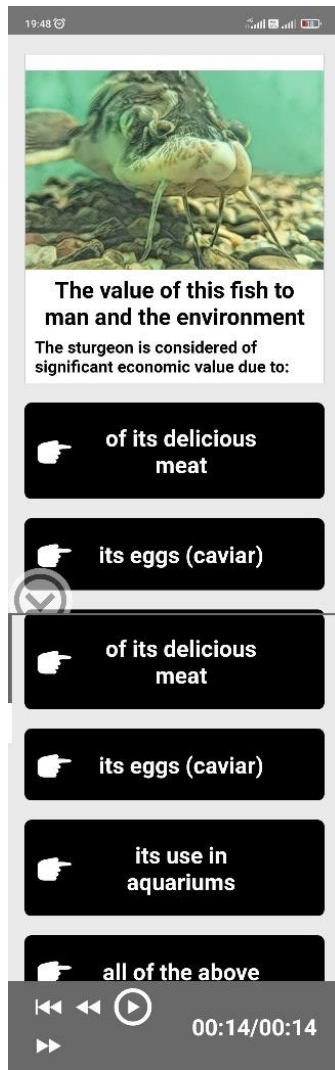
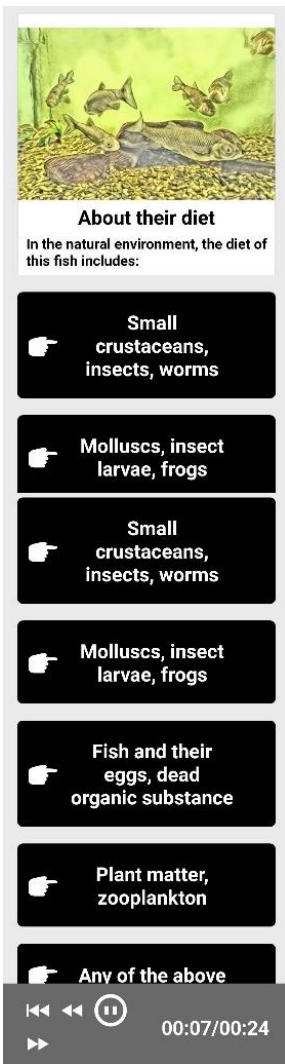
When the users arrive at the right location (red point on the map) they are prompted to enter the correct code to activate digital content



The codes are placed above each tank



An application snapshot



Points are awarded for correct answers

Questions are posed to the users regarding the fish they see in the tank before them

Insights obtained from application use

- The application was tested by all educators who work at the Center for Education for the Environment and Sustainability of Kastoria, Greece. The educators did not experience any problems.
- More than 100 students experienced the application.
- Students were asked to experience the application in small groups after a small demonstration on how to use the application. Almost all students hadn't previously experienced a location-based AR application for indoor spaces.
- The students were left alone to navigate the aquarium while the Center's educators observed their behaviour.
- While younger primary school students (ages 6 to 9) needed some time to get oriented in the aquarium space by using the application map, older students (ages 10 to 17) had no problems navigating in the aquarium using the application.
- It was obvious to the observers that the students were excited with this gamified method of exploring an aquarium and learning about its exhibits.
- Many students also expressed positive opinions about the novelty of the application to their peers and teachers.

Conclusions

- While AR is widely used in education, location-based AR is limited and mainly concerns location-based AR for open spaces (e.g., city tours, games in cultural heritage sites, etc.).
- Location-based AR use cases for interior spaces where the GPS signal is either weak or totally absent are even fewer.
- Position-tracking devices, such as iBeacons, are encountered in literature as the most common way to implement location-based AR for interior spaces. However, these devices come with a cost, and a large number of devices may be needed for museums with many exhibits.
- Furthermore, most AR applications in the literature rely on development tools requiring advanced programming expertise.
- This paper presents a way to create educational location-based AR for interior spaces (e.g., museums, schools, etc.) using a methodology that doesn't require tracking devices and development environments that require advanced programming knowledge. This paper uses Taleblazer as a development platform for location-based AR applications. Taleblazer's environment incorporates a visual blocks-based scripting language similar to Scratch, which is suitable for educators without programming experience.
- Preliminary insights obtained from observing students who used the application are very encouraging. The students showed enthusiasm when using the application, and many positive comments were expressed. As future work, an evaluation using a questionnaire and a large sample of students is on the way.

