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OpenLab Evaluation of CAnTi: Advancing Conservation of Ancient Tiryns through Virtual and Mixed Reality Interactive Applications

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Abstract:

Purpose *- The Conservation of Ancient Tiryns (CAnTi) research project aims to improve the presentation and understanding of conservation and restoration (CnR) data for the Acropolis of Ancient Tiryns. To achieve this goal, the project focuses on designing and implementing virtual and mixed reality interactive applications. These applications serve as innovative tools for visualizing and communicating crucial CnR data, bridging the gap between specialists and the public while enhancing visitors' engagement and experience.*

Design/methodology/approach *- Apart from the finalization of the design and the development of the interactive applications, the evaluation in terms of their efficacy along four fundamental axes presents a field of interest. Firstly, the engagement of the public with the CnR domain will be assessed through the utilization of an OpenLab approach, which enables users to interact with and explore the applications in a user-friendly manner. Secondly, the comprehension of the information material regarding CnR interventions presented through the applications will be evaluated to ensure that the conveyed knowledge is clear and accessible to a wide range of audiences. Thirdly, the user-friendliness and efficiency of the virtual and mixed-reality applications will be closely scrutinized to optimize the overall visitor experience and ensure seamless navigation. Lastly, the satisfaction of specialists, who must be able to communicate complex CnR data with the public supported by the applications, will be gauged to understand how well the proposed approach facilitates their interactions.*

Findings *-Through this comprehensive evaluation, the research team aims to gain valuable insights into the extent to which the developed applications can effectively present and communicate CnR data on behalf of specialists. Additionally, this study aims to identify areas for improvement that can enhance overall visitor engagement and experience during their interaction with the Acropolis of Ancient Tiryns.*

Originality/value *- The findings of this evaluation will contribute to refining the virtual and mixed reality applications and offer new perspectives on engaging the public with the CnR of historical landmarks.*

Index Terms — open lab, mixed reality, conservation, restoration, interactive applications, cultural heritage.

I. INTRODUCTION: OPEN LABS

The Tangible Cultural Heritage (TCH) encompasses monuments, buildings, spaces, and objects with historical, artistic, aesthetic, scientific, ethnological, or anthropological value, serving as a unique and irreplaceable source of knowledge and inspiration. The recognition of the universal value of TCH results in an increased focus on its study, protection, and preservation **[1]**. These processes ensure access to TCH for the wider public, fostering knowledge that can be shared and exchanged with both specialized and general audiences.

While the results of studies, protection, and preservation efforts are often presented to the public through thematic exhibitions or guided tours, the practical aspects of these processes and their significance for TCH are frequently shrouded in mystery. How objects, monuments, buildings, and TCH spaces are studied, how the events related to them are uncovered, and how actions for their protection and preservation are planned and executed are processes that are typically not included in exhibitions or tours. Similarly, the individuals involved in these processes are often overlooked **[2]**. Concurrently, research has indicated a strong interest among visitors in the excavation, maintenance, and restoration processes of monuments. The presence of scientific teams at these sites enhances visitors' experiences **[3]**.

Open labs represent an effective practice for showcasing what happens “behind the scenes”, challenging the

traditional presentation of TCH and highlighting the work of institutions and organizations in the field of TCH. The live presentation of study and maintenance work to visitors is a contemporary trend gaining momentum **[4]**. Allowing visitors access to previously isolated workspaces and laboratories or integrating labs into exhibition spaces (e.g., labs with glass walls) makes the work of specialists visible to visitors. In cases involving interactive participation from the public, open labs provide an opportunity for discussions between visitors and scientists or professionals, offering a more immediate and experiential understanding of scientific processes and practices **[4]**. This represents a new way to enhance public interest in TCH, creating new experiences that differ from traditional visits to cultural heritage sites (such as museum tours or archaeological site visits) and allowing more democratic access to archaeological collections **[5],[6]**. Moreover, open labs can continuously change and renew themselves; the processes and projects of an open lab evolve regularly, following the schedule of each conservation or excavation project.

II. Related Work

Open laboratories have become an increasingly popular practice in museums abroad, adopting various forms. As previously mentioned, an open laboratory can be made visible to the public through a glass wall, showcase, or even be physically accessible to visitors. Additionally, an open laboratory may focus on the conservation of a specific object (e.g., the preservation of a well-known painting) or involve multiple conservation interventions on different objects of the same type or with similar types of damage (e.g., the conservation of a column's vertebrae and its restoration). Today, open laboratories are more commonly found in closed and controlled spaces, such as conservation labs and museums, and less so in open and archaeological sites, as explained below, due to the challenges associated with their smooth operation.

A characteristic example of open conservation laboratories is the Visible Conservation Laboratories at the Smithsonian American Art Museum & National Portrait Gallery, Lunder Conservation Centre **[7]**. Visitors have the unique opportunity to observe conservators at work. The center features glass walls that allow the public to witness all aspects of the conservation process. Visitors can observe the work and learn more about it by listening to related audio tour materials. Another analogous example is the Artifact Lab at the PENNMUSEUM **[8]**. This glass-enclosed laboratory serves as both a traditional active workspace and a part of the exhibition. Visitors can see the tools used in the work and observe conservators preparing different objects for the museum's exhibition. The visitor has the opportunity to witness conservators at work, contributing to the preparation of various objects for display in the museum.

Another case of an open conservation laboratory that focuses on a specific object is Project “Blue Boy” at the Huntington Art Gallery **[9]**. The first significant technical examination and conservation intervention of the “Blue Boy” took place in public view in a specially designed conservation studio created specifically for the project within the Huntington Art Gallery space. A similar case is Operation NightWatch at the Rijksmuseum **[10]**, which is perhaps the largest research and conservation project conducted live within the museum, providing visitors with the opportunity to observe its progress. Essentially, the project can be divided into two main phases: the examination of its preservation condition and the interventionist conservation and restoration processes.

III. CAnTi project open lab

The design of the OpenLab within the framework of the CAnTi project, taking into account relevant international and national examples as well as successful strategies developed to date, primarily in the field of the conservation of cultural heritage, aims to find innovative solutions for the substantial and effective dissemination of information dissemination to the public regarding the conservation and restoration of monuments of cultural heritage. At the same time, it aims to address the disadvantages and risks associated with such projects, both in terms of safety and the experience of visitors and specialists, as emerged from the research presented in a previous section.

The OpenLab in the context of this project is perceived as a set of actions, events, and services related to the promotion and information about interventions at the archaeological site of Tiryns.

The workshop's goal was to familiarize the general public with the process of conserving and restoring the monument. Through specially designed interactive and participatory programs involving both specialized personnel and the monument itself, the workshop aimed to generate knowledge and appreciation for the monument. Public knowledge about the specialized field of monument conservation and restoration enhances the sense of responsibility for the preservation of cultural heritage and, consequently, creates a community with a personal interest in these issues **[11], [12], [13]**.

IV. CAnTi open lab evaluation methodology

The OpenLab will be evaluated by a) participants, i.e., the audience physically present in the open workshop activities, who will use the applications before, during, and after their visit to the archaeological site, and b) specialized scientists from the CAnTi project, who will be responsible for creating and publishing informational material about the interventions. Additionally, they will present relevant processes and information during the scheduled activities of the open workshops.

More specifically, the steps we followed are as follows:

- Test usage of digital applications by the CAnTi project team: This involved trying out the digital applications to identify and correct any functional issues and content-related concerns.

- Creation of material (in PowerPoint and video format) for presenting the individual functions of the applications: Develop content that explains the various features and functions of the applications.
- Installation of the mobile application by users on their personal devices for test use: Users installed the mobile application on their own devices to test its capabilities.
- Evaluation of the applications using structured questionnaires with access through a specific link: Users provided feedback and responses to structured questionnaires, likely delivered through a specific link.
- Statistical analysis of the results: The collected data and feedback were subjected to statistical analysis to derive meaningful insights and conclusions.

More specifically, before collecting research data, the CAnTi project team conducted on-site tests of the application at the actual archaeological site of Tiryns, using different mobile devices to identify any technical issues. After completing the necessary corrections regarding the functionality of the virtual and mixed reality applications, modifications were made to the quantitative research questionnaire, and the research methodology was finalized.

Regarding the evaluation process, initially, the VR application was used at the offices of the Ephorate of Antiquities of Argolida in Tiryns, followed by the use of the AR application at the monument. Finally, a guided presentation of the restoration interventions took place in situ at the monument.

For the VR application, it took approximately 10-20 minutes per person, depending on whether they viewed the entire content in detail and spent time processing the material (transition time between different information and observation of 3D models). About 1–3 minutes were needed for an explanation and familiarization with the use of glasses and controllers. Additionally, the intervention of the Optimum Company's specialist was required to resolve application issues and guide individuals, especially those less familiar with VR applications, as shown in **Fig. 1** and **2**.

Figure 1. VR application during CAnTi Open Lab evaluation

Figure 2. Using the VR applications during CAnTi evaluation

Regarding the MR application, the members of the research team proceeded to the archaeological site for a brief guided tour. During the tour, they showed the visitors points of intervention and addressed questions about the archaeological site.

Finally, the research questionnaire was used with the participants. The final questionnaire for the quantitative research is available online[1].

[1] https://docs.google.com/forms/d/e/1FAIpQLSfy5knoOMVYNRpILbVGSTOF6tVfPZlk7lCAVhiDisloVXzlzw/viewform

V. OPEN LAB EVALUATION RESULTS

A. Quantitative Research Results on Virtual Reality and Mixed Reality Applications

This section presents the overall results of the quantitative research conducted for the project on educational applications of virtual reality and mixed reality. The study involved 30 potential end-users from the Department of Performing and Digital Arts at the University of the Peloponnese, alongside 2 professors and 5 professionals with extensive experience in AR/VR technologies and emerging technologies in cultural heritage **[14]**. Following the presentation of the participants' general opinions and behaviors based on prior experiences, their demographic characteristics are next. Subsequently, the evaluation of the applications is presented, covering their basic features and functions, the services they offer, and the possibility of adding additional services. Finally, the overall attitude and intentions of the respondents towards the application are presented. We provide indicative results from the users' responses to the questionnaire (**Fig. 3-6**).

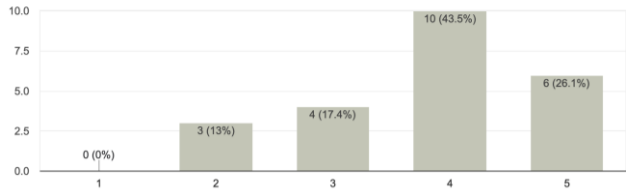

Figure 3. "How satisfied were you with the range of functions offered by the VR application?" (1=low, 5=high)

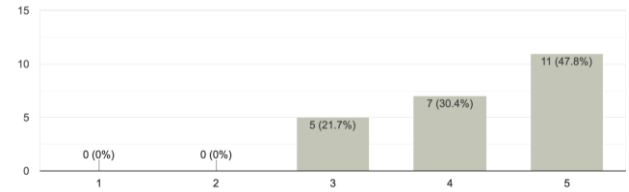

Figure 4. "How interesting was the audiovisual material of the VR application?" (1=low, 5=high)

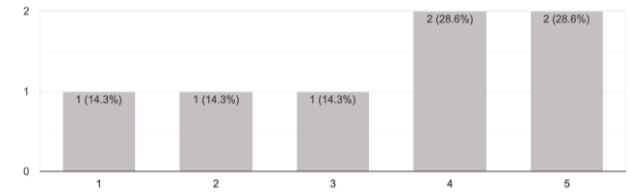

Figure 5. "How satisfied were you with the usability of the MR application?" (1=low, 5=high)

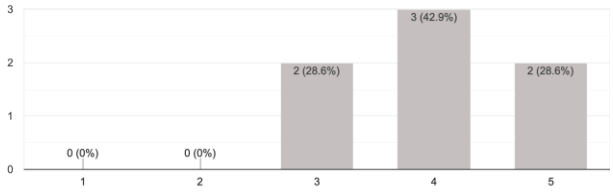

Figure 6. "Did the MR application help you access information about the monument?" (1=low, 5=high)

From the open-ended questions asking users to mention three elements they liked the most and the least about the presentation of the conservation and restoration works on the monument through the VR application, we received a total of 23 written responses from users, which were subjected to thematic analysis. The results of the analysis are reported below.

In the positive aspects of the presentation of works on the monument, a total of thirteen users commented. Four users generally referred to the presentation of the conservation process. User #3 specifically mentions that through the VR application and the presentation approach, "you better understand how the process of conservation works," while user #5 is impressed more specifically with the "process with the soil, they used to make it look like the ancient." Six users commented on the depiction of Tiryns with three-dimensional models. Specifically, user #14 said, "I liked the detail in the models; they looked so realistic that I wanted to touch them." and user #16 mentioned the "freedom to navigate around the three-dimensional models." Additionally, five users specifically mentioned the photographic and audiovisual material, while another five positive references are made to the user interface, highlighting its usability, practicality, and ease of image switching. Finally, four users specifically mentioned the successful narration of the application, its immediacy, and its explanatory character. As user #23 states, "I liked the vocal explanation of the process."

A total of ten users referred to the negative aspects of the experience. The majority of the negative elements focus on the design of user interaction and the lack of participation in the events presented during the experience. Six users refer to deficiencies in focusing functions (zoom) and interaction with the application, while another six negative comments focus on the lack of user interaction with the space and narration in general. As user #8 explicitly states, "I would like more movement and interaction options in the space" of the experience, while user #21 similarly mentions, "I expected to be part of this story and somehow to be able to interact." Among the negative comments, the use of unknown terms, the short duration of the experience, and the excessive information provided during the experience are mentioned. However, these comments are quite isolated and would require further investigation to ascertain whether they have a significant impact on the user experience or not.

In terms of the respective open-ended questions for the

AR experience, we only received comments from four users, as reported below. Two user's commented positively on the narrative aspects of the application, mentioning the vivid dialogues and the fact that the story of Melabus provides a unique vehicle for the participant to become part of the story along the visited path. A negative comment refers to the lack of integration of the narrative with conservation works, and as a user characteristically writes, "It would have been very nice and more helpful if, for example, when analyzing the interior decoration of the walls, there could also be a reconstruction for 1-2 minutes while the monologue at the top is being narrated". Finally, the spatial registration of the content as well as issues with multiple OS support for the experience are also mentioned.

B. Qualitative Research Results on Virtual Reality and Mixed Reality Applications

This section focuses on user observation conducted to collect data regarding the acceptance of virtual and mixed-reality applications by potential users and the prospects for future collaborations. Initially, the participants for evaluation were divided into groups of 2 or 3 people. During the use of the tools and applications, members of the research team observed and recorded the reactions and actions of the participants. At the end of each group session, after a reminder to complete the evaluation questionnaire, a brief discussion and dialogue took place regarding impressions, questions, and comments about the use of the application.

Specifically, the first group appeared to participate with a lot of enthusiasm during the use of the application, a fact that was confirmed at the end, where they showed a very positive reaction, mentioning that they found the content and tools they used very interesting. They also asked if they could go to the point of interest to see firsthand what they observed in the application.

The members of the second group were also enthusiastic during the use of the application. They mentioned at the end that they had used VR applications before, but not with Joysticks. One user mentioned that initially (until getting used to the controller), they skipped some images and videos by mistake and had to watch them again; however, this did not seem negative to them since it was easy to revisit material they initially skipped.

Regarding the third group, we also observed significant interest, as they stayed in the virtual world for a considerable amount of time. At the end, we received positive comments, mentioning that they liked seeing details about interventions they didn't know about. One member of the group mentioned that they really liked the 3D models; they found them very explanatory for understanding the space and appreciated the ability to zoom in and out to see details. They also particularly liked the slideshow in addition to the models.

The 4th group was also excited, finding the material and the application very explanatory. They did not make many comments aboucst the intervention point and the maintenance stages. Similarly, the 5th and 6th groups had a very positive reaction, without particularly commenting on the intervention points and maintenance stages.

Subsequently, the 7th group expressed a particular interest in the application, stating that they especially liked the maintenance part. Next was the 8th group, which had a positive reaction, but one member of the group mentioned feeling dizzy during the use of the virtual navigation helmet.

Then, the 9th and 10th groups stated that they liked it a lot, specifically mentioning that they liked the voice explanation during the navigation. Finally, the 11th and 12th groups had a positive reaction without particularly commenting.

VI. CONCLUSION

The research conducted within the CAnTi project open lab undoubtedly provided rich conclusions beneficial for both the business exploitation of digital applications after the completion of the research project and academic research, which could be the subject of future studies or publications.

Specifically, the quantitative research indicates a significant interest in mixed reality applications, especially among Millennials and Generation Z, with a higher interest from women compared to men. Approximately two-thirds of the participants in the research expressed a high level of interest in experimenting with new applications. Also, the evaluation of the application by users in relation to their expectations is a crucial indicator for the business utilization of the platform. It is encouraging that only 8.7% of the participants found the application to be below their expectations, while 74% stated that the application either met or exceeded their expectations.

Furthermore, participants generally rated the content, design, and audiovisual material of the application positively. However, the weakest aspect of the application appears to be the interaction element. Therefore, improving the interaction features of the application could enhance its business potential. Participants expressed particular interest in 3D models but wanted greater ease in focusing on or zooming in on them. Also, a significant majority (72%) found the application suitable for themselves, and an even higher percentage (79%) expressed intentions to use it in future visits to the location.

In conclusion, for more comprehensive conclusions, future testing and evaluation of the digital tools from a broader sample are deemed useful. Additionally, a deeper investigation into technical issues users may encounter, depending on their devices, application versions, location, and previous experience with similar applications, is required.

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VIII. AUTHORS

Markos Konstantakis serves as a Postdoctoral Researcher at the Department of Cultural Technology and Communication, University of the Aegean, where he is a member of the Intelligent Interaction research group (ii.aegean.gr). He received a Ph.D. in the same department, entitled: "Augmented Cultural User Experience (ACUX)" and a master's degree in "Specialization in Information Systems, Networks, and Telecommunications" from the Faculty of Sciences and Technology of the Hellenic Open University (HOU). Markos completed a degree and a master's degree as a Marine Mechanical Engineer at the National Technical University of Athens (NTUA).

Dr. Angeliki Chrysanthi currently serves as an Lecturer at the Department of Cultural Technology and Communication of the University of the Aegean, in Greece. Her background is in Art History and Archaeology (BA, National and Kapodistrian University of Athens, Greece), in Protection of Monuments (M.Sc., National Technical University of Athens, Greece), and she holds a doctoral degree from the University of Southampton, UK. Her thesis entitled "*Augmenting Archaeological Walks. Theoretical and Methodological Considerations*", examines the role of interpretative design in visitor movement and behaviour in spaces of cultural significance, and the contribution of qualitative research alongside computation and novel technologies to this research inquiry. During and after her postgraduate studies, she worked in her capacity as a Digital Heritage expert and researcher in Greece and mainly abroad. In 2016, she was appointed as Digital Humanities Postdoctoral Research Associate at the University of Sheffield and Visiting Research Fellow at the University of Chester in the UK before moving to Greece in 2017.

Efthymia-Themis Moraitou graduated from the Department of Conservation of Antiquities and Works of Art of the Technological Educational Institute (T.E.I.) of Athens in 2014. As a student, volunteer and finally professional she worked in organized laboratories on artworks conservation, as well as in situ on historic buildings wall paintings preservation and restoration. Due to her strong interest on the application of new technologies on Cultural Sector, she continued her studies and in 2017 she received the MSc in Cultural Informatics and Communication from the Department of Cultural Technology and Communication of the University of the Aegean, majoring on the Design of Digital Cultural Products. Her dissertation focused on the knowledge representation and semantic search using ontology on the domain of artworks conservation. Today, she is a PhD candidate of the Department on the field of semantic technologies on the Cultural Heritage Preservation domain. She is interested in knowledge representation, ontological engineering, semantic web and services, metadata, LOD and digitization applications on Cultural Heritage.

Konstantinos Kotsopoulos is a seasoned project manager and technology consultant with a track record of success in the information technology and services industries. IT strategy, management, software system analysis and design, 2D-3D digitization of cultural

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Nikolaos Papastamatiou is an Application Developer and Software Project manager. Graduated from Aegean University in 1998 with a Bachelor's degree on Mathematics. Masters degree in Distributed and Multimedia Information Systems from Heriot-Watt University, Scotland in 1999. Vocational Training in Project Management from National and Kapodistrian University of Athens. Research interests in the fields of Web Development, Virtual Worlds, Grid Computing, ontologies, semantic web and Natural Language Processing. Specialties: Expertise on information system methodologies, Relational Database Systems, multimedia and hypermedia, distributed systems design, artificial intelligent, networking and interactive systems.

Alkistis Papadimitriou is a graduate of the History and Archeology Department of the University of Athens and a PhD in Classical Archeology from the Albert Ludwig University of Freiburg, Germany. He worked for a number of years on the excavation of the German archaeological institute in the Lower Acropolis of Tiryns and was a scientific assistant to the late excavator Klaus Kilian. Today he is the Superintendent of Antiquities of Argolis.

Associate Prof. George Caridakis (http://ii.ct.aegean.gr/) serves as a faculty member, Assistant Professor, the Department of Cultural Technology & Communication, University of the Aegean where he founded and coordinates the Intelligent Interaction Research Group (ii.aegean.gr), a recently established but dynamic research group already making an impact attracting Regional and National funding and participating in numerous International conferences and workshops. He is also affiliated as an Adjunct Professor at the Athena RC (athenarc.gr/en) and as a Senior Researcher with the Intelligent Systems, Content and Interaction Laboratory, National Technical University of Athens. He offers courses offered in undergraduate and postgraduate levels in different institutions and supervises PhD, MSc and undergraduate theses. He has served in boards and committees and as a reviewer in numerous international scientific journals, conferences and workshops and is a member of the Association for the Advancement of Affective Computing and the board of the Greek ACM SIGCHI Special Interest Group in Computer-Human Interaction.