Eliciting requirements for a multisensory eXtended Reality platform for training and informal learning

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ABSTRACT

Aiming at bridging the gap between the recent advancements in eXtended Reality (XR) research and real-world scenarios, in this paper we describe the first steps of an iterative user-centered methodology developed to elicit user requirements and to design the scenarios for a multi-sensory collaborative XR platform, in the framework of the BRIDGES project. The platform aims to be customizable and flexible, and is intended for use in different pedagogical contexts, instantiated by two pilot scenarios: a) XR training for first-responders and fire brigade staff at international airports and b) XR informal learning experiences addressed to visitors of museums and cultural centers. Through a series of workshops and focus groups with users from relevant organizations, we collected a total of nearly 100 pedagogical, technological, experiential, operational and other user needs from within these two different contexts, and discuss here the challenges and limitations but also the opportunities that were encountered.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**;
HCI design and evaluation methods.

KEYWORDS

eXtended Reality, User-Centered Design, User Requirements, Training, Informal Learning

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1 INTRODUCTION

In 2003, Mary Whetton, in her article on Making Virtual Environments (VE) Compelling [55], noted “The VE promise is that a combination of immersing technologies and well-designed applications will let users experience real, recreated, abstract, or imaginary places that are too big, too small, too far, too costly, or too dangerous to visit in person and let users do things they can’t or wouldn’t do in the real world; for example, they might let medical personnel train, but not on human patients, and let emergency personnel train in dangerous situations, but out of harm’s way. [...] The future promises much more.” Less than two decades later, we are witnessing considerable growth in eXtended Reality (XR), i.e. Virtual Reality (VR), Augmented Reality and/or Mixed Reality technologies and applications, which offer the potential to render this future a viable and sustainable reality. An XR solution can bring significant added-value in different settings and various domains, especially in key sectors that as yet have not benefited from these technologies.

However, XR solutions that integrate immersive and multi-sensory technologies with and within real settings, “in the wild”, are still niche and studies considering the design and evaluation of such platforms are sparse. As XR grows to appeal and penetrate a mass market, it is necessary to establish research methods to guide the design and evaluation of experiences that account for their intended users’ needs. Making XR experiences more accessible to a variety of users is an open challenge [2, 32]. To this end, motivated by the potential added value of XR, we set out to explore the design of an XR platform that will be meaningfully applied and extensively piloted to areas and situations where the benefit from it is clear and

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Figure 1: The Immersive Deck® “platform” can be a series of rooms in any shapes and sizes, where walls, doors and objects within the built environment are mapped onto different virtual scenes (Illusion Walk KG, 2019).

pronounced. Two broad application areas have been carefully chosen, to span the spectrum of different formal and informal training and learning activities: (industrial) training for functional purposes and informal learning for cultural and recreational purposes. In particular, the design is led by two pilot implementations: Pilot 1 which targets the needs of applying XR for training firefighters and first responders at two major international airports, one in Greece and one in Germany, and Pilot 2, which targets the museum educators and visitors of a cultural heritage institution in Greece, aiming at creating immersive learning experiences. In this paper, we briefly describe the collaborative multi-sensory XR platform being developed for this project as well as the different contexts and indicative training and learning application scenarios foreseen. We then present, in Section 3, the methodology adopted for eliciting user needs from the representative target user groups and provide, in Section 4, indicative examples of the resulting requirements that were specified. Finally, we discuss and conclude by highlighting the challenges and limitations in shaping the requirements and the scenarios (Sections 5, 6).

2 XR PLATFORM, CONTEXTS AND SCENARIOS

The goal of this project is to develop a solid technological and theoretical framework in terms of technical development, user-centered design and evaluation methodology for XR. The technical installation, the Immersive Deck [40], consists of a set of closely coupled, commercial off-the-shelf as well as bespoke, technologies (hardware) and tools (software), assembled into a complete, low-cost platform. It includes positional tracking for a group of up to 10 people concurrently. Each user wears a high-end Head Mounted Display (HMD) which is tethered to a laptop that is carried in a backpack, so rendering of the virtual world in the HMD is performed locally on each user to minimize latency. Inside-out optical hand-

Figure 2: Screenshots from the 3D digital reconstructions of a classical Athenian household, created by the Foundation of the Hellenic World (FHW), as part of the educational VR productions presented at its cultural center.

and finger tracking is performed by a stereo-camera that is attached to the HMD and thus allows the tracking of hand movements for haptic interaction. This setup enables free-roam navigation (simply by walking) in large, even multiple, rooms and natural interaction (Figure 1). In a nutshell, the key technical and operational features characterizing the XR platform for which we are called upon to design experiences include: 1) a mixed reality setting of any size and configuration (e.g. multiple rooms, corridors, etc.), combining physical and virtual interaction; multi-user concurrent interaction in the physical and virtual space, supporting a sizeable number (e.g. 10) of co- and remotely-located participants; 2) a low cost solution for tracking the physical area and mapping the virtual world onto the built environment, including the architecture, objects, machinery, equipment and any object related to the scenario of each application; 3) intuitive interaction, where hands and fingers are tracked optically and represented in the virtual world, thus eliminating the need for hand controllers; users can shake hands as they do in real life and navigate the virtual naturally by physically walking around in the real world [34, 39, 41]; 4) multi-sensorial stimulus, improving immersion and maximizing the feeling of presence by incorporating effects such as wind, heat, smell, vibration, in addition to the visual, auditory and tactile.

We aim at “bridging” the gap between interactive technologies and industries by designing XR experiences that can be integrated in different real world industrial and cultural settings to serve various purposes. We thus begun with two pilot scenarios, namely the training of firefighters (Pilot 1) and informal education and recreation for visitors of museums and cultural institutions (Pilot 2). While both scenarios share pedagogical goals and demand a high-quality collaborative experience, the particular objectives differ, and thus create different technical and practical challenges, pushing the design and development of the XR platform to different directions. Designers of XR collaborative experiences must account

for such issues to make the experience accessible by every user regardless of physical condition, height, technical expertise, etc. For the different contexts of the pilots, related design practices have been considered [18, 23, 24], however what is new here is the need to design a single XR collaborative platform that fits diverse cases. The two pilots constitute two completely different contexts, places and user profiles involved.

2.1 Indicative Scenarios

We present two initial scenarios, one for each pilot, that outline the potential use of the described platform.

2.1.1 Pilot 1: “Firefighting simulation”. VR-based training, such as training for industrial design, assembly and maintenance of parts, etc. has been used in industry for over two decades [6, 28, 42]. Lately, VR is increasingly recognized as an important adjunct to traditional modalities of real-life drills. The immersive and participatory nature of VR training offers a unique realistic quality that is not generally present in classroom-based or web-based training [21]. VR, as a reality simulator, can be used to place users in a scenario that depicts potentially real events, but in a controlled setting which alleviates hazardous consequences, and can reduce the time and cost burden that real-life drills can place on participating organizations [22]. This increased practice realism enables participants to gauge their individual and/or team’s ability to execute tasks and decision-making under more closely representative conditions. VR-based training can aid in acquiring spatial knowledge of a terrain [52], and can be repeated unlimited times. Repetition time as well as the feeling of presence that is provided in VR both have positive effects on task performance, enabling the learning situation to be experienced as a real context. This in turn promotes experiential learning as well as the development of operational and formal thinking by facilitating the exploration of different possibilities [6, 35]. Multiple studies have highlighted the benefit of VR applications in first responder and disaster training, e.g. in firefighting [4, 7, 10–12, 16, 29, 31, 43, 50, 54, 56, 57]. An XR solution where virtual obstacles mapped to physical props can be touched, heat or wind can be sensed, and smoke can be smelled, further augments the authenticity of the scenario and the users’ sense of presence.

One of the main training scenarios at airports may involve an emergency situation with a plane, either after a take-off or landing accident or during the refuelling process. Part of the standard procedure is a first response team to evaluate the situation and coordinate further actions. The main goals of such a training unit are reconnaissance of the situation, communication with HQ, team members, and passengers and the habituation to stress, views of such scenery, the sounds as well as the repetition of standard procedures. In preparation for a training session, the trainer has already chosen certain criteria, such as airplane size, level of fire, density of smoke, amount, type and place of passengers and injured persons. Levels of difficulty can be adjusted individually for different teams and their skills. The trainer observes the simulation via a monitor and a “virtual” radio connection. S/he can interfere and trigger special occurrences or even record and remark specific situations for later debriefing.

In such an indicative scenario, 4 to 6 members of this first response team could start right in front of a plane that has just crashed

with a broken landing gear. One turbine has caught fire and heavy smoke has darkened the surroundings while the first passengers are leaving the plane through the emergency exits. The team, with their snoring SCBA (breathing apparatus) on their back, now have to open the door in the right manner in order to get inside the cabin. Screaming passengers in panic are running in to them and obstacles of trolleys make it difficult to find the way through the aisle. Parts of the hull structure have been ripped off, making even the emergency light that shimmers non-visible in the incoming smoke. Waves of heat swap out the darkness. The primary task will be to find all injured persons, secure them and classify their status. Furthermore, they have to apprehend the changing situation and detect additional threats. Throughout the duration of the experience, the status, location, and observations of the team have to be communicated by radio to the operation control. Noise, bad connection and interruptions demand precise wording and radio discipline. One young member reclaims critical low pressure on their breathing apparatus. His/her breathing has become very hectic during the overwhelming action. The team has managed to clear the situation on the inside, while the fire trucks contain the fire on the outside. Mission accomplished, the team can head back to engage in a debriefing in which the entire experience that was recorded for playback can be reviewed and discussed among the team and their trainers.

2.1.2 Pilot 2: XR in informal learning, culture, and entertainment. The benefits of immersive technologies for learning have been highlighted time and again [36, 45]. In informal learning, especially the domain of cultural heritage, the process of exploring, discovering, interacting and identifying afforded by VEs, fosters inquiry that can lead to re-enactment, perspective-taking, and knowledge of the cultural, sociological, and even political importance of objects, ideas, or sites [9]. As much as the term “empathy machine” has been overused, one of the VR medium’s central tenets is indeed this notion that it creates empathy, motivation, excitement, which in turn, can lead to more radical impacts in learning including the facilitation of attitudinal and value change, attention restoration, therapeutic change and personal transformation [37].

An appealing scenario for young and old visiting a cultural venue may involve travelling back in time to experience life in antiquity [8]. The XR experience is designed for groups of up to 5 users thus primarily targeting families and small groups. The XR platform allows the group to partake in a guided storytelling experience inspired from daily life in Classical Athens, following the activities, festivities and social conversations and confrontations of an Athenian family in their house (Figure 2). It is well documented that visitors of historical and archaeological museums have a keen interest in learning more about the past through stories of the private life, not only of the upper classes, officials or religious leaders, but also of the everyday life of people and how they lived and participated in the different events of the community. Classical Athens is a fitting topic both because of its popularity among the Greek and international public and its abundance of interpretive resources to support reconstructions.

In the scenario, visitors may choose their own character and assume the roles of guests invited to the household of a well known middle class pottery maker/merchant in Ancient Athens. The group

will enter the XR experience in a specially constructed physical space that matches the walls of the virtual house. Greeted by their virtual hosts, visitors will be able to physically walk around the house (even ascend to the upper story), gather round the hearth to take part in the preparation of a meal, offer (and indeed smell) aromatic incense to the gods, assemble and generally interact with objects by using their actual hands and gestures. Such an interactive, social and participatory multi-sensorial experience, combining historical accuracy in representation with dramatic storytelling, can enhance knowledge about the past, historical empathy, and resonance [37].

3 METHODOLOGY

Eliciting inclusive requirements to cater to users' needs requires getting to know the users, and understanding their goals, actions and context of interaction [1, 5]. Focusing on the two use-cases of the 2 pilots and driven by the initial, indicative scenarios, we defined a methodology to understand the actual needs of the potential users of the platform and strike a balance between their diversity. This methodology consists of a four-phase process. Note here that with the term users we not only refer to the end-users e.g., the trainees or visitors, but also to the staff of the institutions that will be integrating XR technologies in their work process e.g., trainers, museum educators, facilitators, etc.:

- (1) Understanding and describing the context (otherwise coined as a "sensitizing" study). This phase involves the familiarization with the application domains (in our case, training and informal learning) by getting to know how the respective users and organizations work in each domain. Hence, in this first phase, we collect material concerning each stakeholder's work related to the project (e.g. daily training schedules, visitor experience scenarios, etc.) to describe as best as possible the context for each pilot being developed.
- (2) Define user groups – target audiences for each pilot. We do this through defining "personas".
- (3) Define a methodology for the elicitation of user requirements. In other words, determine a coding scheme for requirements, define categories of requirements, specific fields within this taxonomy, and formatting.
- (4) Elicit user requirements in each category (through workshops, interviews, etc.). Ask partners to prioritize requirements (e.g., mandatory, optional - "nice-to-have")

3.1 Phase 1: Understanding and describing context

As the first step towards an iterative user-centered process for capturing and validating end and middle users' needs, a series of research instruments were used to gain insights on the context of the use-case domains, including:

Questionnaires. Detailed questionnaires were designed and distributed to both airports, the Athens International Airport (AIA) and Flughafen Berlin Brandenburg (FBB), as well as the cultural partner, the Foundation of the Hellenic World (FHW) in the project. These aimed at understanding the context of work of the potential users that are involved in these places i.e., first responders, trainers, trainees and staff of the airports for Pilot 1, and personnel

i.e., museum educators, historians and staff responsible for visitor programs as well as visitors of the cultural institution for Pilot 2. The questions included sections concerning their profiles, goals, current methods and tools used, assessment processes, challenges and limitations encountered, but also expectations and fears from the introduction of XR in their traditional "modus operandi".

Study existing material (documents, videos, etc.) The answers to the questionnaires along with supplementary material collected for each domain, such as protocol and procedures for firefighting missions, descriptions of scenarios, videos, and related documents, were studied in depth and organised. This process was supported by focus groups held with all parties involved and their collaborators (e.g. representatives from the fire brigades, museum storytellers, etc.) for further clarifications and to advance our understanding. Additionally, user requirement elicitation workshops carried out in later Phases included the aforementioned participants and served to iterate on the material that was used to build the list of requirements.

Participation in (onsite) observation. Sensitizing studies and user requirements elicitation involve ethnographic observations [13, 14, 38], on site. In the case of our work, due to the COVID-19 restrictions around Europe, onsite observation was unavoidably limited.

Nevertheless, members of our team were able to observe the smaller-scale preparedness drill titled "Aircraft accident at the Airport", carried out in December 2020 at the AIA. Training drills, part of the Emergency Contingency Plan of the airport, take place annually. This smaller, due to COVID restrictions, drill included a real (training) aircraft but no fire or smoke and fewer than usual people participating. Despite the limitations, the drill lasted for approximately 90 minutes and consisted of 5 stages: alarm; firefighting; passenger rescue and triage; on-site command; organization and operation of management centers; restoration of normal airport functions. Along with the debrief that followed, the information collected during this observation has been essential in shaping the scenario for Pilot 1.

3.2 Phase 2: User group definition through Personas

The target groups share some general points that apply to users of any XR application, However, in our case, two main categories of users are necessarily designated by both the end and intermediate users of the pilots: trainees and trainers of the airport fire brigade (Pilot 1), staff and visitors of the cultural heritage institution or museum (Pilot 2). To make these profiles better understood and realistic, we apply the user-centred design instrument of "personas" i.e. fictional characters to describe the different real users of the XR experiences to be designed. [30, 33, 47]. Personas are profiles of people that do not exist in reality but could exist based on the information that we have about the people that would participate in the experiences. Personas allow us to study the actual target groups' motivations, goals, skills, social and psychological aspects of their personalities, to foresee their needs, expectations from the experience, and context of participation, and take these into account in the scenario design. Through online participatory activities and studying the profile and context of the potential users of the pilots,

we developed 3 personas of firefighter trainers and trainees for pilot 1, and 6 personas of museum visitors and educators for pilot 2 (9 in total: 5 female / 4 male, 6 adults / 3 children aged 11 to 17, and one of them having mobility limitations). These personas, combined with a participatory design approach, have been key to the elicitation of user requirements. Involving users of various backgrounds, culture, abilities, age and gender in the elicitation of user requirements, widens the spectrum of user-centered XR and helps overcome biases and generalized assumptions [17, 20, 26, 49], especially when it comes to embodying the users in the virtual environments [17, 19, 25].

3.3 Phase 3: Codification and themes of user requirements

Numerous resources exist with general guidance on how to best specify user and organisational requirements and objectives [3, 15, 27]. Based on these, we have categorised the user requirements into six themes as follows: 1) General (GE) requirements that apply to any XR experience, e.g. related to motion and cyber sickness or to common hardware specifications; 2) Site (SI) requirements regarding the venue and the specifications of the site where the XR experiences will take place; 3) Pedagogical (PE) requirements to maximise the effectiveness of training, e.g. customisation options for the trainer/educator and of informal learning, e.g. age appropriate style. 4) Experiential (EX) requirements that are needed for creating a positive overall experience for the user e.g., sense of embodiment and immersion, interactivity, multi-sensory stimuli; 5) Technical (TE) requirements that are related to specifications of the XR equipment and experience, e.g. fidelity of the simulations; 6) Operational (OP) practicalities and requirements that are created by physical limitations, e.g. create scenarios with or without the gear. Each requirement has been marked with an ID, the name of the requirement, a priority designation, a description of the requirement, the user persona(s) related to the requirement, and further details about the requirement and its rationale. The structure and codification information can be found in <https://tinyurl.com/msmta>.

3.4 Phase 4: Elicitation of user requirements and prioritization

An iterative approach of defining, refining and revisiting the requirements has been established. This approach included the coordination of five shared and three dedicated to each pilot workshops, held in a period of 6 months, from November 2020 to April 2021. As a result, we collected a total of almost 100 requirements and grouped them into the aforementioned categories: pedagogical, experiential, technical, operational, general, i.e. applying to both Pilots, as well as site-specific requirements, i.e. those applying to each physical site in particular. Each requirement was then described and tagged further on the basis of its specific characteristics. These designations and descriptions were revisited and refined multiple times throughout the process.

4 RESULTS

User research is a laborious process involving the collaboration of multidisciplinary teams, in multiple iterations, and resulting in a substantial body of requirements and subsequent specifications

that are necessary to support the design and implementation of immersive interactive experiences. From the results of the process reported in this paper, we choose to highlight below a subset that is indicative of the complexity of designing for a multi-user XR platform.

4.1 User Roles

An issue that emerged early in the process, particularly in Phase 4, is discerning the different roles of the users who participate at any given time, together, in the different XR experiences. This has implications on the design of multi-user XR in that many of the elicited requirements relate to defining the different user roles that the users assume. The user roles describe a classification of tasks that take place within or outside the XR experience and can be held by the same or different people according to their profiles, skills and needs. User roles will differ depending on the application domain of XR. Yet, we believe, that it is critical to invest effort in identifying and distinguishing these roles early on. A selected example of user roles identified for both pilot experiences includes:

- The role of Experience Participant who is whoever is within the XR collaborative experience. This role can be further analysed into pilot-dependent roles such as Trainee of the fire brigade who participates in the XR training (Pilot 1) or Visitor of the cultural institution who participates in the XR experience (Pilot 2).
- The role of Experience Leader is someone who has specific knowledge about the specific pilot and the institution's goals, e.g. an expert of the fire brigade or the museum who observes from outside the XR experience, evaluates and intervenes only if necessary, to customise the experience or to optimise it for its participants. The Experience Leader should be as less intrusive as possible. Depending on the pilot, this role can be further specified. In Pilot 1 for example, the experience leader could be the Trainer who is a fire brigade expert that watches the training from the outside, customises the experience if needed, marks what happens to provide feedback to the trainees after and can see the replay of the training. The role of trainer enhances the training goals of the experiences.
- The role of the Operator who is a person outside the experience, maintains and changes the equipment, helps participants to wear the backpacks and HMDs, makes sure that safety rules are followed in physical space and takes care of the overall normal and safe operation (e.g. dealing with possible simulator sickness, etc). Ideally this role can be held by any person of the institution's staff after a short training.
- Further roles include those of the Administrator, i.e. someone with technical skills who watches the whole experience from the outside, on a 2D interface, and provides technical support in order to help or guide, if needed, the participants. The Administrator is the omni-present helper in the technical sense but is not necessarily a domain expert in terms of the content/context of the use case. Additionally, the role of the Assessor of the whole experience. This role is important for the institution involved but there is no need for this person to be present during the XR experience.

4.2 Example requirements

Selected examples of pedagogical requirements, one for each Pilot, are presented below. Further requirements are available at <https://tinyurl.com/msmta>.

P1-PE-07 | Communication - coordination skills. Description: memorise or think what the right actions are to coordinate efficiently and quickly with others. The XR scenario should provide the opportunity to trainees to train on efficient and safe ways to communicate with each other if needed, e.g. using signs or tactile feedback as it is done in an actual mission. **Requirement Priority:** High. **Source:** Onsite drill visit, questionnaires and material sent by the airports. **Further information:** Time is very limited and the coordination should be done very quickly and clearly, at a theoretical level the tasks should be known before going onsite and trained before going onsite, and communication actually includes short or quick actions to coordinate without ambiguities or the need to discuss (there is no time!). Sometimes firefighters need to rely a lot on tactile and haptic feedback due to limited vision, e.g. they touch each other's hands to enter the building (see also P1-... haptic feedback).

P2-PE-06 | Experience Leader: Facilitator (Game Master). Description: The XR scenarios should include the creation of a Facilitator role to guide the storyline, provide additional information and help. The role of the Facilitator could be either a virtual character (agent) or an avatar of the museum educator who will be observing the experience from a 2D screen outside and intervening only when necessary, in a seamless manner. In addition to the Administrator who oversees the overall experience, the museum facilitator enhances the educational goals of the experience. **Requirement Priority:** Medium. **Source:** Pilot 2 focus group, questionnaires. **Further information:** See also P2-...customisation options.

5 DISCUSSION

Whilst the experiences of the two pilots are similar in their overall structures, they also present some important differences which come from the goals and contexts. This process of eliciting user requirements has highlighted that balancing similarities and differences is key, and that the points to consider reside on several levels.

Profiles of participants: In Pilot 1 the main target group (trainers and trainees of the fire brigade at an airport) is comprised of a rather homogeneous group in terms of age, skills, motivations, physical condition and profession. Users are mainly men in excellent physical condition, aged 25 to 55 that share the same profession and working environment, and will be revisiting the same experience over time. On the other hand, in Pilot 2, staff and mainly visitors of museums, cultural heritage and other kinds of informal education or recreational institutions, can show a great diversity in their age, motivations, interests, physical condition, profession, language, level of interaction and participation, familiarity with technology, abilities, or cultural background [48]. They can range from younger children to elders, from students to professionals with highly technical skills to people with no familiarity with technologies and XR. The goal of an experience in this context may also be less factual and more abstract [51, 53]. In addition, it is a question how a group of visitors, whether a family, friends, or strangers, should distribute

among them the number of predefined avatars, and to which extent they should be provided with the option to customise their avatars. On one hand, an avatar with different characteristics may encourage a kind of role-playing; on the other hand research suggests that being embodied in an avatar with, e.g. gender switching or voice mismatch [44] may affect the experience of the users as well as the social dynamics of the group, depending on their original relationship in real life. Research on these topics is situated in the area of social VR, however, the XR setting here in the context of the museum differs. First, the motivation of the visitors is different, they might be completely unfamiliar with XR and in a very short time, due to the operational limitation of a museum venue, they will have to become familiar with the environment, engage in a kind of role-playing, participate in rich multi-sensorial activity, and feel safe doing so. Additionally, the cases where there will be a mismatch between visitors' bodies and their representation as different avatars may prevail. Yet, this particular XR setting creates a number of opportunities, e.g. users can touch each others' hand and physical replicas of objects, and therefore feel more immersed.

Context: As noted, the user group in Pilot 1 comprises trainees who must use the platform as part of their obligatory regular training activity, therefore, participation is compulsory. Participants are committed in the long-term and have the chance to follow on-boarding informational sessions before embarking on the XR training. On the other hand, visitors in Pilot 2 are there by choice, to spend some quality leisure time with their friends and family or as a school group during an educational visit. Although many informal learning venues offer pre-visit material for educators to prepare before the forthcoming visit, it is necessary for the XR experience to carefully incorporate all elements of participatory engagement if it is to leverage its full educational potential.

Pedagogical objectives and goals: both pilots share pedagogical goals, however the contexts differ. The training in Pilot 1 takes place in a formal environment with clear protocols, very specific learning objectives and goals. The experiences in Pilot 2 happen in a more relaxed environment, the educational objectives should be fulfilled in the context of informal learning while simultaneously providing an entertaining experience for its audiences. Both scenarios share requirements for multi-sensorial simulations such as wind, heat or smell. For example, in Pilot 1, the heat or fire simulators and wind will be integrated to make the first-responders training more realistic and will allow to create a number of different situations and levels of difficulty depending, e.g. on weather conditions, intensity or location of the fire. Also smells, such as burnt plastic or other material will add to the simulation of realistic conditions that might not be pleasant for the participants but they will make the training more efficient. On the other hand, in Pilot 2, smell should be chosen very carefully in order to be as historically accurate as possible, but also pleasant for the majority of the users. Including olfactory stimuli, a field of research that is less explored in HCI, can pose a number of research questions, e.g. what kind of aromas were prominent in an ancient Athenian home, how can these be simulated, and how would this affect the visitor experience.

Time limitations and flexibility: a key contextual difference between the two pilots lies in time and flexibility. Whereas for Pilot 1 all participants should and have the time to be trained (and assessed) equally, Pilot 2 should provide flexibility to its participants

in terms of both time and participation. Moreover, operational and equipment-related requirements, and visitor time constraints, in conjunction with the use of high-end technology, may pose additional challenges when designing for public spaces [46].

6 CONCLUSION

In this paper we have presented the methodology of eliciting user requirements for a flexible XR platform that can support multi-sensory, collaborative pedagogical experiences in different contexts. So far, through drafting two scenarios, crafting nine personas for the two pilots, and applying a participatory approach that includes the long-term engagement of users from airport fire brigades to cultural heritage institutions, we have identified different user roles and documented one hundred requirements, that are categorised into six themes. The process of eliciting requirements, however, as part of an iterative user-centred approach is an ongoing endeavour of continuous refinement.

While a number of studies for VR have been held in the last decades, XR experiences present some unique chances and challenges that are bound to their multi-sensorial, multi-user and hybrid nature. The initial set of requirements and their given prioritisation serves as the basis for the design of the platform and shaping the use-case scenarios. As this first iteration depicts, the needs extend the usability/user experience design to operational, site-specific, and pedagogical requirements that emerge from the actual, real-life needs of the specific contexts of application and create more complex user-roles than a typical single-user VR experience. The next steps are the testing of the draft scenarios with real users and the development of the prototype experiences that will be evaluated. Ultimately, we aspire to contribute with a comprehensive user-centered design framework of best practices that will support designers to deploy rich, immersive XR experiences in various formal and informal pedagogical scenarios. And to develop a methodology for the meaningful, well-rounded evaluation of XR technologies, tools and experiences that can lead to adopt XR as generally applicable at a large scale to a variety of use cases.

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