CreAIXR: Fostering Creativity with Generative AI in XR environments

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***Abstract*—Fostering creativity is paramount for cultivating innovative minds capable of addressing complex challenges. Modern technologies like eXtended Reality (XR) and Artificial Intelligence (AI) may nurture grounds supporting creative thinking by providing immersive and manipulable environments. An open research question is how such technologies may best lead to such a possible result. To help move one step closer to an answer, we present a portable XR platform, namely CreAIXR, where objects may be creatively defined and manipulated with AI paradigms. CreAIXR leverages web technologies, XR, and generative AI where creatives are immersed in a composable experience, allowing them to collaborate and customize an immersive environment through XR paradigms and generative AI. We here describe this system along with its validation through experiments carried out with a group of individuals having a background in the field of visual arts.**

***Index Terms*—Extended Reality, Artificial Intelligence, Creativity, Generative Artificial Intelligence, Stable Diffusion.**

I. INTRODUCTION

Nurturing creativity stands as a cornerstone in the cultivation of innovative thinkers capable of tackling multifaceted challenges. However, each person possesses independent working abilities and needs. Fulfilling every person's requirements through traditional approaches amounts to a challenging task [3]. This phenomenon is even more evident in creative and artistic studies like visual arts, where the essence of artistic expression often gets lost in convoluted textbooks and abstract concepts, hindering experimenters' ability to grasp fundamental creative principles to be then re-applied [3]. Thus the urgency of developing tools that offer more effective pathways to develop creative skills [15].

Creativity, however, remains a complex and enigmatic aspect of the human mind. Despite numerous attempts, it remains elusive to pin down and quantify. This concept encompasses two discernible cognitive components crucial to our daily creative endeavors: divergent and convergent thinking [10]. Divergent thinking embodies a mindset conducive to idea generation, where criteria for selection are loosely defined, and multiple solutions are considered acceptable. Hence, it hinges upon mental flexibility. Conversely, convergent thinking entails a more focused approach, seeking singular solutions to well-defined problems, demanding persistence and concentration [10], [24]. Nearly a century ago, Wallas [38] proposed a four-stage model for the creative process, starting with preparation (i.e., problem exploration), incubation (i.e., unconscious elaboration), illumination, for the narrowing down of potential solutions, and verification, for solution scrutinization. The initial stages of this model lean more towards divergent thinking, while the latter towards convergent thinking.

In such a context, professionals, educators, and researchers have been experimenting with novel technologies to define new paths that could support divergent and convergent thinking [21], [28], [41]. Recent works have been investigating how a composition of eXtended Reality (XR) and Artificial Intelligence (AI) paradigms, recently named Extended Artificial Intelligence, may lead to the edification of fruitful creative environments [13], [31], [32]. One of the key findings from such works is that providing a learning-by-doing approach exposing the opportunity to manipulate digital elements, improves learning motivations while stimulating creativity [9], [15], [20]. Considering art, experiences like immersive virtual galleries, collaborative workshops, or virtual trips to cultural sites demonstrated to enrich the learning process [13], [15], [20], [32]. Moreover, it was highlighted how Extended Artificial Intelligence paradigms can remove mental creativity barriers, stimulating original ideas [13]. In particular, XR can provide versatile tools for spatial manipulation, visualization, and collaboration, transporting creators to immersive environments. Creators can so engage with virtual content in dynamic and interactive ways without spatial constraints and resource limits, creating a fertile environment for developing new ideas. If paired with web technologies a collaborative layer can be implemented to make such systems accessible from anywhere, enabling real-time interactions among professionals, educators, and learners. However, XR systems often operate within predetermined actions and interactions, thus constraining users' ability to explore and freely create [15]. Integrating AI methods, such as Deep Learning (DL), amounts to a possible solution. In particular, DL generative algorithms offer the chance to craft and tailor immersive environments, offering personalized and adaptive experiences, and supporting divergent thinking [18]. Such technologies also enable iterative and creative processes, encouraging users to explore and experiment with their creative ideas [18].

Despite such potential, there remains a noticeable gap in

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the literature concerning comprehensive systems and research endeavors that offer a holistic approach to user creative development through XR and AI technologies. Specifically, there is a lack of frameworks that seamlessly combine XR with a modular approach, AI-driven evolution, and an easy-to-manipulate and extended environment. This is indeed a well-established challenge within the Metaverse [42].

Additionally, there are limited resources for facilitating collaborative sessions among creatives, a process crucial for effective creative outcomes, and involving the presence of moderators. Moderators play a vital role in these sessions, acting as mediators, facilitators, and supervisors to ensure a more efficient creative flow [11].

To address this gap, we introduce CreAIXR, a creativity-enabling environment merging generative AI and XR to support the creative processes. The platform incorporates the role of a moderator with special user privileges and allows users to collaborate in the customization of their environments by integrating existing immersive elements or generating new ones using AI.

The whole system aims to guide and enhance collaborative creativity, fostering both divergent and convergent thinking toward achieving creative goals. In order to validate CreAIXR, we consider a group of creatives which is tasked with collaborating on the creation of an art exhibition. In particular, CreAIXR is used to generate some artworks through generative AI and to find a suitable distribution of these works in the provided virtual space.

II. Related Works

The current technological advancements within AI and XR realms have opened unprecedented avenues for fostering creativity across various domains. The exploration of AI and XR solutions aimed at stimulating creativity, particularly through the facilitation of divergent and convergent thinking processes, has received significant attention in academic research [13].

In the literature, many works encourage the exploitation of AI-empowered creative tools and stress their potential to support various stages of the creative process, although advocating for a more human-centered approach in AI interaction to foster innovation [13], [14], [37]. They find that existing AI-driven tools primarily support idea generation and execution rather than early stages of co-creation [14]. For example in [37] the authors investigate the impact of AI-generated images on design fixation and divergent thinking in visual ideation tasks, suggesting that the effectiveness of AI co-ideation depends on how participants create prompts and generate ideas based on AI suggestions.

The pivotal role of XR technologies in addressing the mind's fixation by engaging different cognitive and behavioral functions, thus enhancing creativity and innovation, is discussed in [13]. The authors emphasize the role of XR in addressing cognitive anchoring and promoting innovative thinking, suggesting that XR environments, tailored to the users [7], [16], offer alternative strategies to traditional creative processes. In [26] the authors underscore the potential of XR technologies, particularly VR, in fostering flow states that enhance creative thinking, specifically within the context of composing percussive beats.

Furthermore, [17], [21], [41] explores the role of VR in enhancing spatial reasoning skills and fostering creativity in educational settings, demonstrating the effectiveness of immersive VR environments in improving spatial ability and encouraging creative problem-solving among students. Similarly, [12] investigate the effects of VR environments on students' creative thinking abilities, highlighting the potential of VR as a tool for active learning and imagination stimulation.

To the best of our knowledge, only a few works merge both AI and XR solutions to support the creative process. In [34] the authors introduced Calliope, a VR system enabling real-time exploration of generative design solutions, highlighting the synergy between human users and AI algorithms in virtual environments. The findings of this work demonstrate the potential of AI-driven co-ideation and generative design processes in XR environments for collaborative creativity. Similarly, in [8], the authors propose a platform to enhance creativity in engineering design, presenting a novel framework for AI-facilitated, VR-based brainstorming. The framework addresses traditional brainstorming limitations by prioritizing facilitation, stimulation, and immersion, ultimately enriching designers' creative experiences. This study underscores VR's ability to inspire creativity and AI's role in facilitating dynamic moderation, to foster competitive product innovation.

Unlike existing literature, our CreAIXR platform incorporates the role of the moderator with special privileges, moreover it allows users to collaborate in the customization of the virtual environments and it integrates generative AI for the creation of novel elements.

III. System Architecture

The proposed CreAIXR system was designed and developed on top of a recent previous contribution [29] to enable a wide range of immersive collaborative features, leveraging a multi-player client-server architecture. The CreAIXR architecture, depicted in Figure 1, was thought to provide continuous synchronization and data exchange between clients and servers, which maintains the main logic.

CreAIXR resorts to a stack of web (XR) technologies and DL ones, to provide clients with an immersive collaborative environment, allowing for (i) scene manipulation through standard approaches; (ii) integrating 3D objects from external databases, (iii) generating immersive items through AI methods. Within this context, CreAIXR features are modularized based on user privileges, distinguishing them between moderators and creators. To develop such features, the server implements a REST API interface with Node.js, which exploits Socket.io to serve the main immersive environments and provides a simple log-in mechanism and multi-player synchronous update, along with a 3D data management layer. Moreover, an additional server in Python was developed using the Flask web framework, to interface with different generative AI models with a modular architectural approach. It is worth

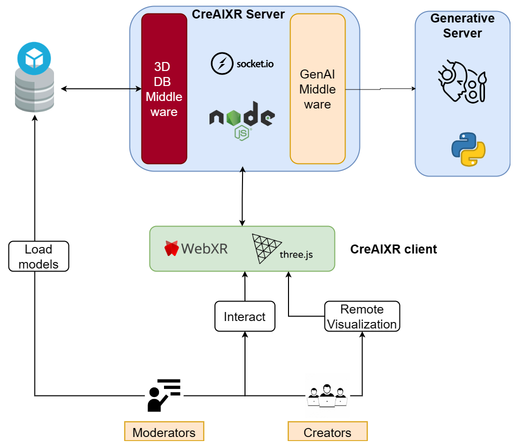


Fig. 1: CreAIXR system architecture.

noticing that we implemented a simple yet effective remote rendering approach to let users with low-performance devices join the collaborative sessions as viewers. Such a service leverages Puppeteer to emulate a client-side application on the server to capture rendering frames, which are then streamed to clients through websockets [39].

The client, instead, is built on top of Three.js, a JavaScript library used for creating interactive 3D graphics in web browsers, that provides tools for building scenes, rendering objects, and handling user interaction. We then integrate Three.js [1] with WebXR APIs [2] and Three Mesh framework [3] to provide system compatibility with XR devices, using the WebXRManager interfaces included in it. Such integration modularizes the user interactions according to the adopted device, in our case, Smartphones, Desktop PCs, and the XR devices that support the WebXR interface.

In the following, we will detail how we implemented the mentioned features, starting from the data modeling regarding both user profiles and immersive scenes. This data modeling design was thought to make CreAIXR a data-driven immersive system.

A. Scene and User Data modeling

Data concerning scenes and users is encoded in JSON key-value data structures [5], [29]. Considering scenes, the representing JSON files encapsulate information about the entire structure of 3D objects within a graph, including nodes and edges linking such nodes. To clarify and explain its structure, we report an exemplar definition in Listing 1.

Listing 1: Exemplar JSON representing a 3D scene.

```
{ "sceneName": "Generative_Gallery",
  "environment":{
    "mainlight":{"direction":[...],
    "shadows":false}
  },
  "scene_graph":{
    "nodes":{
      "building":{
        "url":" path/to/scene.gltf",
        "editable": false,
        "transform": {....},
      },
      "3D_object_1":{
        "url": ...,
        "editable":true,
        "transform": {...}
      },
       "hierarchy_edges": {".": ["
           environment":{["3D_object_1"]}]}
    }
  },
  "annotation_graph": {
    "nodes": {
      "annotation_user_1_shape": {"
          convexshapes": [...]},
      "annotation_user_2_draw": {
      "drawing": [...]}
      }
    },
    "hierarchy_edges": {".": ["annotation_1
        ","annotation_2","annotation_3"]}
  }}}
```

The presented JSON schema encapsulates the tree hierarchical representation of a 3D immersive scene, which is stored on a database on the server side of CreAIXR and that is the server from all the clients that has the responsibility to interpret such file and render it. This data structure arranges scene elements, their roto-translation, and the integration of user-generated annotations.

The `sceneName` attribute, serves as a concise identifier for the immersive environment under consideration. In adopting the appellation "Generative_Gallery", this designation imbues the virtual space with an evocative identity. The `environment` section embodies specifications governing the scene's illumination dynamics and other possible environmental variables (like the virtual space of the environment).

The `scene_graph` module delineates the spatial composition of the scene, portraying a graph of interconnected nodes representing distinct 3D objects. Each node, like `building` and subsequent `3D_object_1`, possesses additional attributes dictating its source (URL or file path), editability, and transformation matrices. In our case, the possible set of 3D objects amounts to those already stored in the server, objects imported from the external 3D database (e.g., Sketchfab) or generated by the considered generative AI model. The `hierarchy_edges` component depicts instead the hierarchical relationships between the objects, detailing the parent-child dynamics. Supplementing the visual elements, the `annotation_graph` component provides a structure for storing user-generated spatial annotations. Nodes such as `annotation_user_1_shape` and `annotation_user_2_draw`, represent examples of the type of spatial annotations we implemented (freehand draw and geometric) over 3D objects (those will be further detailed in Section IV-B). Both the scene graph and the annotation

[1] https://threejs.org/
[2] https://immersiveweb.dev/
[3] https://github.com/felixmariotto/three-mesh-ui

graph contain the hierarchy for the objects contained, indicating their parental relationships (i.e., parent, children, sibling) starting from the root node, denoted as ".".

This particular codification provides a flexible approach for all the different loading and manipulation operations. Indeed, once a client is connected to the server and decides to load or create a scene, the server will load/create and parse a JSON file that contains the reported fields and send the result to all the connected clients. Each time a client makes a modification on the scene, a new field is added and the updates are propagated to all the other clients while at the same time stored permanently on the server file system. Such structure was thought to define a data-driven immersive platform, that could be simply manipulated and modified, by just adding a new entry in a semi-structured data file like a JSON.

Finally, the user JSON simply contains fields related to its privilege and role in the system (moderator vs creator), one or more session tokens used to exchange data among the immersive session, and external multimedia databases. Moreover, to improve the usability and speed of use of our system, we define a "bookmark objects" field, that will be used to spawn a menu to immediately generate novel copies of the objects there contained.

B. 3D Collaborative Scene Rendering and WebXR integration

CreAIXR employs a client-server model where each client renders the 3D scene provided by the server and communicates user interactions back to the server to fetch data from different sources, modulated through a data manager component, and provides a scene modified according to them. In Figure 2, we visually depict a use-case diagram that shows how the main subjects of our system, moderator and creators, can start/join a collaborative CreAIXR experience.

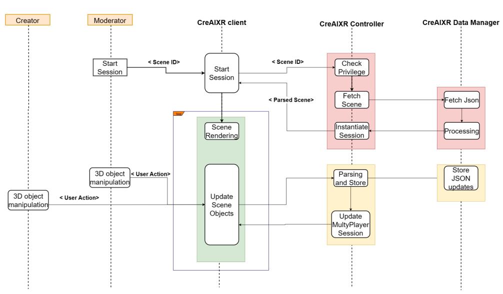


Fig. 2: Sequence Diagram for collaborative CreAIXR session init and 3D standard manipulations.

In practice, a moderator can at any time start a collaborative session by selecting an immersive scene. The client then sends this request to the back-end controller through a REST interface, which checks the moderator privileges, and asks the Data Manager to fetch and parse the scene corresponding JSON file. After that, such parsed data is sent back to the client, which starts the rendering loop. In the first rendering, each 3D object detailed in the JSON is loaded from a remote server path, or downloaded from an external database, according to the relative description detailed in Section III-A. After its rendering, with a simple URL, any user can join the remote session and start providing modifications to any of the 3D objects (e.g., roto-translation, scaling, annotations) in the scene, while also adding new ones. Finally, both moderator and creators can generate novel immersive items. All of these features will be detailed in the following Sections.

It is worth noticing that, all the client-user interactions are modulated concerning the device in use thanks to the developed WebXR integration. In fact, by integrating WebXR technology which can discriminate different XR devices and adapts the interface and the user interactions according to it. This approach, if paired with the adopted networked paradigms, enables CreAIXR for cross-reality scenarios, where different users could live the same different experience with different degrees of reality. It is worth noticing that, we tested all the features of CreAIXR by simultaneously joining the same networked session with a Desktop PC browser and different WebXR-compatible headsets: (i) Oculus Quest; (ii) Magic Leap 2; and (iii) HTC-Vive Pro.

C. 3D Manipulations and External Database Integration

As detailed in the previous sections, both the moderator and the creator could manipulate already spawned 3D objects in the scene or spawn new ones. In case of manipulation of existing 3D objects, the user could use well-establish user interaction events (e.g., click, drag, roll) to modify the position, scale, and rotation of all the 3D objects within the scene. At the same time, he/she could generate objects (i.e., spatial annotations) to annotate each of the existing ones using a multi-modal approach (i.e., text, vocal records).

The user is also provided with a set of tools that allow her/him to integrate 3D models from external databases. Both moderators and creators, according to their privilege levels, could search for a specific 3D model, download it, or upload new ones. In our implementation, we utilized one of the most widely adopted platforms for sharing 3D models: Sketchfab[4] [2], [6]. This decision was motivated by several compelling factors, among which the hosting and sharing services for 3D objects, and a set of APIs for searching, downloading, and uploading 3D models. When interfacing with SketchFab the system will provide the user a simple interface for textually searching 3D objects and spawning them in the immersive environment. It is worth noticing that, all the here mentioned actions will immediately update the JSON file representing the scene for all the players connected to the collaborative session and store it for future usage.

D. Generative Deep Learning Module

Considering the already proven effectiveness of the Generative AI models applications for creativity, we here provide an integration of a middleware able to interface with many of such models for the generation of immersive items [22]. To improve architectural modularity we built an additional Flask Python web server as depicted in Figure 3, contacted by our

[4]https://sketchfab.com/feed

main CreAIXR server when an item generation is required. Considering that such models typically require a relevant amount of GPU resources, we implemented a simple queue mechanism so that such a server could manage to generate novel images even with a limited number of GPUs. In practice, entry queues maintain the requests made by all the users and furnish them to one of the n Generative Models instantiated and available in a pool of m replicas to let it be used in one of the available GPUS. Then, the generated outcome is stored in another queue, which streams back the images to the main server, which then proceeds with an object spawning into the corresponding immersive session.

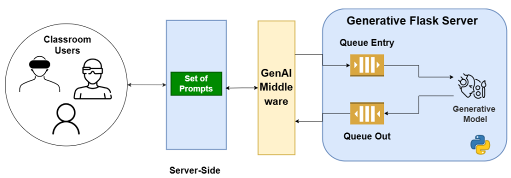


Fig. 3: Generative AI server integration architecture.

Despite its generality, we here provide the first version of such a generative feature, focusing on the generation of 2D images starting from the textual description, known as text-to-image generation [23]. Considering the choice of the text-to-image model, we picked a recent Generative Diffusion model named Stable Diffusion [23]. We selected such a model as a trade-off between generation quality and efficiency. We so integrated its original implementation in our server [5].

IV. CreAIXR applied for creative education: a Generative Museums scenario

Considering the architectural flexibility of CreAIXR, different kinds of immersive scenarios could be defined. We so designed a scenario for a particular creative education scenario: Museology Arts Curatorship. This corresponds to the curation and management of artistic collections within museum settings but also the organization of artwork exhibitions, research art history, and theory. For such a subject, XR plays a pivotal role: creating a configurable spatial immersive environment, that students can use to express and improve, in a collaborative way, their creativity through organizing locations and exhibition layouts [19]. The role of generative AI becomes then relevant when users imagine which kind of style and subject fits better with the location, but also for generating ideas and taking inspiration [4]. For this reason, we defined an immersive environment with these features as follows.

A. Immersive environment

As mentioned, the flexibility of our systems allows us to choose any 3D object as the surrounding environment in the immersive scenario. Considering our use case we selected a real-world scenario where a real university-level course on Arts & Museology is held. We so modeled the 3D model related to its cloister, at the center of its arcade, to create a well-structured museum space to provide an easy-to-use layout to organize and place artworks. In Figure 4 we report the immersive environment along with its interface UI.

Fig. 4: Generative museum scenario and User Interface (top bar).

B. User experience

In this section, we will detail the main features provided by the CreAIXR immersive user interface, which interlaces with all the paradigms and technologies already described. Those features amount to *Scene Exploration*; *3D object management*; *Artwork Generation*. To support the explanation, we demonstrated all the features visually, with a view like the one introduced in Figure 4.

a) Scene exploration: CreAIXR offers users a comprehensive visualization and exploration experience of the current environment. Users can navigate using teleportation, orbit movement, or continuous locomotion, catering to different preferences [1]. Teleportation provides quick, precise movement ideal for specific exploration, while orbit movement offers a dynamic, immersive experience circling objects of interest. Continuous locomotion allows free movement with a "fly effect". These options are adaptable across various devices. As mentioned, CreAIXR provides a simple yet effective spatial annotation system. This means that users could explore the environment, 3D objects, and also immersive notes that were posed by others in current and past collaborative sessions. The annotation system will be further detailed in the following.

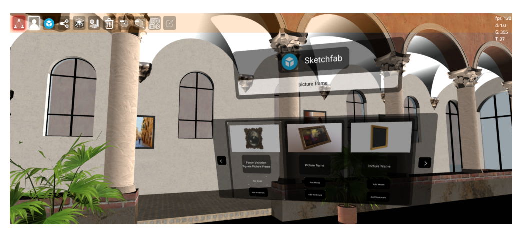


Fig. 5: Import 3D models from external database.

b) 3D object management: Having developed an integration with an external multimedia database (i.e., Sketchfab), we can scrape from all the available 3D models. The user could search for a particular kind of 3D object by providing a textual prompt, written with a virtual keyboard rendered in front of her/him. Then, a list of panels with a visual description of the matched 3D models is visualized (the user could also

[5] Stable Diffusion implementation: https://github.com/CompVis/stable-diffusion

bookmark objects). The user could then choose one of them, and render it in the environment (see Figure 5). With any object in the scene, the user could proceed by executing different actions on it like moving, dropping, scaling, and deleting them. It is worth noticing that, interactions are modular, device-adaptive, and following UI standards [27], [40]. For example, while being in VR, dragging is done by triggering, and scaling/rotation with the pad. On the desktop, the same is done with mouse pointing/holding and wheeling.

Various annotation methods enhance scene context for collaborative use, including freehand and geometric notes. They aim to provide specific location-based data and enhance collaborative aspects, also in an asynchronous fashion. Users can so draw on objects (freehand) by pointing a ray, or add simple notes (geometric) by creating interactive spheres. The geometric annotation can also be extended to semantically highlight a certain area of a 3D object defining a set of vertices that create a convex shape. In each kind of annotation, the user could provide meta-data to it, including text and vocal records. Finally, we implemented a mechanism of Undo and Redo for all the 3D object manipulations and annotations. An example of spatial annotation is reported in Figure 6.

Fig. 6: Geometric annotation on the generated picture.

c) Immersive text-to-image: Having at our disposal an integration with a generative AI Text-to-Image model, we designed a UI to let all our users access it. In particular, a simple UI keyboard and text-input floating fields were defined as depicted in Figure 7a. By simply writing a prompt, users can generate any kind of painting they want. Each prompt will be always prefixed with the statement “A painting of <user_prompt>” to generate a painting, as the ones depicted in Figure 7b. The user could then manipulate the generated immersive painting and place it whenever s/he prefers over the environment, providing a unique way to express and improve both creativity and organization museum skills.

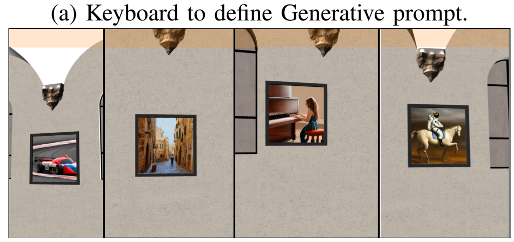
V. Experimental Settings and Results

A. Apparatus

The hardware setup used for the experiment is the following:

- A server hosting the Flask backend running Stable Diffusion instance (powered by NVIDIA Tesla V100 GPU);
- A server hosting the Node.js back-end running CreAIXR;
- One or more WebXR-compatible client devices. Considering the experimental classroom setting we adopted Desktop PCs and Smartphones.

(a) Keyboard to define Generative prompt.



(b) Generated Paintings.

Fig. 7: Generative AI Interface.

B. Participants, experimental setting and questionnaires

We recruited 41 students from the Bachelor’s Degree in Drama, Art, and Music Studies. The considered population had an average age of 23.17 ($\pm$3.78) years and was composed of 24 female and 17 male students. The number of participants is sufficient to acquire the feedback data necessary for the present analysis [25]. They tested the application and answered a pre-experience and a post-experience survey. Through the pre-experience questionnaire, we investigated participants’ experiences and familiarity with XR and immersive simulation environments. In Table I we report the pre-questionnaire submitted to the participants.

Code	Question	Answer Type
PRE1	Have you ever experienced XR or an immersive simulation environment?	Binary (0,1)
PRE2	Have you ever used an XR device (e.g., HTC-Vive, Oculus Quest)?	Binary (0,1)
PRE3	Have you ever experienced immersive content using a smartphone (e.g., Google Cardboard)?	Binary (0,1)
PRE4	Have you ever used a WebXR application before?	Binary (0,1)
PRE5	Have you ever participated in a digital simulation experience in class?	Binary (0,1)

TABLE I: Questions Items of the Pre-questionnaire.

After answering such pre-questionnaire, the class was asked to collaboratively carry out a curatorship project where the goal was to generate and organize photographs in a way they deemed aesthetically pleasant within the given immersive space (see 4, 5). Then, users answered a post-experience questionnaire, that was composed of the well-known System Usability Scale (SUS) [36] with positive (SUS+) and negative (SUS-) questions, the Technology Acceptance Model (TAM) [35] to assess their perceived comfort and XR usability. In particular, for the sake of brevity, we omitted the SUS questionnaire but the interested reader can refer to [36], whereas in Table II we draw the questionnaire TAM for

Perceived Ease of Use (PE) and TAM for Perceived Usefulness (PU), which we adapted for the objective of our experimental setting.

Code	Question	Answer Type
TAM PE1	I find it is easy to achieve my learning goals using the application. Please select the most appropriate answer:	5-point Likert scale
TAM PE2	I think the application easy to use. Please select the most appropriate answer:	5-point Likert scale
TAM PE3	The interaction with the application is simple. Please select the most appropriate answer:	5-point Likert scale
TAM PE4	It's easy for me to remember how to perform various operations when using the application. Please select the most appropriate answer:	5-point Likert scale
TAM PE5	I find the whole application easy to use for tasks relevant to the creative industry sector. Please select the most appropriate answer:	5-point Likert scale
TAM PU1	The application meets the specific needs of a user belonging to the creative industry sector. Please select the most appropriate answer:	5-point Likert scale
TAM PU2	The application allows me to address issues related to the creative industry sector more efficiently. Please select the most appropriate answer:	5-point Likert scale
TAM PU3	Using the application increases my productivity and creativity. Please select the most appropriate answer:	5-point Likert scale
TAM PU4	Using the application simplifies the process of creating a virtual museum. Please select the most appropriate answer:	5-point Likert scale
TAM PU5	I find that the whole system/application is useful in the creative industry sectors. Please select the most appropriate answer:	5-point Likert scale

TABLE II: Questions Items of the TAM PE and PU questionnaire.

C. Data analysis

The pre-questionnaire highlighted a generally low experience towards the usage of all different kinds of immersive tools, considering both fully immersive and mobile ones. Only 39.0% of our users tried an XR or a simulation environment experience before (PRE1), while only 7% and 12% have used an XR headset and experienced immersive content through smartphones respectively. Finally, 5% of the total users have experienced a WebXR application or attended a digital simulation for a class. The recruited subjects thus appeared suitable to test the usability and the technology acceptance of our platform.

Group	Cronbach's Alpha
SUS+	**0.706**
SUS−	**0.824**
TAM-PE	**0.870**
TAM-PU	**0.874**

TABLE III: Reliability of proposed survey

Considering the scales from the post-experience questionnaire, all the collected data has undergone a reliability check to test its internal consistency and validate our research. To this aim, we computed the Cronbach's alpha index [33]. The results reported in Table III report the Cronbach's Alpha for SUS+, SUS−, TAM-PE, and TAM-PU, which suggest that those items consistently measure the intended constructs ($>= 0.70$, as indicated [30]), indicating the reliability of the following analysis. We then summarized the obtained results per each construct by drawing box plots, which are visually reported in Figure 8. In particular, the SUS scale results are depicted in Figure 8a and Figure 8b showing that, despite being only in an experimental phase, the system already enjoys a fair degree of usability. However, users have uncertainty about the overall integration of all the functionalities of the system (SUS-5, see [36]). We so investigated qualitatively these results with the users, which highlighted that the main criticalities originated from the speed of the available network connection. We then analyzed the TAM-PE and TAM-PU, the results are depicted in Figure 8c and 8d. The average scores point towards 3.5 for TAM-PE questionnaire items, thus indicating that the users perceived the application as easy to use. Concerning TAM-PU outcomes (Figure 8d), users exhibited significant confidence in the usefulness of the system, even outlining some criticalities towards its applicability in all creative sectors. These findings suggest a favorable disposition toward the application's accessibility and usefulness within our users, which aligns with their intention to continue using the system.

VI. Conclusions

This paper presents CreAIXR, a platform merging WebXR with AI for creative purposes. CreAIXR provides personalized generative experiences through collaborative and immersive environments where users can enhance their creativity using deep-learning modules. CreAIXR has been assessed carrying out a user study where participants created a virtual museum with the use of generative AI in an XR experience. The findings point towards a positive attitude. Future works will adopt different generative models and a contextual UI.

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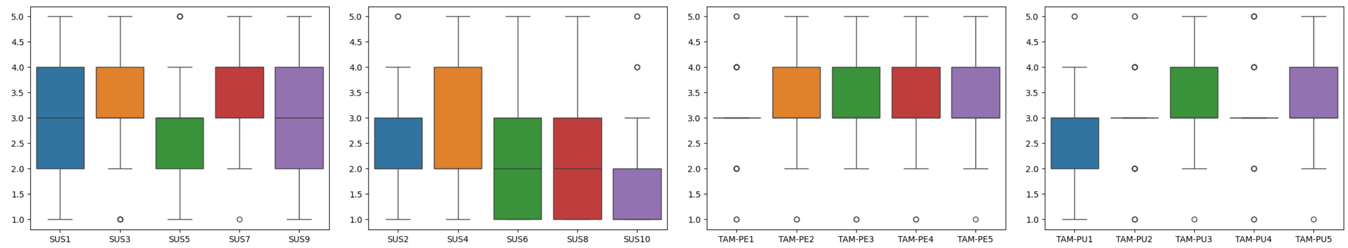

(a) SUS+ Questions boxplots. (b) SUS- Questions boxplots. (c) TAM PE boxplots. (d) TAM PU boxplots.

Fig. 8: Boxplots for all the question items included in the SUS (positive and negative) and TAM-PE and TAM-PU questionnaires.

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