XR2LEARN

D4.2 XR-APPLICATION DELIVERY PROGRAMME

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Disclaimer

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List of abbreviations

XR	Extended reality
AR	Augmented reality
MR	Mixed reality
SW	Software
SME	Small and medium-sized enterprises
NFT	Non-fungible token
IPR	Intellectual property rights
EU	European Union
KPI	Key performance indicator
KER	Key exploitable results
MRL	Market Readiness level
TRL	Technology readiness level
OC	Open call
WP	Work package
MVP	Minimum Viable Product
VAT	Valued Added Tax
FAQ	Frequently Asked Questions
ICT	Information and Communications Technology
CET	Central European Time
ESR	Evaluation Summary Report

PIC	Participant Identification Code
EC	European Commission
Partners' names and acronyms	
CNIT	CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LE TELECOMUNICAZIONI
F6S	F6S NETWORK IRELAND LIMITED
MAG	MAGGIOLI SPA
LS	LIGHT AND SHADOWS
SYN	SYNELIXIS SOLUTIONS SA
SUPSI	SCUOLA UNIVERSITARIA PROFESSIONALE DELLA SVIZZERA ITALIANA
UM	UNIVERSITEIT MAASTRICHT
HOU	HELLENIC OPEN UNIVERSITY
EADTU	EUROPEAN ASSOCIATION OF DISTANCE TEACHING UNIVERSITIES
EITM	EIT MANUFACTURING SOUTH SRL

EXECUTIVE SUMMARY

This report introduces the first open call in terms of projects and execution. The first open call (OC#1) was launched to select and fund innovative XR projects capable of enriching the XR2Learn ecosystem. This deliverable, D4.2, presents the execution process and outcomes of OC#1, detailing the selection, implementation, and evaluation of the seven funded projects, as well as the produced results.

The open call received 92 applications, from which 76 proposals passed the eligibility check. The evaluation process, conducted by external experts, assessed the projects based on concept innovation, technology, impact, and team expertise. Ultimately, seven projects were selected for funding, covering diverse applications in industrial training, occupational safety, forestry, and astronaut training.

Each sub-project progressed through three structured phases- Design, Development, and Growth- to refine concepts, implement solutions, and establish business strategies. Throughout the execution, the XR2Learn consortium provided technical and business support, facilitating reviews, distributing the funding, and aiding the sub-projects in their dissemination activities. The sub-projects demonstrated strong alignment with Industry 5.0 principles, with several achieving promising results in immersive training, AI-powered XR applications, and collaborative virtual environments.

The deliverable outlines the key technical outcomes of each project and highlights dissemination efforts, including participation in high-profile industry events and academic conferences. Additionally, it provides an overview of the Unique Value Proposition (UVP) per project. With the completion of OC#1, XR2Learn lays a solid foundation for further innovation, setting the stage for future open calls and broader adoption of XR technologies in industrial and educational contexts.

1. Introduction

The present document presents information about the execution of the first open call of XR2Learn, as part of WP4 and task T4.2 “XR application delivery”. The scope of Open Call #1 was to select 7-14 proposals to develop XR applications focusing mainly on Industry 5.0, to enrich the XR2Lean ecosystem. The design and application process of the first open call was presented in document D4.1. [1]

The projects of the first open call started in January 2024 and concluded their activities in December 2024, lasting in total 12 months. The document starts the analysis from the proposal selection process, and provides insights regarding statistics of the applications received, as well as the evaluation procedure followed to make the final selection of the projects. Additionally, it provides details regarding each of the phases of the open call and the activities undertaken under each phase. Finally, it presents the results of the first open call. Specifically, the structure of the document is the following:

- **Open Call Statistics and Evaluation:** A section that provides insights and statistics regarding the proposals submitted and the open call procedures, from the evaluation of the proposals until the final section of the sub-projects.
- **Execution of Open Call #1:** A section that describes the administrative procedures for executing the open call procedures and monitoring the progress of the projects through each phase.
    - **Design Phase:** This section describes the activities, deliverables and review process of the design phase.
    - **Development Phase:** This section describes the activities, deliverables and review process of the development phase.
    - **Growth Phase:** This section describes the activities, deliverables and review process of the growth phase.
- **Results:** This section describes the activities, deliverables and review process of the design phase. It provides an overview of the results produced per sub-project with an emphasis on the technical results and applications implemented, the dissemination events the projects participated in their duration and their Unique Value Propositions (UVP).

[1] https://xr2learn.eu/wp-content/uploads/2023/09/XR2Learn_D4.1_Open-Call-documentation-reports-and-analytics.pdf

2. Statistics and Evaluation process

2.1 Statistics on submitted proposals

The first open call opened for submissions in July 2023, closed in September 2023 and received in total 92 applications. After the closing of applications, the eligibility checks process was conducted to identify and exclude proposals that did not meet the criteria and guidelines outlined in Annex 2, *Guide for Applicants*[2], available on the XR2Learn website. As a result of this process, 14 proposals were deemed ineligible and rejected, which reflects around 15% of the total number of applications submitted.

The eligible proposals originated from legal entities established in **20 different countries**. Demonstrating the broad geographical reach of the open call. The countries with the most participants are the following:

- Spain (9)
- France (9)
- Italy (8)
- Greece (6)
- Ireland (4)
- Turkey (4)

The overall distribution of the countries is depicted in the graph below:

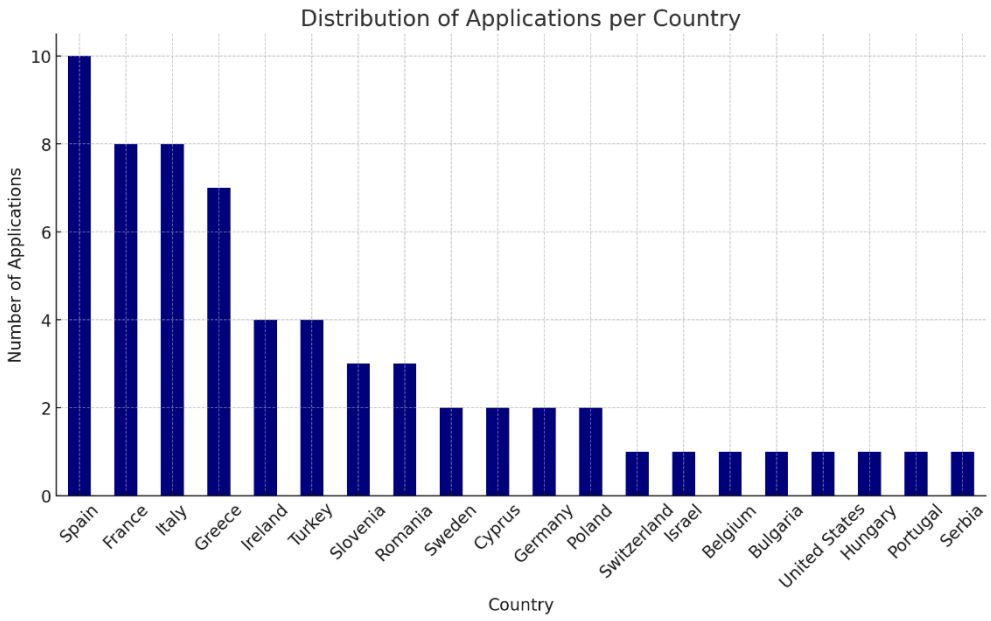

Figure 1 Distribution of applications per country

[2] https://xr2learn.eu/wp-content/uploads/2023/06/XR2Learn-Annex-2-Guide-for-Applicants.pdf

The insights on the countries from which proposals originated from, could indicate a strong interest or expertise in XR-related fields in the Southern European regions (Spain, France, Italy, Greece). The results however could also indicate stronger dissemination of the call in these regions.

Looking into the **market domain** of the applicants, the results align with the purpose and targeted audience of the call, with the majority being active in the domain of AR/VR and being under the umbrella of the technical provider. As the goal of the call is the enrichment of the XR2Learn ecosystem with technology the results prove the communication of the call to the appropriate audience and enhance the sense of clarity in the materials provided. In more detail, the top markets are outlined below:

- AR/VR (53)
- Software (46)
- Education (14)
- Manufacturing (13)
- Health/Medical (11)
- AI (10)

Regarding the **open-source** aspect, an analysis of the proposals indicates that the majority of applicants are willing to release their results as open-source. Since this was part of the evaluation criteria, the high level of commitment reflects strong alignment with the call's objectives, as illustrated in the figure below.

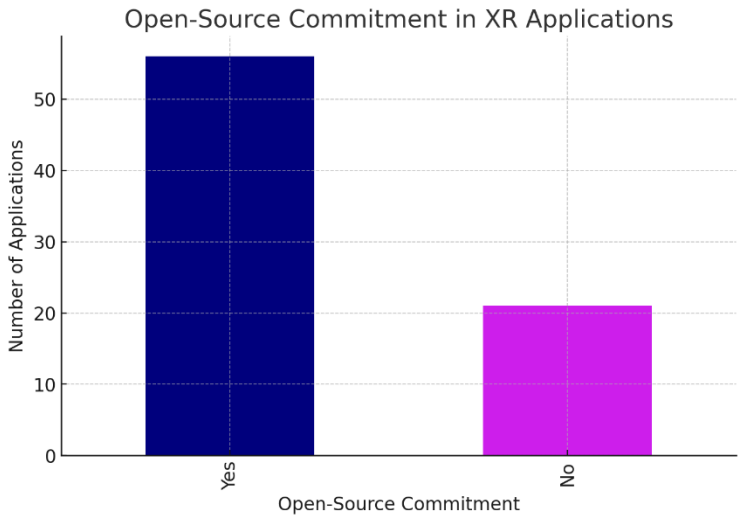

FIGURE 2 APPLICATIONS COMMITTING TO OPEN-SOURCE GRAPH

2.2 Evaluation process

After the proposal submission phase, the **evaluation process** begins. The selection of proposals followed two key procedures:

a) **Eligibility checks** – As previously described, this step ensured that proposals adhered to the call's rules. Submissions exceeding financial limits or originating from ineligible countries were disqualified.

b) **External remote evaluations** – Proposals were assessed based on four distinct criteria to facilitate the final selection process.

Open call for external experts

To facilitate the evaluation process and create a pool of experts, XR2Learn organised and executed a dedicated call. The call was published on the XR2Learn website [3] and targeted individuals with proven experience in XR technology, education and business development. The call was hosted in the F6S platform as well and concluded on October 6th, 2023. In total 38 applications were submitted.

The experts to evaluate the proposals were selected according to the following criteria:

1. There should be enough experts so that each expert should evaluate from 8 to 24 proposals (currently maximum 20 minimum 8)
2. No experts will evaluate an application that includes a legal entity located in the same country with the expert
3. The experts' gender should be ideally balanced between male and female (7 male and 7 Female)
4. The experts' affiliation should be ideally balanced between industry and education (7 EDU/Research and 7 IND/SME)
5. Having relevant expertise in AR/VR/XR, AI and Education is considered (Based on the CV if uploaded or google search)
6. Having relevant expertise in Open Call Evaluation is considered (Based on the CV if uploaded or previous collaboration)

Employing these criteria, 14 experts were selected to execute the evaluation process. The selected pool of experts demonstrated an equal gender distribution with 7 males and 7 females. From a geographical perspective, the experts originated from 9 different countries. Additionally, the types of organisations from which the experts belonged to are outlined below:

- Education (7)
- SME (3)
- Public Body (1)
- Non-Profit (1)
- Research Organisation (1)
- International Organisation (1)

The experts will also be employed in the evaluation process of the second open call.

[3] https://xr2learn.eu/open-calls/open-call-1-xr2learn-experts-expression-of-interest/

Evaluation process and statistics

The experts selected were introduced to the evaluation process via a video conference call on the 10th of October 2023 and they were called to evaluate the proposals on four main criteria, namely:

- Concept and Innovation
- Technology
- Impact
- Applicant/Entity Team

Detailed information regarding the criteria can be found in D4.1. The experts evaluated each criterion with a mark between 1 and 10. The threshold to pass each criterion is 6 and the overall threshold is 26. Proposals that received less than 26 as the overall score or less than 6 in one of the criteria were automatically rejected. Each proposal was assigned to two experts. The experts first evaluated the proposals individually and afterwards communicated and provided a single Evaluation Summary Report (ESR). The evaluations were completed on the 6th of December 2023. According to the ESRs received we can assess the quality of the proposals received.

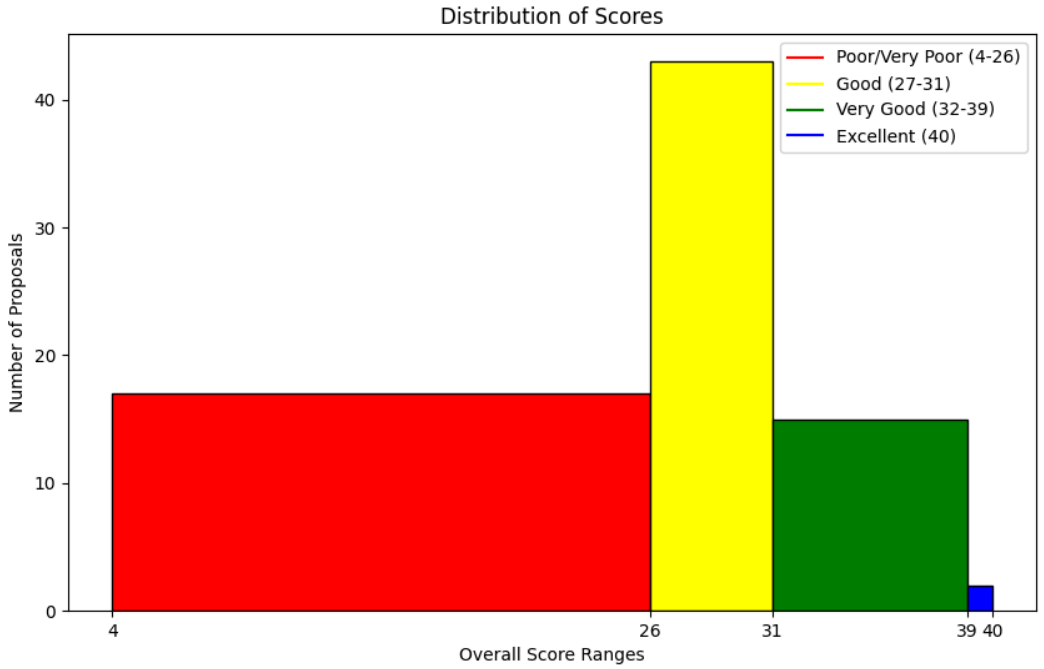

FIGURE 3 PROPOSALS SCORES DISTRIBUTION GRAPH

The above figure displays the distribution of the overall score of the proposals. It is verified that the majority of the proposals received scores above the threshold of acceptance (26). Specifically:

- 67.10% (51 out of the 76 evaluated) of the proposals were above 26 as the overall score which is considered as good quality.
- 15.78% (12 out of the 76) of the proposals were 32 and above, which is considered a very good quality.
- 3.94% (3 out of the 76) of the proposals were above 36, which is considered almost excellent to excellent quality.
- The mean values and average for the overall scores and individual criteria are depicted in the table below along with detailed information about the distribution.

Table 1 Quality of the received proposals

	Overall	Concept and Innovation	Technology	Impact	Applicant Entity/Team
Mean Score	28	7	7	7	8
Average Score	28,065	6,657	6,657	7,026	7,5
Fail/Poor/Very Poor	17	11	9	8	7
Good	45	41	52	43	29
Very Good	13	22	13	22	34
Excellent	1	2	2	3	6

These results reflect the overall high-quality of the proposals received.

2.3 Selection and contract signature

Following the receival of the ESR reports, the final ranking of the proposals was initialised taking into consideration the available funding (€2.100.000), the scores, and the alignment of the projects to the industry 5.0, as a minimum 70% of the budget (€1.470.00) should be allocated for such projects. The projects were ranked according to a predefined set of rules and procedures that has been described in D4.1. Following the completion of the ranking process, seven projects were selected to be funded. The proposal coordinators were informed about the results on the 6th of December 2023, receiving a letter of acceptance or rejection together with an anonymised version of the ESR.

2.3.1 Selected sub-projects and statistics

The selected projects are displayed in the following table.

Table 2 Open Call #1 accepted projects

Project Acronym	Title	Country of coordinator	Partners
PROXIMA	Proximity Machinery through Distributed Augmented Reality HMI Layers for Empowering Industrial operators in Low Resources Scenarios	Italy	1. BSD SOCIETA A RESPONSABILITA' LIMITATA 2. ALMA MATER STUDIORUM – UNIVERSITA' DI BOLOGNA 3. PROTESA S.P.A.
EVR-OSH-5	VR-based Education of Occupational Safety and Health for the era of Industry 5	Hungary	1. Zengo Kereskedelmi és Szolgáltató Korlátolt Felelősségű Társaság 2. "TOPSAFE" Munkavédelmi és Üzemi Higiéniai Eszközöket Forgalmazó Kereskedelmi és Szolgáltató Korlátolt Felelősségű Társaság
CARATE	Collaborative Augmented Reality Astronaut Training Experience	Ireland	1. WEKIT Experience Capturing Solutions Limited 2. Aerospace Logistics Technology Engineering Company
XR4HRC	Excellence in Extended Reality for Human-Robot Collaboration	Turkey	1. Lider Teknoloji Gelistirme Muhendislik Taahhut Sanayi ve Ticaret Limited Sirketi 2. Eskisehir Osmangazi University 3. BEST Institut für berufsbezogene Weiterbildung und Personaltraining GmbH
PaperXR	PAper Printing workErtRaining using eXtended Reality	Bulgaria	1. NEXUSIT Ltd. 2. D. Panagiotopoulos & Co GP - Future Format 3. UPAT - Special Account for Research Grants

XR2IND	XR technologies to empower immersive industrial 5.0 training	Cyprus	1. INNOV-ACTS LIMITED 2. OTE Academy
X-Alfy	eXtended reality for Awareness and Learning in Forestry 5.0	Germany	1. Venaka TreLeaf GbR 2. Technical University of Zvolen

Additionally, Figure 4 displays an infographic with more statistics and insights related to the projects accepted:

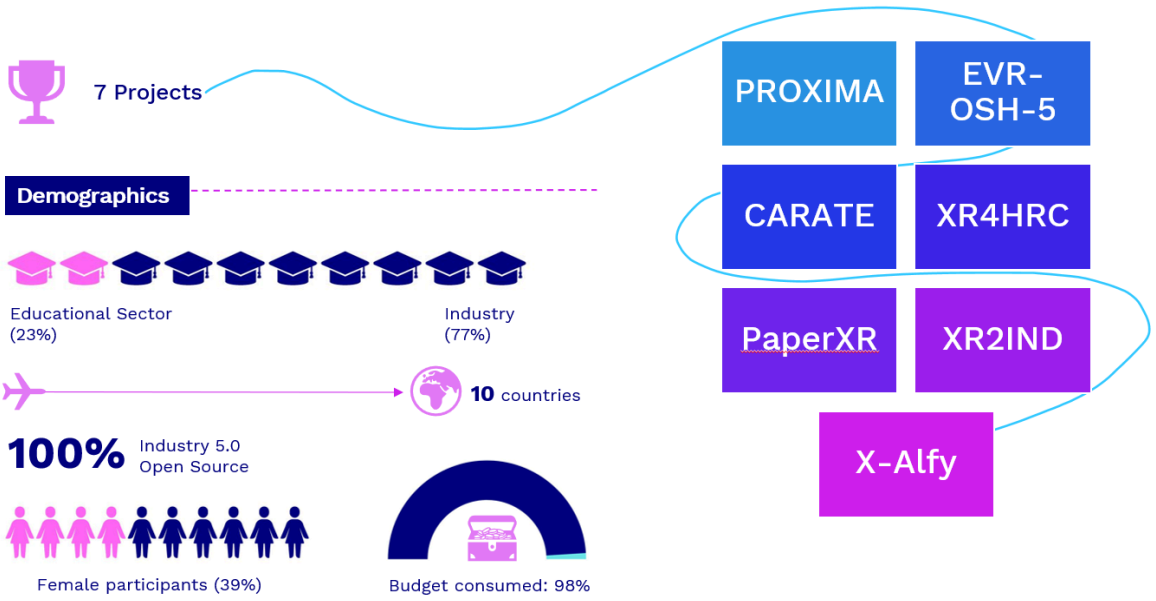

FIGURE 4 ACCEPTED PROJECTS INFOGRAPHIC

The selected projects represent a diverse and international collaboration, with participants originating from ten different countries. Among the 17 unique participants, 10 entities are SMEs, emphasizing the strong presence of small and medium-sized enterprises in the initiative.

A noteworthy aspect is the gender representation, with 39% female participants, indicating progress toward a more balanced inclusion of women in the field.

The participating legal entities primarily belong to the industrial sector (77%), reflecting a strong focus on real-world applications of XR technologies. However, the educational sector (23%) is also represented, ensuring that expertise from academia contributes to innovation.

Additionally, all selected projects align with Industry 5.0 principles and commit to 100% open-source development, fostering transparency, collaboration, and accessibility within the XR ecosystem.

2.3.2 Contract Preparation

The XR2Learn coordinator informed the EU of the results and prepared the sub-projects contracts for the accepted projects. The items covered under the contracts were:

- To address the comments (if any) in the Evaluation Summary Report of the proposals, especially potential Ethical issues.
- To validate the status information, at least the following documents will be required for all applicants/ consortium members of each sub-project:
    - Legal existence of all applicants.
    - Financial Stability of all SMEs.
    - In cases where the number of employees and/or the ownership of an SME is not clearly identified: any other supporting documents which demonstrate headcount and ownership such as payroll details, annual reports, national regional association records, etc.
- To provide the sub-project coordinator Bank account information.

At the contract preparation each SME provided a valid VAT.

The contract signature process was successfully completed, and the accepted sub-projects started their activities on the 1st of January 2024.

3. EXECUTION OF OPEN CALL #1

The present. The accepted sub-projects kicked off their activities on the 1st of January 2024, with a planned duration until the 31st of January 2024. The 12 months of activity are distributed in three different phases, with different goals, designed to guide and support the applicants in the successful delivery of the XR applications. Specifically, the sub-phases are the following:

- Design phase: The sub-projects design their solutions and plan their activities
- Development phase: The sub-projects implement their solutions
- Growth phase: The sub-projects develop their business plan and their sustainability

The execution for each of the sub-phases will be analysed in the following sub-sections.

FIGURE 5 OPEN CALL #1 PHASES

3.1 DESIGN Phase

The design phase started in January 2024 and concluded on the 31st of March 2024, with a total duration of 3 months. In this phase, the projects were called to:

- clarify the details of their application
- elaborate on their plans in the technical solution as well as the business parameters
- provide a detailed description of their design and architecture
- assess the potential impact in the XR2Learn related domains and Europe

3.1.1 Activities and support provided

Throughout this phase, the XR2Learn partners provided continuous support to the projects through phone/remote calls and via email, with technical partners playing a key role in guiding the development.

In March 2024, the projects participated in the XR2Learn consortium plenary meeting in Paris. During this meeting, the projects had the opportunity to introduce themselves, attend presentations from the XR2Learn partners, showcasing the technical and business offerings. For example, a presentation of the XR2Learn platform, which sparked discussions and enhanced the sub-projects' understanding of the technology, facilitating their smooth onboarding. The projects attended the "*Ecosystem and business model workshop*" hosted by EITM, which steered the discussions towards the business aspects of the projects' solutions. Finally, projects received hands-on tutorials on XR2Learn enablers and engaged in one-on-one meetings with XR2Learn technical partners, allowing them to finalize the technical aspects of their designs with direct expert guidance.

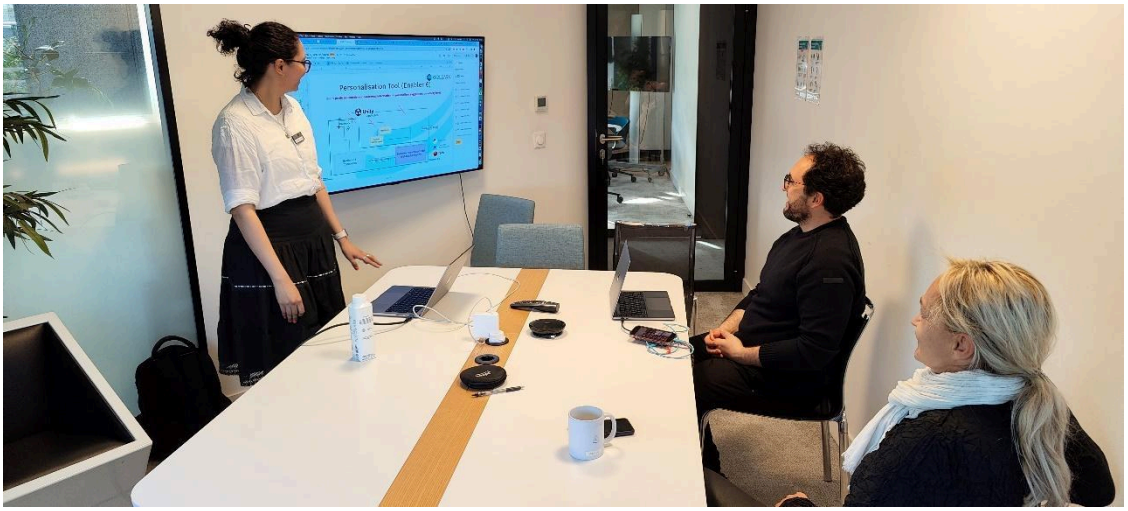

FIGURE 6 TECHNICAL MEETING WITH XR2LEARN PARTNER IN PARIS

3.1.2 Deliverables

The DESIGN phase is considered to conclude with the successful delivery of the D1 deliverable "Detailed XR Tools – Application Design". The deliverable covers the following aspects:

a) Motivation and technological background of the proposed XR Application

b) XR Application to Educational scenarios

c) Detailed design of the proposed XR Application

d) Economic/business impact potential

To streamline the report submission process, a shared Google Drive was set up, providing each project with a dedicated subfolder for secure and organized access. This platform was officially designated as the primary submission channel for deliverables within the XR2Learn sub-projects consortiums.

All sub-projects successfully submitted Report D1 at least five days before the deadline and therefore the review process could proceed.

3.1.3 Review and payment

The first review of the open call projects was organised on March 3rd, 2024. Two reviewers were selected from the "pool of experts" and were given access to the deliverables prior to the review meeting. Additionally, a partner from the consortium was present to moderate the meeting, specifically SYN. Each project prepared a 30-minute presentation with time allocated for discussion with the reviewers. Following these evaluations, all projects were confirmed to have successfully completed the DESIGN Phase, with their D1 deliverables formally accepted.

Upon acceptance of the reports and the successful completion of the phase, the projects submitted a financial statement to the XR2Learn coordinator, formally requesting 30% of the total sub-project funding. The requested funds were then disbursed to the sub-project coordinators as a lump sum.

3.2 DEVELOP Phase

The DEVELOP Phase commenced in April 2024, and lasted until October 2024, with a total duration of 7 months. This phase was highly technical, with a strong emphasis on the development and implementation of each project's prototype.

During this period, projects were expected to complete the technical implementation of their proposed applications, as outlined in the DESIGN Phase. A key requirement was to achieve a Technology Readiness Level (TRL) above 6 and a Manufacturing Readiness Level (MRL) of at least 3, ensuring that the developed solutions were both technologically mature and viable for further scaling and integration

3.2.1 Activities and support provided

Support from XR2Learn partners continued throughout the DEVELOP Phase, ensuring that projects received the necessary technical and operational guidance. Assistance was provided primarily via email and phone calls, with WP3 technical partners offering support related to the XR2Learn enablers and WP2 partners addressing queries concerning the platform and marketplace.

Two of the XR2Learn projects participated in the first review meeting of the XR2Learn project in July in Brussels, namely CARATE and PROXIMA. There they presented an overview of their progress, shared preliminary technical results, and provided insights into the support received from XR2Learn partners up to that point.

3.2.2 Deliverables

This phase included three deliverables, specifically:

- **D2 – XR Tools/Application MVP Documentation:** The deliverable should provide details regarding the XR Tools and Applications developed, as well as the implantation approach and provided functionalities. Additionally, it should include detailed analysis and screenshots demonstrating the developed software. As all the projects committed to providing their applications as open-source, the deliverable should include the code as an attachment or uploaded in a public repository under appropriate license.
- **D3 – Test and Validation:** This report should provide detailed information about the system prototype, the methods for validating and testing as well as the results of the validation. It should also investigate in a dedicated section the

impact potential, the exploitation plan and overall business considerations of the application.

- **D4 – Project Video:** A video with a duration of 5-10 minutes that showcases the project team, the IoT application and the results.

Deliverable D2 was delivered by the sub-projects in September 2024, in the dedicated shared drive as described in the previous section. Deliverables D3 and D4 were delivered in October 2024, in the same location. Regarding D4 – Project Video, as the projects had already prepared introductory videos for the dissemination activities of the project that had already been published, they were allowed to prepare more dedicated videos and therefore have a shorter duration. All the videos delivered by the sub-projects are published in the YouTube channel of XR2Learn (***https://youtube.com/playlist?list=PLEQ16mGm1uxdvGH_EAo9rOq49Hv-6Gfhq&si=AGI9XFiDnjyYQCrV***)

3.2.3 Review and payment

The review of the DEVELOP phase took place on November 5th, 2024, moderated by a representative of SYN from the XR2Learn consortium, and two external experts from the pool created during the evaluation of the proposals. Each project had an hour to present the materials and discuss the comments or questions from the reviewers. Specifically, the review included a short presentation (10-15 minutes), a detailed demonstration of the software developed (25-30 minutes) and 15-20 minutes allocated for questions and answers. All deliverables were accepted by the reviewers, except for deliverable D3 by the EVR-OSH-5 project. As extracted from the review report:

The validation part is mainly dedicated to technical validation with a test set, with scarce and insufficient information on the testing with users including quantitative/qualitative results

The reviewers suggested the following actions:

The tool has been developed and shown in the review, but it is missing the learning aspect of the project, which is the base of XR2Learn. This part is weak and the explanations given in the review indicated that this objective has not been achieved. It is recommended that proper testing with users is carried out in the coming weeks, with proper design and scientific base. Results should be obtained and D3 should be improved, and it will be evaluated again.

EVR-OSH-5 resubmitted the deliverable in the proposed timeline and the acceptance or rejection is investigated in the GROWTH phase review.

Following the review results, the projects provided the F2 financial statements requesting 50% of the funding, except for EVR-OSH-5 which would not be compensated for deliverable D3 which was rejected, and the requested funding was reduced accordingly. The XR2Learn coordinator released the relevant payments.

3.3 GROWTH Phase

The GROWTH phase started in November 2024 and lasted until the end of the projects' duration in December 2024, for a total of 2 months. The goal of this phase was the finalization of the sub-projects with a focus on the future business aspects on how their solutions are going to be exploited and sustained. During this phase the projects focused on participating in physical meetings with potential investors and finalizing their business plans.

3.3.1 Activities and support provided

The support from the XR2Learn consortium continued, with a focus on the business aspects. The open call projects received support via email and phone call from the XR2Learn business partners, such as EITM and EADTU.

The sub-projects were invited to join the XR2Learn consortium in the AWE XR EU Exhibition in Vienna. The exhibition took place on the 28th-30th of October 2024. In the exhibition all the sub-projects participated, showcasing their solutions in the XR2Learn booth. The expenses for the booth were covered by the XR2Learn consortium budget and no financial contribution was requested by the OC1 projects.

Figure 7 XR2Learn booth in AWE Exhibition

3.3.2 Deliverables

This phase consisted of a last deliverable, specifically, D5 "Exploitation and Sustainability". The reports should include information about the dissemination, exploitation and commercialization activities, and assess the potential for sustainability. The deliverable was submitted by all the projects in the proposed timeline, at least 5 working days prior to the submission deadline.

3.3.3 Review and payment

The review took place on the 8th of January 2025, moderated by a representative from SYN, and performed by two reviewers from the pool of experts.

The review was expected to last for 30 minutes per sub-project, where each consortium should make a short presentation of the sub-project (10-15 minutes), keeping 10-15 minutes for questions and answers.

The following projects successfully completed the review process with all the deliverables accepted:

- CARATE
- PaperXR
- PROXIMA
- X-Alfy
- XR2IND
- XR4HRC

For the EVR-OSH-5 project, the reviewers rejected D3 (which was re-submitted) and D5. After the resubmission of the deliverables in the proposed timeline, the review was facilitated again on the 24th of January 2025 for the EVR-OSH-5 where the external reviewers accepted both deliverables and the project was successfully concluded.

The projects requested for the remaining of the funding via financial statements, which was successfully released via lump sum.

4. Results

The present section reports the results achieved by the sub-projects during their execution, as reported in the respective deliverables submitted to the XR2Learn project. Some of the technical results of the projects outlined in this section, are available via the XR2Learn platform.

4.1 CARATE

The CARATE software features an XR Tool Application based on the MirageXR software. It is a collaborative augmented reality astronaut training platform that integrates XR (Extended Reality) learning, gamification, and enterprise interoperability. It is designed to enhance astronaut training by improving real-time collaboration, digital twins, AI-driven instruction, and compatibility with learning management systems (LMS).

4.1.1 Technical Results

CARATE aims to develop a market-ready MVP, advancing technology readiness levels (TRLs) from 3 and 4 to 6 for three key technical project outcomes:

(1) XR real-time collaboration for co-design and for learning,

(2) XR gamification for learning

(3) XR enterprise interoperability with Learning Management Systems.

These key technical outcomes are achieved through a set of features that have been developed in the CARATE project and are presented below.

1. XR Real-time Collaboration for Co-design and Learning

Collaboration tools that allow users to work together in real-time virtual environments with an avatar-based telepresence employing the ReadyPlayer.me avatars with voice synchronization. Users can initiate and join training sessions securely. AR content is available for both in-person and remote participants.

Real-time scanned 3D models of training environments enhance remote learning.

AI-powered Virtual Instructors simulate trainer guidance.

2. XR Gamification for Learning

Engaging XR instruction for self-paced astronaut learning with step-by-step guidance for new users and training processes. The software features UI improvements, gesture-based interactions, and enhanced 3D visualization. The learner's progress is monitored using xAPI and integrating with Moodle.

3. XR Enterprise Interoperability with Learning Management Systems

A real-time Learning eXperience Repository (LxR) enables seamless content creation, storage, and distribution. The XR content can be linked with Moodle courses and competency frameworks. The system features a Single Sign-On (SSO) for secure authentication across learning systems. It supports real-time voice, data exchange, and collaboration.

4. Apple Vision Pro Support

The application supports gesture-based controls and spatial computing in Apple Vision Pro, with upgraded shaders and UI rendering for enhanced realism.

6. 3D Assets & Digital Twins

A library of reusable 3D models, including astronaut tools and equipment.

A high-resolution scan of the ISS Columbus Module for immersive AR experiences.

Educational Scenarios supported

CARATE is designed to support three primary astronaut training scenarios:

- Development of Procedures & Training Materials (collaborative authoring of AR content).
- Crew Training with Real-time Instructor Support (interactive training with live instructor feedback).
- Crew Training and Operation without Real-time Support (self-guided, AI-assisted training in space).

FIGURE 8 CARATE - CREW INSTRUCTOR

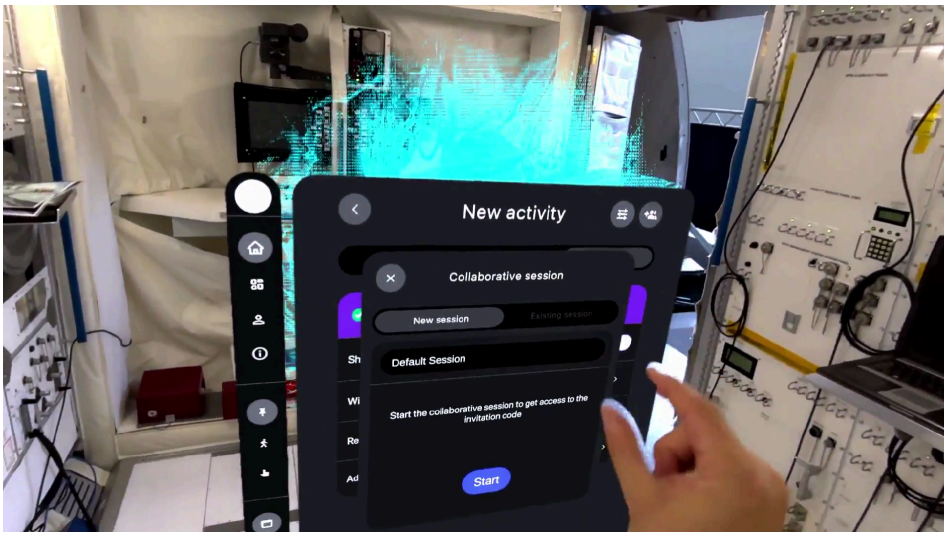

FIGURE 9 CARATE – COLLABORATIVE SESSION DASHBOARD

4.1.2 Dissemination and UVP

Events attended

Space Tech Expo Europe

CARATE exhibited their solution at SpaceTech in Bremen, which was attended by 9100+ attendees and 739 exhibitors. Over the course of three days, they made a total of 95 documented contacts, of which we classified about 24 as real leads with follow up. They subsequently have set up a Trello CRM board with which we track interaction with these contacts. This also included high-level talks with the Irish Space Agency, the UK space agency, UAE space agency, and DLR.

AWE Europe

It took place in Vienna from October 29-30, 2024. AWE was attended by 140 speakers, 120+ exhibitors and nearly 2000 attendees. CARATE project gave many presentations over the course of the two days, making 26 documented contacts, resulting in six they considered to be leads (including one investor).

UVP

CARATE is an advanced XR platform delivering tailored training, real-time guidance, and expert support for space missions, enhancing procedural accuracy, operational efficiency , and safety through adaptable content, data-driven insights, and cross-device compatibility.

Its key features and their specific value proposition are:

1. Collaboration and Telepresence

- Application: CARATE's collaboration facility enhances real-time co-design and learning through virtual telepresence features, enabling users to collaborate seamlessly in the Metaverse

- Value: Reduces time and cost in bringing together the team involved in knowledge exchange from across the globe, providing an engaging, spatially grounded medium.

2. In-Situ Authoring:

- Application: Allows experts to create training modules tailored to real-world space environments, such as spacecraft maintenance or habitat assembly on lunar or Mars missions.
- Value: Reduces time and cost for developing training content while ensuring accuracy and adaptability to evolving mission scenarios.

3. Step-by-Step XR Guidance:

- Application: Provides hands-free, visual instructions directly in astronauts' fields of view, aiding complex procedures like equipment repairs or scientific experiments in microgravity.
- Value: Increases procedural accuracy, reduces cognitive strain, and ensures mission-critical tasks are executed flawlessly.

4. Real-Time Expert Support:

- Application: Enables live communication and guidance through holographic overlays, essential for missions where communication delays with Earth are unavoidable.
- Value: Reduces mission risks, supports autonomous decision-making, and enhances operational confidence during extended missions.

5. AI-enabled virtual instructors:

- Application: Supplement procedures with AIs where human experts are not available or their deployment is not deemed efficient.
- Value: Improve learning outcomes with tailored, conversational content. Instant feedback.

6. Data Analytics and Insights:

- Application: Monitors performance during training and missions, providing insights to refine processes and address gaps in knowledge or skills.
- Value: Builds a data-driven approach to continuous improvement and enhances readiness for future missions.

7. Cross-Device Compatibility:

- Application: Seamlessly integrates with various XR devices for space applications, such as headsets designed for microgravity or confined environments.
- Value: Offers flexibility and scalability for training and operational use across space programs.

8. Regulatory Compliance Training:

- Application: Standardizes space mission training protocols, ensuring safety and operational guidelines adherence.
- Value: Minimizes risks and enhances safety in highly regulated and unforgiving space environments.

9. Secure Metaverse-level Server Infrastructure

- Application: Secure client-server architecture enables real-time data exchange and AI use.
- Value: Facilitates scalability to organisation-wide, supports execution of system-spanning tasks through enterprise interoperability with existing (legacy) system landscape.

4.2 EVR-OSH-5

EVR-OSH-5 is about testing the knowledge and preparedness of employees related to work safety protocols and working hazards. For this, the consortium developed two standalone VR applications (ProtFall and SafeRob) and a Windows tool, completed with a stress detection workflow.

4.2.1 Technical Results

1. Immersive VR Training Environments for OSH

The delivered VR applications (ProtFall and SafeRob) create realistic, scenario-based training environments.

- **ProtFall** simulates work-at-height situations, where users learn to navigate, select and use safety equipment, and execute repair procedures within a virtual representation of a storage building rooftop.
- **SafeRob** provides a collaborative simulation for robot system maintenance, enabling multiple users to work together on troubleshooting and repair tasks in a shared virtual space.

These environments utilize fixed teleportation, climbing mechanics, and interactive hotspots to mimic real-world movement and decision-making.

2. Real-time Stress Detection and Adaptive Responses

A dedicated stress detection workflow (VRStressD) is integrated into the VR applications. Using biosensor data (e.g., from a Polar H10), the system monitors physiological stress indicators such as heart rate variability and adjusts the training environment accordingly. When stress levels reach critical thresholds, the system triggers adaptive responses such as displaying reassuring messages, initiating breathing techniques, and modifying audio-visual feedback to help users regain calm and focus.

3. Multiplayer Collaboration and Interactive Maintenance Simulations

The VR applications incorporate multiplayer functionality via Photon PUN, allowing real-time collaboration between users. In the SafeRob scenario, for example, two roles, Mechanic and Electrician, work together to diagnose and repair issues in a simulated industrial environment, following step-by-step safety protocols. This collaborative feature enables live interaction, coordinated actions, and mutual problem-solving, enhancing the realism and effectiveness of the training.

4. Comprehensive OSH Training Modules

The training content is structured into detailed modules that cover critical aspects of OSH, including equipment selection, proper use of safety gear, hazard recognition, and emergency response procedures. Each module is designed to provide step-by-step guidance, ensuring that users can practice and internalize the correct procedures in a risk-free virtual setting.

5. Windows Tool for VR Session Observation (ObserVR)

The ObserVR tool complements the VR applications by offering real-time monitoring and reporting capabilities on a Windows platform. It supports the management of up to 10 VR headsets simultaneously, allowing instructors to switch dynamically between connected devices, view live screens, capture screenshots, and generate session-specific reports. This tool enhances the overall training process by facilitating detailed analysis and feedback.

6. 3D Assets & Scenario-Specific Content

A curated library of 3D models and digital assets has been developed, including realistic safety equipment, tools, and environmental elements. Digital replicas of industrial settings and work environments are integrated into the VR scenarios, significantly enhancing immersive experience and providing users with a realistic context for OSH training.

Educational Scenarios supported

EVR-OSH-5 is designed to support a variety of training scenarios, including:

- **Work-at-Height Safety Training (ProtFall):** Collaborative authoring of procedures for safe ascent, equipment utilization, and emergency descent.

• **Robot System Maintenance (SafeRob):** Interactive simulations for troubleshooting and repairing industrial robotic systems, with live collaboration between different roles.
• **Real-Time OSH Monitoring and Reporting (ObserVR):** A Windows-based solution that enables instructors to observe, evaluate, and report on VR training sessions in real time.

Figure 10 EVR-OSH-5 - Inventory dashboard

Figure 11 EVR-OSH-5 – Application environment

4.2.2 Dissemination and UVP

Events attended

Industry Days

They attended the "Industry Days" exhibition in Budapest from 7-10 May. The primary aim of the exhibition was networking. Companies interested mainly in the automotive sector were present. They assessed the potential demand for VR training materials. As the Hungarian distributor of the manufacturer UVEX, they were also involved in the trade presentation, which gave them a greater opportunity to engage with visitors.

ExpoProtection

They participated in the "Expo Protection" exhibition in Paris from 3-5 November (Expoprotection: Risk Prevention and Management). They attended the exhibition with a product ready for testing. Here the primary target was the manufacturers of protective equipment. They continued the contacts they had made earlier in the year, when they had the opportunity to meet in person. Here they presented the VR goggles, the objectives and explained how they could 13 get involved and participate in the finished project. They told them how they could benefit and what business opportunities they could expect.

AWE XR Exhibition

The consortium participated in the AWE exhibition in Vienna on 29-30 October. There they had the opportunity to exhibit at the joint XR2learn stand and present their development results to the visitors of the event. During the event, they had the chance to learn about XR-related updates, try out new tools and listen to valuable presentations. At the joint XR2learn booth, they also presented Protfall, SafeRob (both scanners) and ObserVR to the public. Among the exhibitors, their project was represented with its solution for standalone VR. The testers of the application were satisfied with the results of the development.

UVP

This project is designed primarily for workers while supporting occupational safety professionals (HSE managers) in their challenge to deliver effective, recurring training without resorting to a monotonous recitation of technical texts. Instead, it integrates adaptive, interactive VR-based training into daily routines, enabling workers to practice safety protocols through realistic simulations of common workplace hazards, interactive decision points, and error scenarios. By improving situational awareness and fostering proper decision-making when risks arise, the system enhances worker preparedness and safety culture, resulting in fewer accidents and lost workdays. Additionally, features like stress detection allow the software to adapt to individual emotional states and provide valuable insights for KPI assessments, addressing generational differences in technology adoption and ultimately preventing accidents across industries such as automotive, construction, and logistics.

4.3 Paper XR

The PaperXR project focuses on the development of advanced XR tools and applications to revolutionize workforce training in the printing industry. These tools provide an immersive, interactive environment allowing workers to train in virtual spaces replicating real-world scenarios. The objective of these tools is to create a training platform that is engaging and precise in its ability to simulate the operation, maintenance, and troubleshooting of complex printing machinery. Using XR technologies such as Virtual Reality (VR) PaperXR offers an innovative approach to learning that goes beyond traditional training methods, providing hands-on experience without the need for physical equipment or real-world risks.

4.3.1 Technical Results

The functionality of the PaperXR VR application is centered around providing an immersive, interactive experience for simulating and customizing printing manufacturing processes. Key features include natural object manipulation, where users can grab, push, pull, and interact with virtual components using VR controllers, enabled by the INTERACT plugin. The system ensures precise collision detection, allowing for accurate handling of industrial models with both convex and concave parts, regardless of their complexity or polygon count. Additionally, users can adjust parameters like gap clearance, friction, and compliance, which impact how virtual objects fit, move, and interact within the environment. Customization of the manufacturing steps is a major functionality. Users can tailor the scenario either through the VR interface using direct interaction or via an external JSON file, which provides flexible, file-based configuration. The scenario also includes dynamic written instructions on panels and audio guidance, which update with each process step.

Detailed analysis of the software provided:

- **3D Modelling:**
    - Use of the Creo Part parametric design platform to model the individual parts that constitute each machine component.
    - Use of Creo Assembly to piece together the individual components into a cohesive model of the printing machine. This platform was especially valuable for assembling both the fixed and movable parts, ensuring their proper interaction and alignment.
    - The 3D part modelling module where each component of the printing machine was designed using parametric techniques in Creo Part. This module emphasized defining accurate geometric properties and maintaining the integrity of each part's size, shape, and functional constraints.
    - The 3D assembly module was responsible for bringing the individual parts together in Creo Assembly.

- The 3D animation and simulation module that was developed to manage the machine's dynamic elements. This module integrated the moving parts and ensured that the simulations replicated real-world operations, with animations reflecting the machinery's actual movement and behaviour.
- The LOD optimization module was specifically designed to reduce the computational load of the 3D models.
- The quality control module focused on verifying that the 3D models met all the necessary standards for accuracy and functionality.

- **VR Application:**
  - User interaction module: designed to enhance the user experience by facilitating seamless engagement with the virtual environment through VR controllers. This module enables natural and intuitive interactions, allowing users to manipulate virtual objects as they would in the real world. Key functionalities include the ability to grab, push, and pull various components of the printing machine, providing trainees with a hands-on experience that closely mirrors actual operational tasks. Additionally, the User Interaction Module features accurate collision detection with industrial models, ensuring that all interactions are precise and responsive.
  - Customization module: designed to empower users by enabling them to input specific values for various manufacturing scenarios. This functionality allows for real-time adjustments made through the VR interface of the scenario builder, giving users the flexibility to tailor their training experiences dynamically
  - Instruction Display module: plays a vital role in guiding users throughout the manufacturing process by providing clear and accessible instructions. Written instructions are displayed on panels that remain visible until the next step is initiated, ensuring that users can follow the training material without losing their place.
  - Graphics and Visualization module: essential for managing the visual presentation within the PaperXR application, ensuring a high-quality user experience. This module integrates 3D models converted from. STEP to .FBX formats, allowing for detailed and realistic representations of the printing machinery.
  - Data Management module: fundamental in overseeing configuration data and user inputs within the PaperXR application. It efficiently loads and parses JSON configuration files at runtime, ensuring that all necessary data is readily accessible for smooth operation.

Educational Scenarios supported

- **Scenario 1** refers to the printing machine preparation and setup. The first scenario focuses on the crucial tasks in transitioning the printing machine from dormancy to full operational readiness. Trainees are introduced to the Man Roland 700 4-color sheet-fed offset printing machine, engaging in hands-on tasks that mirror real-world preparation for a print job.

- **Scenario 2** refers to the quality control. The second scenario focuses on developing trainees' skills in print quality control, a vital aspect of the printing process. This scenario emphasizes the importance of monitoring and ensuring colour accuracy and consistency during a print run using the Spectator Drive, a tool integrated into the virtual environment. Trainees will actively engage with this tool to continuously monitor colour values, learning how to interpret readings and compare them against client- specified colour profiles.

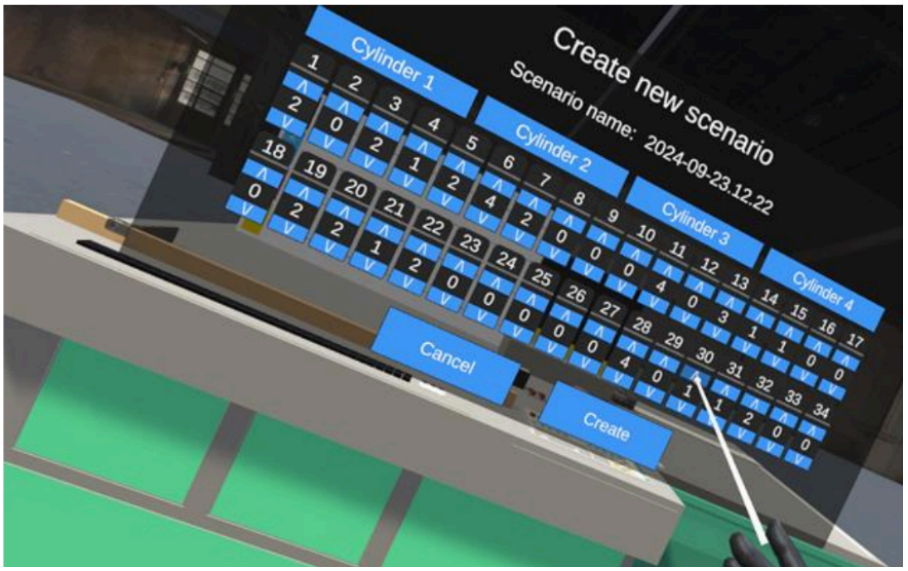

Figure 12 PaperXR - Creating a scenario

FIGURE 13 PAPERXR - ENVIRONMENT

4.3.2 Dissemination and UVP

Events attended

ALGOCLOUD 2024

NEXUS and UPAT partners of PaperXR co-authored and presented a scientific publication at the ALGOCLOUD 2024 symposium, part of the prestigious ALGO 2024 conference, held in Egham, UK, from September 2-6, 2024. The paper, titled "Edge-based Federated Learning Methods for Remaining Useful Life Estimation in IIoT" (D. Amaxilatis, S. Papachristofilou, and C. Zaroliagis), was included in the Lecture Notes in Computer Science series (Springer, Vol. 15455, 2024, to appear).

AWE EU 2024

They participated in the AWE (Augmented World Expo) EU 2024, held on October 29-30, 2024, in Vienna, Austria. Alongside they showcased a live demonstration of the XR application tailored for the printing industry. This hands-on exhibit highlighted the transformative potential of XR technologies in industrial training and operations. AWE EU 2024 attracted over 2000 participants, providing an unparalleled opportunity to engage with industry leaders, innovators, and stakeholders, further amplifying the project's visibility and impact.

Athens Art Book Fair 2024

Engaged independent publishers and artists, demonstrating how XR technologies can enhance traditional publishing methods.

Frankfurt Book Fair 2024

Highlighted immersive content applications to global publishers, opening discussions for pilot projects and licensing opportunities.

Paris Photo 2024

Presented XR innovations to photographers and curators, showcasing potential in visual arts and experiential storytelling.

Thessaloniki Book Fair 2024

Connected with regional publishers and cultural institutions, exploring localized applications for PaperXR in heritage and education.

UVP

PaperXR solution helps businesses and organizations improve training efficiency by lowering operational costs, while enhancing knowledge retention and user engagement.

PaperXR revolutionizes workforce training by providing an immersive, risk-free XR platform that bridges the gap between theory and hands-on expertise, enabling workers to master complex machinery with confidence.

The solution minimizes operational costs, reduces resource waste, and enhances safety while seamlessly integrating into existing training systems, ensuring scalability across diverse industries. As a future-proof and eco-friendly innovation, PaperXR empowers industries to achieve efficiency, sustainability, and workforce excellence in an increasingly digital world.

4.4 PROXIMA

The PROXIMA Project proposes the Mixed Reality Training Kit with the name of XTENDIT, whose reference is on ‘extended’ and mixed nature of reality, and whose vision addresses the continuity of experience among physical, virtual and digital realms, by implementing an iterative and incremental exchange among the different realities.

4.4.1 Technical Results

FIGURE 14 PROXIMA – ECOSYSTEM GRAPH

The XTENDIT Training Kit components are the following:

- Head mount camera (CAMG): Camera system mounted on eyeglass frame for video recording. Several full HD models are available. Supports video recording, power on/off.
- Platform Authoring & Repository (PPLAT): PROXIMA Platform is a web application for training authoring that manages notes and markers. It serves both to configure the path on a line and to handle the JSON files exchanged with the PROXIMA system apps to create or obtain content. The PROXIMA technician uses it to calibrate the position of markers on the line.
- PROXIMA APP Technician Version (PAPPT): PROXIMA APP Technician Version (Standalone App not published on app stores). Version intended for configuration of the experience by the PROXIMA technician in the company. The application is developed only on Android devices and is not intended for public use. It will be installed on the operator's device only with a dedicated APK.
- PROXIMA APP Learning Experience (PAPPS): Public version of the App, available for the apprentice on Apple and Android Stores. Planned features include: note-taking and associating videos recorded with the head-mount camera and possible audio. At any time after the training, the APP allows viewing of collected information in AR. There is a ticket-based messaging system with the trainer who conducted the course.
- PROXIMA Tablet Assisted training (PTAPP): Stand-alone tablet solution for apprentice use during the assisted training phase. The app is not available in stores but is dedicated solely to in-house training. Positioned on a portable physical stand, it can be used by either holding a physical TAG or placing it on

the fixed support. The app displays the AR scene similar to the PAPPS app but includes video call functions with the trainer assisting the apprentice during the machine learning testing phase.

- APP VR for VR Headset (HAPP): Stand-alone Virtual Reality application to be used on Oculus Pro or Quest 3 or similar devices programmable through UNITY, to be utilised in a dedicated space within the company after completing the course with the trainer. The experience involves overlaying apprentice-taken notes on a virtual model of the machine on the production line. The apprentice can read the notes, move them around, and add new ones. It uses an interface to navigate between different TAGs.

Educational Scenarios Supported

PROXIMA Mixed Reality vision addresses the continuity of experience among physical, virtual and digital realms, by implementing an iterative and incremental exchange that moves:

- **from work context to augmented reality**, i.e. in the definition of physical points of interest to convey multimedia training contents and implement proximity guidance;

- from augmented reality to virtual reality, since trainees will have the opportunity of an immersive and reflective training in VR, and back to reality for trial and error approach on the machine;

- from the augmented workplace to digital workspace, i.e. with on-field, contextualized and situational support implemented on AR and with the possibility of navigating digital contents and modules in the digital environment of the community of practices.

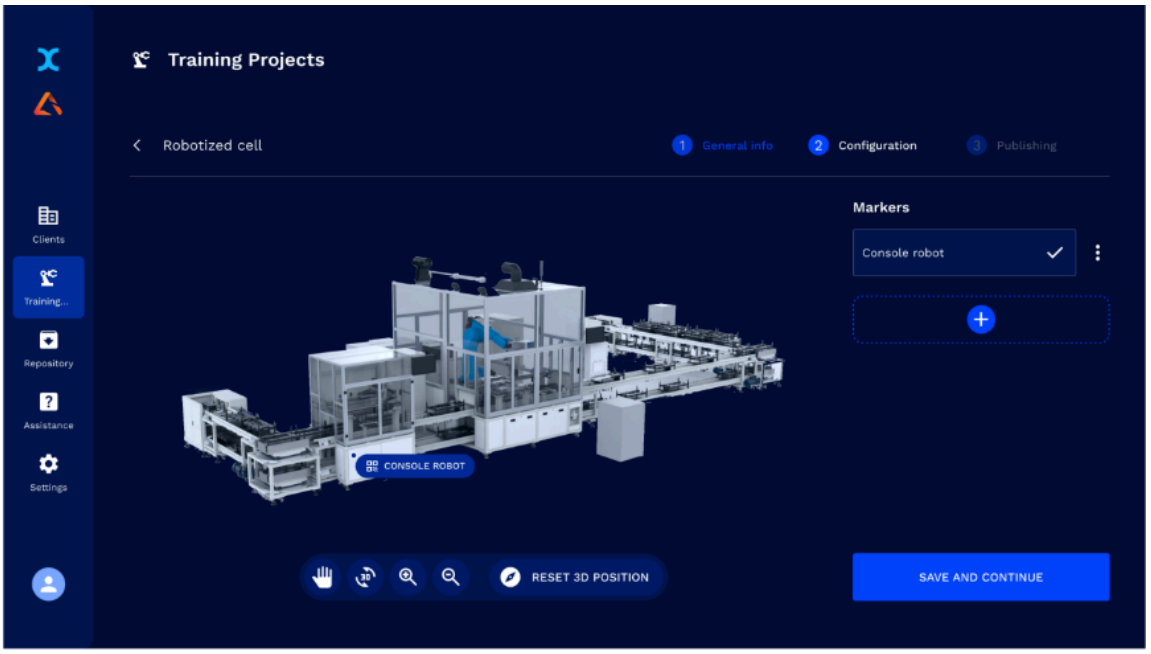

FIGURE 15 PROXIMA - PPLAT: TRAINING PROJECT SECTION

FIGURE 16 PROXIMA - HAPP MARKER DETAIL

4.4.2 Dissemination and UVP

Events attended

The project team engaged in many industry-specific events and exhibitions as part of the overall dissemination strategy. Those interactions have provided precious opportunities to speak with experts in the respective domains and stakeholders in society, fostering discussion about the future advanced applications of XR technologies.

Following are the events in which the project team participated:

- MECSPE, Bologna (BO), Italy, 5-7.03.24
- Laval Virtual, Vienna, 11-12.04.24
- Hannover Messe, Hanover, 22-24.04.24
- Netcomm Forum, Milan (MI), Italy, 8-10.05.24
- Convention della Lamiera (TecnoLamiera e Tecnologie Meccaniche), Bergamo (BG), Italy, 17.05.24
- SPS 2024, Parma (PR), Italy, 28-30.05.24
- WeMakeFuture, Bologna (BO), Italy, 13-15.06.24
- Farete, Bologna (BO), Italy, 4-5.09.24
- BIMU, Milan (MI), Italy, 9-12.10.24
- AWE, Vienna, Austria, 29-30.10.24
- A&T Automation and Testing, Vicenza (VI), Italy, 6-8.11.24
- LearningMore Festival, Modena (MO), Italy, 8-10.11.24
- Sepem, Turin (TO), Italy, 3-4.12.24
- Proxima XR case submitted to Manufacturing: AI-driven predictive maintenance, process optimization, supply chain management, and robotics, at the Innovate for Impact - The AI for Good Challenge to Meet the SDGs, 6.12.24
- D4SME workshop: Boosting SME digitalisation for local development, Turin (TO), Italy, 12.12.24

UVP

X-tend.it is a solution designed to facilitate seamless, adaptive interactions between operators and industrial machinery through advanced XR-based human-machine interfaces (HMI XR). By integrating Extended Reality (XR), the Internet of Things (IoT), and AI, X-tend.it enhances operational efficiency, safety, and user empowerment. This solution provides a scalable, real-time interface that adapts to user needs, supporting agile decision-making and promoting an optimal balance between machine autonomy and human control. X-tend.it is built on the “Resilient Operator 5.0” framework, empowering skilled operators to harness creativity and problem-solving skills in complex environments. This approach equips operators to tackle challenges and foster sustainable solutions, fostering a workforce that can adapt quickly to dynamic operational demands.

4.5 XR2IND

4.5.1 Technical Results

The XR2IND MVP leverages an innovative integration of AI-driven conversational interfaces and immersive VR environments towards enhancing XR-based industrial training applications in-line with Industry 5.0 principles. The system relies on two primary components, namely:

- **the LLM Chat Engine**, which provides real-time, context-aware guidance, and
- **the VR application,** which offers hands-on virtual simulations.

These components work in tandem to deliver highly personalized and interactive training experiences.

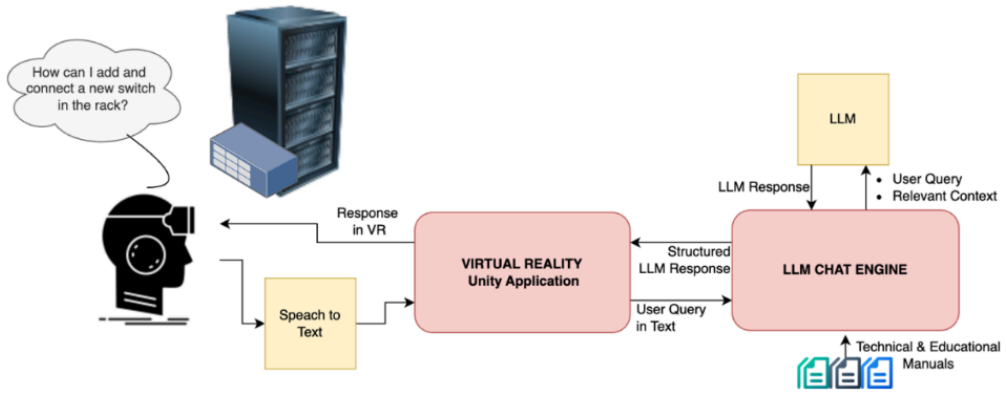

FIGURE 17 XR2IND - PROCESS AND DATAFLOWÙ

The LLM Chat Engine

It is implemented as RESTful service offering API endpoints for:

1. chat
2. document uploading
3. session configuration (e.g., trainee experience)

Internally, the LLM Chat Engine is based on the FastAPI framework and consists of the following components/functions:

- Document Parsing and Chunking: This component breaks down large documents into smaller, manageable chunks, making it easier for the system to process and retrieve relevant information.
- Document Text to Embeddings: This element converts parsed document text into numerical embeddings. It allows the LLM to understand and map the content for more efficient querying and context retrieval.

- Document Indexing Storage: This component organizes and stores the processed document data in a structured index of a Vector database. It facilitates quick access and retrieval during user interactions.

- Querying Tools and LLM Agent: These elements enable user queries to be processed by the LLM, which then searches the indexed data to deliver accurate, context-specific responses.

VR Models and Components

The VR application has been built using Unity's XR Interaction Toolkit. It offers three distinct virtual environments: tutorial, assembly, and troubleshooting. These three environments enable trainees to practice essential tasks using interactive 3D models of routers, switches, and various components such as cables, Small Form-Factor Pluggables (SFPs), fan compartments, and line cards. Specifically:

- Tutorial Room: The tutorial environment helps trainees familiarize themselves with VR controls, which is particularly important for those experiencing Virtual Reality for the first time. This room focuses on providing an intuitive and smooth introduction to the virtual environment and its interaction mechanisms.

- Assembly Room: In the assembly room, trainees are tasked with constructing routers using individual components. This hands-on environment challenges users to correctly assemble routers by following the steps required to put together different pieces, such as line cards, SFPs, and power supplies.

- Troubleshooting Room: Here, trainees face a simulated network routing room where multiple routers are installed. Their objective is to diagnose and troubleshoot random network problems. This environment mirrors real-world troubleshooting scenarios, encouraging users to apply their problem-solving skills to identify and resolve issues.

Across all environments, the system integrates support from the AI-powered Large Language Model (LLM), which assists trainees by interpreting and responding to voice commands.

The main subcomponents of the VR application are:

- Speech-to-Text Component

- 3D interactive models

- The whiteboard

FIGURE 18 XR2IND - VIRTUAL ENVIRONMENT WITH WHITEBOARD

4.5.2 Dissemination and UVP

Events attended

The project attended the AWE Exhibition in Vienna which disseminated and promoted XR2IND.

UVP

The XR2IND solution is an innovative VR-based training system designed for industrial workers in telecommunications and other sectors that have switchgear processes. It offers a unique combination of personalization, real-time guidance, and ergonomic design. Its standout feature is the integration of an AI-powered conversational co-pilot, which provides users with natural language instructions and real-time support during training tasks, such as the assembly, repair, and operation of switchgear equipment. This functionality enhances the learning experience of the worker and ensures that workers can develop skills efficiently and safely in a controlled virtual environment. Overall XR2IND delivers a highly immersive and adaptive training platform that addresses the challenges of modern industrial training while reducing dependency on physical equipment and improving workforce readiness. Overall, the USP of the solution lies in its ability to delivery immersive, safe, ergonomic, interactive and practical hands-on training to workers, which makes it's a valuable solution for upskilling and reskilling engineers/workers in various industrial sectors.

Improved Learning Outcomes: Higher knowledge retention through practical, immersive, personalized and interactive experiences thanks to the integration of co-pilot considerations.

• **Cost Efficiency:** Considerable reduction in training costs by eliminating physical setups and travel expenses.

• **Enhanced Safety:** Safe simulation of high-risk environments for industries like energy (e.g., power plants) and telecommunication (e.g., telecommunications equipment).

• **Customization:** Tailored VR modules for specific industrial tasks, such as equipment repair or emergency response drills with emphasis on the support for switchgear tasks.

• **Scalability:** Easy deployment across multiple locations (classrooms) and for different target groups without additional infrastructure costs. Emphasis is paid on the scalable provision of co-pilot services that are to be integrated in third-party XR-based industrial training applications.

4.6 XR4HRC

4.6.1 Technical Results

The software architecture of the XR4HRC project is designed to support immersive training experiences in Virtual Reality (VR) using the Meta Quest 3 platform. A key component in the software architecture is the INTERACT plugin, which has been integrated to enable advanced interaction with 3D objects and realistic physics simulation. The VR environment is designed around comprehensive training scenarios, which consist of modular structures. Each scenario is broken down into distinct modules that guide the user through specific tasks or procedures. In addition to training, the software also offers an exam option, allowing users to assess their knowledge and proficiency in a simulated environment. The integration of both training and assessment within the VR environment enhances learning outcomes by combining practice with evaluation in a single, immersive platform.

Specifically, the application components are the following:

VR Components

- INTERACT Plugin: The INTERACT plugin of XR2Learn is a core component of the VR experience, allowing users to interact intuitively with 3D virtual objects. Through this plugin, users can grasp and manipulate objects, operate machinery, and perform step-by-step procedures on robotic systems.

- Multiplayer Support: The VR application provides multiplayer support, enabling one instructor and multiple students to interact within the same training environment.

- Exam Mode: The Exam Mode in the VR platform allows users to test the skills they have learned. In this mode, users complete specific tasks in scenarios that simulate real-world operations and receive instant feedback on their performance at the end of each task.

- Database: The VR system also incorporates a database to store user information, enabling detailed tracking of the user's training progress and exam results.

AR Components

The AR components enable users to complete tasks in real-world environments with virtual guidance and instructions. The Meta XR SDK is the core enabler of the AR experience.

Common Components

Unity Engine: The entire application is developed on the Unity engine, which serves as the main platform for creating both virtual and augmented reality scenarios.

User Interface (UI): The user interface (UI) is designed to be intuitive and user-friendly across both platforms. Through the UI, users can easily navigate between modules and receive real-time feedback on their tasks.

3D Models: The 3D models used in the application feature detailed designs of industrial robots and machinery. These models simulate real-world environments and machines, supporting hands-on learning within the training scenarios. Each model is tailored to specific training scenarios and provides visual guidance during procedures.

Scenario Modules and Procedures: The application is built on well-defined scenario modules and procedures designed for effective training. Each scenario consists of step-by-step modules that teach users how to perform specific tasks.

Training Mode: The training mode guides users step-by-step in completing tasks on both VR and AR platforms.

Educational scenarios supported

• Scenario 1: Occupational Health and Safety Protocols

• Scenario 2: Orientation in the Laboratory Environment

• Scenario 3: General Maintenance of Robotic Systems

FIGURE 19 XR4HRC - MODE SELECTION

FIGURE 20 XR4HRC - SCENARIO 1 ENVIRONMENT

4.6.2 Dissemination and UVP

Events attended

AWE EU 2024

On October 29-30, they participated in the AWE EU Exhibition held in Vienna under the umbrella of the XR2Learn Project, showcasing the progress and outcomes of the XR4HRC initiative. During this event, they had the opportunity to present a live demonstration of their Virtual Reality (VR) application, which is a core component of the XR4HRC project. Beyond the demonstration, the event served as an excellent platform to engage with stakeholders from various sectors, including academia, industry, and technology development.

BUMATECH

They participated in the Bursa Machine Technologies Fair (BUMATECH), one of Turkey's leading events for machinery manufacturing, robotics, and automation. The fair, held at Tüyap Bursa International Fair and Congress Center, brought together key players from the industrial sector to showcase cutting-edge technologies. At the event, they promoted the XR4HRC project, distributing brochures and conducting meetings to explore commercialization opportunities.

Immersive Tech Week 2024

From December 4-6, they participated in the Immersive Tech Week in Rotterdam, an international hub for XR innovations. This event offered valuable opportunities to explore cutting-edge XR technologies and other ongoing projects in the field. They increased the visibility of both XR2Learn and XR4HRC projects by distributing brochures.

UVP

The validated VR solutions of XR4HRC enable immersive training simulations, allowing workers to practice complex tasks in a virtual environment without real-world risks. This can contribute to improving safety and efficiency and reducing costs. The VR solutions also allow engineers to visualize the (robotic arm) models at a human scale, making it easier to evaluate and assess components before physical repair or maintenance, for instance. In addition, it could also be used for remote collaboration. VR facilitates remote collaboration among teams or experts, where individuals can virtually meet and work together in a shared virtual environment regardless of their physical locations. The respective value proposition is that the clients (users and companies) will have an immersive training experience that needs shorter time and brings better lesson transfer into practice.

- **Companies** in specific can benefit from solutions that may be scalable but offer all the same quality standards and are not dependent on individual instructors or trainers' performance. In a longer use phase, this means it is a cost-effective long-term training solution with improved outcomes compared to traditional methods for corporate clients.

- **For individuals,** the value proposition is: Gain access to the most realistic real-life scenarios that combine knowledge and skills training in a "secure" environment an individual can enter and run at their own pace without disturbance or intervening of others. Also, learning in a positive connoted environment ("fun" and "flow") and activity can positively impact the learning; this may lead to lower drop-out rates, higher motivation, and also self-learning competencies.

4.7 X-Alfy

4.7.1 Technical Results

The main technical objective of the project is to provide advanced AI-based eXtended reality tools for Forestry, addressing three different yet complementary application areas: Teaching, Learning and Environmental Awareness. To achieve this main project objective, three main AI-based tools for the generation of XR applications in teaching and learning of forestry are being developed. The core novel technical developments are encapsulated in the implementation of three main AI-based Tools for the generation of XR applications.

T1: Superresolution

A tool that aims to perform super-resolution in both images and videos and allow professionals from different fields to upgrade low resolution content to higher resolutions with visually appealing picture fidelity. It is based on both, emerging complex generative AI techniques and Lossless Pooling Convolutional Networks for video processing. However, the final results are strongly dependent on both, quantity and quality of used training data. To address the quantity data challenge, in this project crowdsourcing of high-quality data is targeted. Hence both quality and quantity are addressed.

T2: AI-Driven Generation of Virtual Content

AI-based tool for the generation of fictive, virtual content simulating the process of decay or the effect of catastrophic fires in a given forest landscape. Using a real image from a healthy forest landscape, the proposed generative/diffusion AI tool will create a new realistic virtual image of the same landscape after a catastrophic forest fire, for example. Hence, the proposed tool can be exploited in the context of forestry conservation lessons. More critically the tool can become instrumental in the generation of awareness and contribute to the reduction of human triggered forest fires.

T3: Tree Species Classifier

It is an AI-based tool (T3) for automated classification of tree species. This tool is used to generate complementary semantic descriptions to the visual AR content generated with T1. It assists in the creation of semantic metadata for visual information. The aim is to further augment visual content with important semantic information to be exploited in teaching and learning courses. The main objective is to enable automated classification and recognition of plant species with only few labelled samples. This tool is also key for crowdsourcing of information needed for both training of the AI models being developed and for educational purposes. Hence, with time it is expected that the image database will significantly grow enabling better re-training and classifications results.

Mobile Application

Complementing the three tools (T1-T3), a mobile application for data gathering and testing, as well as, for showcasing the addressed educational and awareness scenarios, is implemented. The aim is to enable: a) easy capturing and sharing of low resolution pictures and short clips of forest landscapes, trees and leaves; and b) showcasing the capabilities of the proposed tools for the generation of virtual and augmented visual content.

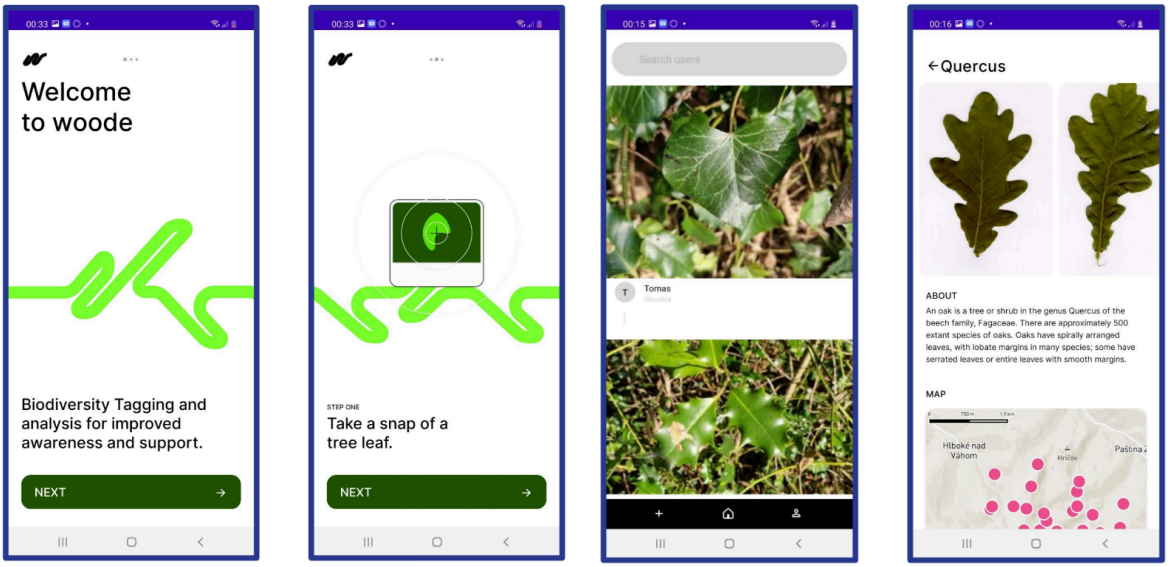

FIGURE 21 X-ALFY MOBILE APP

4.7.2 Dissemination and UVP

Events attended

AWE EU 2024

X-Alfy participated in the AWE EU exhibition in Vienna, where they demonstrated their application and promoted the XR4HRC project as well as XR2Learn.

UVP

X-Alfy delivers an integrated suite of AI-based extended reality tools specifically designed for forestry, uniting three innovative technologies into a single mobile application, Woode. The project leverages advanced super-resolution imaging (T1) to convert low-resolution forest images into highly detailed visual content, employs AI-driven virtual content generation (T2) to realistically simulate scenarios such as catastrophic fires and subsequent regeneration, and incorporates an automated tree species classifier (T3) to enrich visual data with semantic information. Together, these tools enhance teaching, learning, and environmental awareness by providing immersive, interactive experiences that support sustainable forest management and education in the forestry sector.

5. Conclusions

The execution of the first XR2Learn open call has successfully contributed to advancing XR applications within Industry 5.0, showcasing the potential of immersive technologies across multiple sectors. The structured three-phase approach (Design, Development, and Growth) ensured that the funded projects evolved from conceptual proposals into tangible, deployable solutions.

Key takeaways from OC#1 include:

- **Strong Interest**: The call attracted **92 applications** from 20 different countries, demonstrating a high level of engagement from SMEs, research institutions, and industry players.
- **Quality of the proposals received**: The proposals submitted were of high-quality as showcased by the results of the ESR reports.
- **Quality of Funded Projects**: The seven selected projects displayed technological excellence, focusing on VR-based occupational safety, XR-enhanced astronaut training, AI-driven industrial learning, and forestry education.
- **Technical Advancements**: The projects leveraged AI, immersive simulations, and collaborative virtual environments to enhance training, learning, and industrial processes.
- **Business and Sustainability Prospects**: Several projects demonstrated strong commercialization potential, with business strategies developed to ensure long-term viability beyond the XR2Learn funding.

Through continuous support from the XR2Learn consortium, the projects benefited from tailored guidance, review mechanisms, and networking opportunities. Their participation in events, such as **AWE EU, SpaceTech, and Immersive Tech Week**, further amplified their visibility and market reach.

Moving forward, the insights gained from OC#1 will inform the design of future open calls. One such decision is adopting the funnel approach on the second open call, to include more projects and enrich the XR2Learn ecosystem. Additionally, based on our experience, this approach fosters healthy competition among the projects, motivating them to perform better and deliver superior results.

The objective of the XR2Learn OC#1 to enrich the ecosystem with innovative XR applications has been successfully achieved. A total of seven innovative applications have delivered high-quality results and contributed their content and materials in the XR2Learn platform, reinforcing the project's commitment to innovation and open collaboration.