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WP3 – XR Technology PUSH

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- LIST OF ABBREVIATIONS

BA	Beacon application
CNN	Convolutional neural network
EdTech	Educational Technologies
KPI	Key performance indicator
MFCC	Mel-frequency cepstral coefficients
MLP	Multilayer perceptron
SSL	Self-supervised learning
WP	Work package
XR	Extended reality
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 deliverable, D3.3 Technical support services, represents the first of two reports, planned for the months 24 and 48 of the XR2Learn project, respectively. It details the progress of two pivotal tasks: the development of the Educational Framework and the provision of Technical Support. These efforts are aimed at advancing the project's educational objectives and ensuring a robust technical infrastructure to support ongoing work.

The first version of the XR2Learn Educational Framework has been completed and made publicly available through the XR2Learn open repositories. Additionally, concise Instructional Design (ID) guidelines with structured examples have been presented as an article in the project WiKi to be used by stakeholders as a step-by-step guide to design their educational scenarios.

To complement the educational framework, we accomplished several technical support milestones. We developed and continuously updated a technical wiki hosted on GitHub, providing centralised documentation, resources, and guidelines for project participants to facilitate collaboration and knowledge sharing. Additionally, we produced comprehensive written and video guides on beacon applications and enablers, serving as educational resources to enhance understanding and effective utilisation of these technologies within the project. Our team provided expert assistance to project participants, helping them proficiently use enablers to enhance their contributions and promote best practices within the project. We also extended specialised support and guidance to the winners of OC1 and OC2, ensuring they have access to the necessary resources and technical assistance to succeed in their initiatives aligned with the project's objectives.

The successful execution of these tasks has fortified our educational infrastructure and technical capabilities within the research project. As the first of two deliverables, this report outlines the foundational work accomplished to date.

1 INTRODUCTION

This internal report serves as the first of two deliverables for the XR2Learn project, documenting the completion of two critical tasks: the development of an educational framework and the provision of technical support. These efforts are essential in advancing the project's objectives and establishing a solid foundation for future initiatives.

The creation of a comprehensive educational framework was undertaken to standardize and enhance the educational components within our project. The first version of this framework has been completed and reviewed internally. It addresses a range of pivotal topics, including:

- *Introduction to Our Project Across Disciplines and Learning Modes*: Providing an overview of how our project integrates with various academic disciplines and accommodates different learning environments and styles.
- *European Initiatives and Policy Actions*: Examining relevant European educational initiatives and policy actions that influence and support our project's objectives.
- *Distinguishing and Defining XR (AR, VR, and MR)*: Clarifying the definitions and differences between Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), and their specific applications in education.
- *Defining Dimensions of XR in Education*: Exploring the various dimensions—such as technological, pedagogical, and experiential—that XR technologies bring to educational settings.
- *Leveraging XR Technologies in Education*: Analyzing the advantages, disadvantages, and overall impact of XR technologies on student learning outcomes, including engagement, motivation, and knowledge retention.
- *Types of Scenarios Augmented with XR Technologies*: Identifying different educational scenarios and contexts where XR technologies can be effectively implemented to enhance learning experiences.
- *Proposed Educational Framework and Stages (Instructional Design)*: Presenting our proposed framework, outlining the stages of instructional design tailored to integrating XR technologies into the curriculum.
- *Learning Objectives*: Establishing clear and measurable learning objectives that align with the use of XR technologies, ensuring they meet educational standards and learner needs.
- *XR Content Creation*: Providing guidelines and best practices for creating effective and engaging educational content using XR technologies.
- *Pedagogical Strategies for Implementing XR in Education*: Recommending teaching strategies and methodologies for educators to effectively incorporate XR into their instructional practices.
- *Integrating XR in Virtual Learning Environments (VLEs)*: Offering strategies for seamlessly incorporating XR technologies within existing Virtual Learning Environments to enrich the digital learning ecosystem.

Additional topics will be included in the second version of the framework to further expand its scope and applicability.

Complementing the educational framework, we have achieved significant milestones in providing technical support. We have created 13 pages on the technical wiki hosted on the project’s GitHub, offering centralized documentation, resources, and guidelines that facilitate collaboration and knowledge sharing among project participants. Our team has provided support to various OC1 winners, assisting them with technicalities regarding enablers beacon applications and XR technologies, and helping them utilize these tools proficiently. We have already begun supporting OC2 winners, extending our expertise to help them navigate technical aspects related to enablers.

Additionally, a feedback form was sent to the OC1 winners regarding their experience with the technical support. The responses were positive and provided valuable insights on how to improve the wiki for future users, such as the OC2 winners. This feedback has been instrumental in refining our technical resources to better meet the needs of project participants.

We have also developed comprehensive written and video guides on beacon applications and enablers, serving as educational resources to enhance understanding and effective utilization of these technologies within the project.

This report will delve into the methodologies employed in developing the educational framework and delivering technical support, discussing the challenges encountered and the solutions implemented. It will also highlight the outcomes achieved and their impact on the project's progress. By providing a detailed account of these efforts, we aim to foster transparency, facilitate continuous improvement, and set the stage for the subsequent deliverable. The insights gained from this phase will inform future actions and contribute to the overall success of our research project.

2 EDUCATIONAL FRAMEWORK

2.1 INTRODUCTION

The XR2Learn Educational Framework focuses on integrating Extended Reality (XR) technologies—AR, VR, and MR—into education, enhancing interactive and immersive learning experiences. It outlines the benefits of XR, such as increased engagement, accessibility, and personalized learning, while addressing challenges like accessibility and content design. The framework includes detailed instructional models like the XR2LEARN ASSURE Model, leveraging pedagogical strategies and integration into curricula to maximize XR's educational potential. Supported by European initiatives and policies, it emphasizes collaboration, teacher training, and scalability to revolutionize teaching and learning practices.

2.2 DETAILED WORK SUMMARY

2.2.1 Introduction to XR2Learn Across Disciplines and Learning Modes

This chapter serves as an overarching introduction to the diverse functionalities of Extended Reality (XR) technologies across educational and professional contexts. It explores how XR transforms traditional teaching and training by offering immersive and interactive experiences that enhance performance, comprehension, and engagement. Key applications in medical education are highlighted, where XR facilitates skill development through safe, realistic simulations and supports patient education.

The chapter also delves into XR's role in corporate settings, enhancing skill training, streamlining employee onboarding, and improving operational efficiency through virtual environments. Beyond professional training, XR enriches customer and student experiences, with virtual tours and classroom simulations exemplifying its ability to make learning more engaging and accessible.

By showcasing its broad applications, the chapter establishes XR as a transformative tool with growing potential to revolutionize practices across disciplines, underscoring its adaptability and effectiveness in various learning modes.

2.2.2 European initiatives and policy actions

European initiatives and policy actions are actively promoting the integration of Extended Reality (XR) technologies in education to enhance learning experiences and drive digital transformation. Key initiatives and policies include:

- **Horizon Europe:** The EU's primary research and innovation funding program (2021-2027) emphasizes digital transformation in education, funding XR projects to develop innovative teaching methods and improve student engagement.
- **Digital Education Action Plan (2021-2027):** Outlines the European Commission's vision for inclusive digital education, supporting XR integration to create immersive learning environments and develop digital competencies.
- **Next Generation EU:** A recovery plan investing in digital transformation, including deploying XR technologies in education to ensure innovation and continuity.
- **European Strategy for Universities:** Encourages universities to adopt XR

technologies to enhance teaching, learning, and research activities.

Policy actions supporting XR integration

- **European Skills Agenda:** A five-year plan emphasizing digital skills, boosting digital literacy among educators and students to facilitate XR adoption in curricula.
- **Digital Decade Policy Programme 2030:** Sets targets for Europe's digital transformation, supporting the development of technologies like XR to enhance educational systems.
- **Creative Europe Programme:** Funds projects using innovative digital technologies, including XR, to enhance cultural and educational content.
- **Erasmus+ Programme:** Supports projects that incorporate XR technologies to enhance collaborative learning and international exchange.

These initiatives provide funding and support, creating a conducive environment for adopting XR in education. By aligning with these policies, the **XR2Learn** project contributes to the digital advancement of Europe's educational sector, promoting innovation and enhancing learning experiences across disciplines and learning modes.

2.2.3 Distinguishing and defining XR (AR, VR and MR)

In this section an attempt is made to define the different types of Extended Reality (XR) and present their major applications. XR technologies are transforming education by offering immersive and interactive learning environments. The XR term contains various types of technologies like Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). These technologies improve students' engagement, their understanding of complex concepts, and provide hands-on, practical experiences.

VR is ideal for simulations and training. It is highly effective in creating realistic, engaging experiences for many fields in education, and training. AR overlays digital elements onto the real world, enriching user interaction and enabling applications such as 3D molecular visualisation, anatomy exploration, and virtual field trips. MR blends real and virtual worlds, which allows users to interact with both seamlessly. Examples include architectural CAD modelling and collaborative XR classrooms.

XR educational applications cover many fields. Science education adapts virtual labs and 3D molecular modelling. Medical training employs surgical simulations for risk-free practice. In engineering, XR finds application in structural analysis and virtual prototyping. Geography uses virtual field trips and geological simulations. Mathematics students are able to use 3D geometry exploration and interactive graphs. XR also promotes language learning and art education with virtual galleries and 3D modelling. It supports professional development through workplace simulations and training for emerging situations. For special education, XR provides personalised learning environments and social skills training.

XR applications in education have lots of benefits such as increased engagement, personalised learning, and low-cost solutions, as XR can substitute physical materials and procedures with digital simulations. XR has a potential to revolutionise education and this offers to educators powerful tools to create engaging, effective, and accessible learning experiences.

2.2.4 Defining Dimensions of XR in Education

This chapter explores key issues in the fidelity and immersive capabilities of Extended Reality (XR) and their implications for education. XR spans a spectrum from fully immersive Virtual Reality (VR), suited for high-fidelity simulations, to Augmented Reality (AR), which integrates digital elements into physical spaces for real-time, contextual learning. Achieving the right level of immersion requires careful design to balance engagement with usability challenges.

High-fidelity XR environments, such as advanced simulators, offer realistic training experiences critical for skill acquisition, while more accessible, lower-fidelity solutions suffice for conceptual learning, striking a balance between cost and effectiveness. Additionally, XR promotes active learner participation through tools like AR for structured education and gamified VR experiences, enhancing engagement and practical understanding.

Co-presence, facilitated by shared virtual spaces, supports collaboration and teamwork but necessitates inclusive design and realistic avatars to maximize interaction.

In conclusion, XR redefines education by integrating immersive, high-fidelity, and interactive experiences, addressing challenges such as usability, inclusivity, and the technical complexities of immersive learning.

2.2.5 Leveraging XR technologies in education - advantages, disadvantages, and impact on Student Learning

This chapter focuses on the integration of Extended Reality (XR) technologies, including Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), into educational settings. It examines the benefits and drawbacks of XR, its impact on student learning effectiveness, and the challenges associated with different learning models.

Advantages of Using XR in Educational Environments

This section highlights how XR technologies enhance education by increasing student engagement through immersive and interactive experiences. It discusses how XR can improve understanding of complex concepts, offer personalized learning opportunities, and facilitate collaboration and communication among students.

Disadvantages of Using XR in Educational Environments

Here, the document addresses potential drawbacks such as high implementation costs, technical challenges, and the learning curve associated with new technologies. It also considers health and safety concerns like motion sickness, potential distractions, and issues related to equity and accessibility for all students.

Impact of XR on Learning Effectiveness of Students

This part analyzes how XR affects student learning outcomes, noting improvements in cognitive skills, retention, and recall. It discusses how immersive learning can enhance engagement and motivation, and examines studies that measure the educational benefits of XR technologies.

Potential Challenges in Different Learning Models

The final section explores obstacles in integrating XR across various educational models, including traditional classrooms, blended learning, and online education. It considers challenges such as curriculum integration, teacher preparedness, resource allocation, technical requirements, and ensuring accessibility for students with diverse needs.

Overall, the document provides a concise examination of the role of XR technologies in education, weighing their advantages against the disadvantages. It emphasizes the need to address challenges to maximize the positive impact of XR on student learning.

2.2.6 Types of sceneries augmented with XR technologies

This chapter explores various environments where Extended Reality (XR) technologies, including Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), are utilized to enhance educational and training experiences. It focuses on two primary settings:

Laboratories

This section discusses the integration of XR technologies in laboratory environments to revolutionize science and technology education. The key areas covered include:

- XR in Science & Technology Laboratories: Explains how XR can replicate laboratory settings, allowing students to conduct experiments in a virtual space that mimics real-life labs.
- Virtual Labs: Describes fully digital laboratories where experiments are simulated using VR or AR, enabling learners to explore concepts without the need for physical equipment.
- Remote Labs: Highlights the use of XR to access and control real laboratory equipment remotely. This allows students to perform experiments from different locations, increasing accessibility.

The use of XR in laboratories offers several benefits:

- Enhanced Learning Opportunities: Students can perform experiments that might be too dangerous, expensive, or impractical in a traditional lab setting.
- Increased Accessibility: Provides opportunities for institutions lacking extensive lab facilities to offer comprehensive science education.
- Repeatability and Flexibility: Experiments can be repeated multiple times without additional cost or resource consumption, aiding in better understanding.

Real Training Settings

This section examines how XR technologies are applied in real-world training scenarios across various industries:

- Medical Training: XR is used to simulate surgeries and clinical procedures, allowing medical students and professionals to practice in a risk-free environment.
- Industrial Training: Workers receive hands-on experience with complex machinery and equipment through XR simulations, improving safety and efficiency.
- Emergency Response Training: First responders use XR to prepare for disasters and emergency situations, enhancing readiness and decision-making skills.
- Aviation and Military Training: Pilots and military personnel train using XR simulations to experience realistic flight and combat scenarios without the associated risks.

Benefits of using XR in real training settings include:

- Risk Reduction: Trainees can practice high-risk tasks without endangering themselves or others.

- Cost Efficiency: Reduces the need for expensive equipment and resources for training purposes.
- Immediate Feedback: XR systems can provide real-time analytics and feedback, allowing for rapid skill improvement.
- Enhanced Engagement: Immersive experiences increase trainee engagement and retention of information.

In conclusion, this chapter underscores the transformative impact of XR technologies in augmenting educational and training environments. By leveraging XR in laboratories and real training settings, educators and trainers can provide immersive, interactive, and accessible learning experiences. This not only enhances skill development and knowledge acquisition but also addresses limitations of traditional training methods by reducing risks and costs while increasing engagement and effectiveness.

2.2.7 Proposed educational framework and proposed stages (Instructional Designing)

In this section an extended Instructional Design (ID) model is proposed. This model is adapted to the needs of our project. The XR2Learn-ID model is a hybrid Instructional Design framework that was developed in order to be used in immersive Virtual Reality (VR) environments, for addressing the limitations of traditional educational models in these environments. It is a combination of existing frameworks and more specifically the ASSURE Instructional Design model and the TPACK framework. The purpose behind the proposed combination was to ensure a balanced integration of content, pedagogy, and technology. The framework is structured in six stages, each of which is adapted for VR properly:

- **Analyse learners:** This step examines students' demographics, their prior knowledge, their learning style, and their technological readiness in order to ensure a customised and effective learning experience.
- **State objectives:** This step includes the definition of clear and measurable goals across content, pedagogy, and technology, guided by Bloom’s taxonomy.
- **Select media and materials:** In this step VR content and tools are chosen to align with objectives, ensuring compatibility with available technology while enhancing the learning experience.
- **Utilise media and materials:** This step involves the preparation of VR activities and their integration into lessons, the testing of the equipment, and the facilitation of immersive and interactive experiences.
- **Require learner participation:** In this step active and collaborative learning is encouraged through hands-on tasks, group activities, and real-time feedback within VR environments.
- **Evaluate and revise:** This is the step where the learning outcomes are assessed through formative and summative evaluations, incorporating feedback to refine and improve instructional design.

The integration of the TPACK framework ensures that VR is used effectively in order to support innovative teaching methods and enhance the delivery of the content. Each step of the above model incorporates Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK).

2.2.8 Learning objectives

This section highlights the importance of learning objectives in education and their alignment with Bloom's Taxonomy, particularly in the context of Extended Reality (XR) technologies.

Learning Objectives

Learning objectives are crucial as they:

- **Guide Instruction:** They help educators plan and deliver content in a structured and coherent manner.
- **Clarify Expectations:** Communicate to students what is expected, aligning their efforts with educational goals.
- **Provide a Basis for Assessment:** Allow educators to evaluate whether students have achieved desired outcomes.
- **Enhance Learning:** Focus student efforts on key areas, promoting deeper understanding and retention.

The goal is to define clear, measurable, and achievable targets that ensure alignment between teaching methods, assessments, and desired outcomes. Challenges in defining learning objectives include balancing specificity and flexibility, ensuring measurability, aligning with broader educational goals, addressing the complexity of learning across different domains (cognitive, affective, psychomotor), and accounting for student diversity.

XR and Bloom's Taxonomy

XR technologies enhance learning experiences and align with Bloom's Taxonomy by:

- **Simulation Potential:** Allowing exploration of difficult or hazardous environments safely.
- **Immersive Quality:** Providing engaging and realistic experiences that enhance understanding and retention.
- **Replicability:** Ensuring consistent training opportunities regardless of time or location.
- **Behavior Capture:** Offering detailed feedback to refine skills.
- **Multi-user Interaction:** Facilitating collaboration and cooperative learning in virtual settings.
- **External Observation:** Enabling educators to monitor and assess performance, extending learning to observers.

XR can support all levels of Bloom's Taxonomy across various learning environments, such as location-based, time-based, or sequence-based settings.

2.2.9 XR Content creation

This section outlines the process of developing educational content using Extended Reality (XR) technologies, emphasizing the integration of software design and learning design to create meaningful and effective learning experiences. The XR2Learn Educational Framework guides this integration.

Designing for XR requires a user-centric approach that addresses both the immersive nature of the medium and pedagogical objectives. Key principles include organizing spatial environments for optimal navigation, creating flexible interactions that adapt to user behavior, prioritizing user comfort to minimize motion sickness, simplifying design to avoid overwhelming users, optimizing for hardware capabilities, providing clear and consistent feedback, and allowing for trial and error to facilitate exploratory learning.

The general design process is structured and iterative:

- **Defining Goals** involves establishing clear educational objectives aligned with learning outcomes and the target audience.

- **Research** includes analyzing available XR tools and understanding the needs of the learners to inform development decisions.
- **Analysis and Planning** synthesize findings into a cohesive plan with detailed user personas and interaction flows to ensure resonance with the intended audience.
- **Content and Interaction Design** focuses on creating instructional content and interactions, utilizing frameworks like Bloom's Taxonomy and incorporating XR-specific features for engagement.
- **Prototyping** involves creating low-fidelity and high-fidelity prototypes to test core interactions and gather feedback, refining the product based on user responses.
- **Testing** evaluates the XR product's usability, accessibility, and alignment with educational goals through methods like heuristic evaluation and pre-/post-tests.
- **Launch** requires careful planning to provide technical support and user training, ensuring educators and learners can effectively utilize the XR content.
- **Iteration** is an ongoing process of refining and enhancing the XR product based on user feedback and performance data, aligning with the principle of continuous improvement.

Integration with educational dimensions—immersion, fidelity, and learner agency—is central to achieving effective learning experiences. Immersion enhances engagement by enveloping learners within the XR environment, while fidelity balances realism and cognitive load to prevent overwhelming users. Learner agency empowers students to interact with and manipulate the XR environment, fostering active learning and critical thinking.

Particularly important are considerations on selecting appropriate XR hardware and software that align with learning goals, utilizing XR's capability to capture rich data on learner behavior for personalized support and content improvement, and ensuring accessibility and inclusivity. Designing XR experiences that cater to a diverse range of learners involves features like adjustable text size, voice narration, and alternative navigation options, making the content accessible to individuals with disabilities and promoting equitable access.

2.2.10 Pedagogical Strategies for Implementing XR in Education

Extended Reality (XR) enhances education by creating immersive, interactive environments that foster active engagement and experiential learning. It enables hands-on exploration of complex concepts, such as geological processes or historical events, making learning both engaging and memorable. This chapter explains how XR supports scaffolding with adaptive tools and guided tutorials, offering personalized learning while addressing ethical concerns like data privacy and accessibility. Collaborative learning is enriched through VR and AR projects that promote teamwork, multidisciplinary approaches, and global collaboration. Pedagogical models like Flipped Classroom, Project-Based Learning (PBL), and Inquiry-Based Learning (IBL) integrate seamlessly with XR, allowing students to explore, experiment, and present findings interactively. XR also facilitates robust evaluation through performance tracking and embedded assessments in realistic scenarios. By blending these strategies, XR transforms education into a dynamic, inclusive experience that equips learners with the skills and knowledge needed for real-world challenges.

2.2.11 Integrating XR in Virtual Learning Environments (VLEs)

The integration of Extended Reality (XR) into Virtual Learning Environments (VLEs) is a serious issue for the developers and the instructors. This is becoming more complex when analytics and student tracking is involved. This section introduces the main integration options for XR applications in VLEs. VLEs are digital platforms that support course management, content delivery, assessments, and interaction between educators and students. Popular platforms such as Moodle, Blackboard, Canvas, and Schoology are discussed. Moodle is emphasised for its flexibility and suitability for XR integration due to its open-source and plugin-based architecture.

Moodle's technical structure, because of its modular design, enables seamless integration of XR content. XR can be embedded in Moodle through direct embedding or other integration methods. Direct embedding includes 360-degree videos, WebXR experiences, and AR overlays. For instance, educators can embed 360-degree virtual tours or AR visualisations directly into courses using URLs or HTML.

For more complex XR simulations where student tracking options are needed, integration methods like SCORM and xAPI are preferred. SCORM packages, often developed in platforms like Unity, allow XR simulations to be embedded and monitored through Moodle's SCORM module. Another option is xAPI, or Experience API, and it goes further by capturing detailed learner interactions, such as decisions made within a simulation. These decisions are stored in a Learning Record Store (LRS) connected to Moodle.

The document emphasises the benefits of XR integration, including improved engagement, interactive learning, and detailed analytics for educators. Moodle's ability to support various XR formats and provide data-driven insights makes it an effective tool for advancing immersive learning experiences. By combining XR technologies with VLEs, educators can create dynamic, interactive environments that enhance traditional teaching methods and cater to diverse educational needs.

2.3 CURRENT RESULTS AND OUTCOMES

The first version of the XR2Learn Educational Framework has been completed and made publicly available through the XR2Learn open repositories. Additionally, concise Instructional Design (ID) guidelines with structured examples have been presented as an article in the project WiKi to be used by stakeholders as a step-by-step guide to design their educational scenarios (https://github.com/XR2Learn/.github/wiki/The-XR2Learn-Educational-Framework). Following the recommendations of the first project review the Instructional Design principles of the XR2Learn Educational Framework has been presented in a dedicated webinar organized in December 2024 addressed to the participants of the second Open Call (OC) as a prerequisite for implementing their educational use cases.

2.4 NEXT STEPS

The next steps include the development of the second version of the XR2Learn Educational Framework, which is planned to be extended to cover the following topics:

- Curriculum Integration
- Evaluation and Assessment in XR
- Feedback
- Accessibility and Inclusion
- Teacher Training
- Student Engagement and Motivation

- Ethical and Safety Considerations
- Community Involvement
- Collaboration and Social Interaction
- Budget and Resources
- Scaling and Sustainability
- Case studies in XR implementation for different educational contexts

The second version of the XR2Learn Educational Framework will be reported in deliverable D5.5 due in M48.

3 TECHNICAL SUPPORT

3.1 INTRODUCTION

The technical support component of the XR2Learn project is pivotal in ensuring the implementation and operation of its initiatives. Aimed primarily at external users, the technical support serves as a gateway for educators, practitioners, and Open Call (OC) winners to enter and navigate the world of Extended Reality (XR) technologies. This chapter outlines the efforts undertaken to develop comprehensive technical resources, provide expert assistance, and gather user feedback to continuously improve our support mechanisms, on top of detailing the future plans and efforts to improve upon the current work and maintain active and successful support.

3.2 DETAILED WORK SUMMARY

Our technical support activities have been multifaceted, focusing on creating accessible resources, offering personalized assistance, and refining our approach based on user input.

3.2.1 Creation and Maintenance of Technical Wiki on GitHub

Development of the Wiki

We established a technical wiki hosted on the project's GitHub, designed as a centralized repository for documentation, tutorials, and guidelines related to our project's beacon applications and enablers. A total of 13 pages have been created, ranging from introductory pieces on enablers and beacon applications, to how-to guides on how to use the provided technologies.

Public Repositories with Comprehensive Documentation

In addition to the wiki, we have created ad-hoc README files that provide step-by-step instructions on how to set up, install, and configure the software in each of the public repositories. These README files are crafted to be user-friendly, ensuring that users with minimal technical expertise can successfully implement our technologies. The documentation covers:

- Prerequisites: Outlining the necessary software, hardware, and system requirements needed before installation.
- Installation Instructions: Providing clear and concise steps for installing the software, including command-line inputs and screenshots where applicable.
- Configuration Guidelines: Explaining how to configure the software to meet specific needs, including customization options and settings adjustments.
- Usage Examples: Offering examples of how to utilize the software effectively, including sample projects or scenarios.
- Troubleshooting Tips: Addressing common issues and their solutions to assist users in overcoming potential obstacles.

GitHub Issues

To further enhance collaboration regarding software development and user support, we have implemented GitHub Issues on each of our public repositories. This feature allows us to centralize the tracking of issues, bugs, and suggestions, making it easier for users to report problems, request new features, and receive assistance.

By utilizing GitHub Issues, we organize all feedback in one place and facilitate direct interaction between users and our development team. Each issue can be assigned to a specific team member, allowing us to track who is responsible for addressing it and ensuring accountability in the support process. This assignment mechanism helps us monitor the progress of each issue from reporting to resolution, providing transparency and timely updates to users.

The public nature of GitHub Issues also allows users to view previously reported issues and their solutions. This visibility enables users to troubleshoot independently, reduces duplicate reports, and encourages them to contribute to ongoing discussions. It fosters a collaborative community where users can learn from one another and share insights.

Furthermore, GitHub Issues helps us maintain a clear record of how support is being delivered and by whom. This systematic approach enhances user support by ensuring that assistance is provided efficiently and effectively. It not only aids in the swift identification and fixing of bugs but also strengthens the relationship between our team and the user community. By keeping detailed records, we can analyze common issues, improve our resources, and adapt our support strategies to better meet user needs.

Overall, implementing GitHub Issues has significantly improved our ability to support users and track assistance. It has created a more responsive and engaging environment around our project, ultimately fostering a collaborative and supportive community.

Continuous Updates

The wiki is regularly maintained and updated to reflect the latest advancements and to incorporate new information based on user feedback and technological developments.

3.2.2 Development of Video Guides

Engaging video content was created to visually demonstrate the functionalities and applications of our technologies, enhancing user understanding and engagement. The project's youtube channel (https://www.youtube.com/@XR2Learn) contains more than 20 videos that demonstrate beacon applications and enablers in various ways.

3.2.3 Support Provided to OC1 Winners

Our team offered personalized technical support to various winners of the first Open Call (OC1), helping them navigate technical challenges and effectively integrate enablers into their projects. The following is a comprehensive list of interactions with OC1 winners in the first 24 months:

Project	Type & duration	Date	Topics	Comments
PROXIMA	Remote 1 hour	February 2024	INTERACT introduction; INTERACT use cases; INTERACT business model;	Interact licences were provided to test feasibility

			UX design	
PROXIMA	Remote 1 hour	May 2024	Personalization Enablers presentation; Discussion on the application of Personalization enablers in PROXIMA	-
EVR-OSH-5	Remote 50 min	February 2024	Presentation of EVR-OSH-5; INTERACT presentation; Questions about Magic Xroom, hardware, availability and licensing; Questions about Paris presentation; Questions about marketing	Answers about licensing were provided during the Paris meeting
XR4HRC	Remote 1 hour	February 2024	XR4HRC scenarios description; INTERACT presentation; Advice on using multi-user frameworks in Unity;	Interact licences were provided to test feasibility and the kinematics module
EVR-OSH-5	Remote 1 hour	April 2024	Questions about sensors to collect data; Questions about integration of new sensors with Personalization Enablers; Discussion about possible use cases (difficulty adjustment, stress detection, annotations)	Referred to Magic Xroom documentation regarding the already integrated sensors

We ensured that OC1 winners had easy access to all technical resources, including the wiki and guides, to facilitate their project development processes.

3.2.4 Initiation of Support for OC2 Winners

Building upon the successful support provided to the winners of the first Open Call (OC1), we have begun offering technical support to potential participants of the second Open Call (OC2). Recognizing the importance of early engagement and preparation, our efforts are focused on assisting these potential applicants in understanding and utilizing our enablers effectively, thereby enhancing the quality of their proposals and readiness for the upcoming call.

We have provided means to facilitate contributions from interested parties and provided resources to help them familiarize themselves with our technologies. This includes granting access to our technical wiki, public repositories, and comprehensive guides.

Understanding that each prospective project may have unique requirements, we have made ourselves available for consultations to address specific questions and provide guidance. This personalized support aims to help applicants develop robust project proposals that align with our enablers and maximize their chances of success in the OC2 selection process.

In anticipation of the announcement of OC2 winners in the coming months, we are planning to continue the support strategies that proved effective during OC1. This includes organizing orientation sessions, maintaining the available resources to ensure they are helpful and accessible, and establishing dedicated communication channels to ensure that once the winners are announced, they can swiftly and effectively access our enablers into their projects.

By offering support to potential OC2 participants now and planning comprehensive assistance for future winners, we aim to facilitate a smooth integration process, enhance their projects' outcomes, and contribute to the success of XR2Learn.

3.2.5 Feedback Collection and Implementation

To further strengthen our technical support services, we placed significant emphasis on collecting and implementing feedback from our users. This process was essential in ensuring that our resources not only met but exceeded the expectations of those relying on them. Below is an enhanced overview of our feedback initiatives:

Feedback Form Distribution

To gain insights into the effectiveness of our technical wiki and support services, we developed and distributed a comprehensive feedback form to all OC1 winners. The form was designed to capture detailed information about their experiences, including:

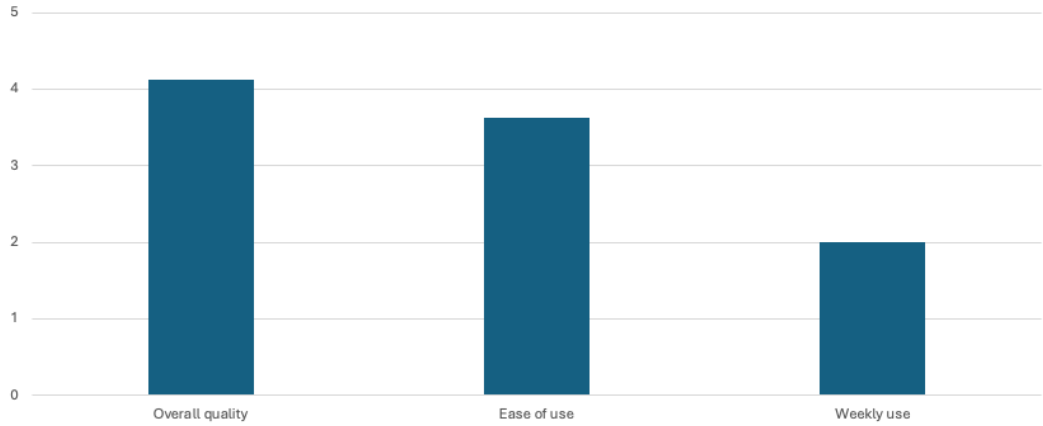
- *Usability of Resources:* Assessing how user-friendly and accessible the technical wiki, public repositories, and guides were.
- *Quality of Support*: Evaluating the responsiveness and helpfulness of our support team.
- *Resource Effectiveness*: Understanding how well the resources assisted them in achieving their project goals.
- *Areas for Improvement*: Providing an opportunity for users to suggest enhancements or identify any challenges they faced.

We encouraged candid responses by assuring participants that their feedback would directly influence future improvements.

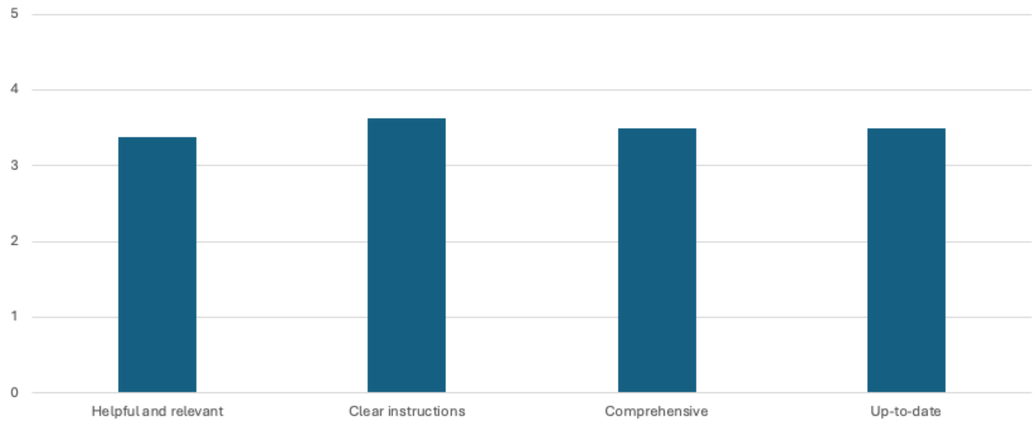
To visually present the key findings from the feedback, the following includes images, charts, and data summaries that illustrate the participants' responses and insights.

Users were asked to evaluate each part on a scale from 0 to 5, with additional open questions for each section.

General Feedback



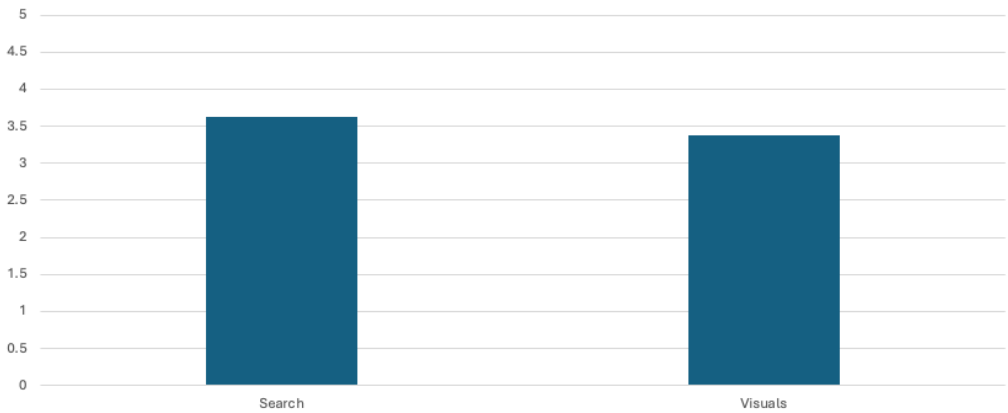
Content evaluation



Open question: general improvements suggestions?

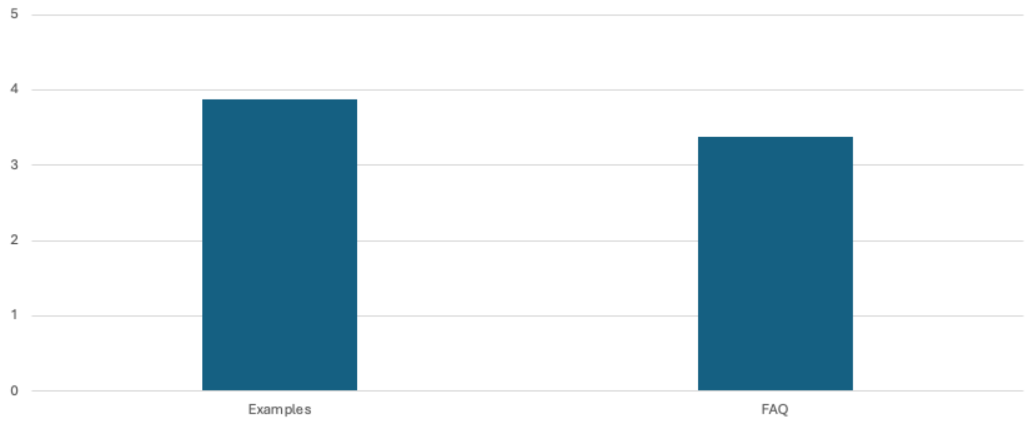
- More "How to" Tutorials
- The areas in my specific interest are not well covered but this is due to the nature on our subproject
- Examples and use cases

Usability and UX



Some users report difficulties in navigating the pages.

Specific features



Users request more diagrams.

Suggestions for improvements

1. What features or resources would you like to see added?
   - How to examples, How to videos
   - Downloadable Guides
   - Reusable services and software applications
   - More detailed examples
2. Improvements for the content structure or navigation?
   - Organization based on developer journeys
   - Better navigation with better explanation of what each component can provide

Improvements Based on Feedback

While the positive feedback was encouraging, the form also yielded valuable suggestions for enhancement, which has already been partly implemented ahead of the second open call:

- *Desire for More Examples*: Users expressed interest in additional practical examples and case studies to better illustrate the applications of the enablers.
- *Enhanced Navigation*: Some participants suggested improvements to the technical wiki's navigation to facilitate quicker access to specific topics.
- *Regular Updates*: There was a request for more frequent updates on new features, bug fixes, and enhancements to stay informed about the latest developments.

Plans to increment the tech wiki pages and enhance them are currently being discussed internally. A specialized document is being created to keep track of the work ahead of us, in regards to what needs updating and what should be created, with particular focus on enablers, in preparation of OC2.

3.3 CURRENT RESULTS AND OUTCOMES

This chapter presents the current results and outcomes of our technical support efforts, which have significantly advanced our objective of providing robust assistance to project participants and external users navigating the world of Extended Reality (XR) technologies.

Technical Support Initiatives

Substantial progress has been made in offering comprehensive technical support, particularly to the Open Call (OC) winners. Our initiatives have focused on creating accessible resources, providing personalized assistance, and establishing mechanisms for continuous improvement.

We developed a technical wiki hosted on GitHub, featuring thirteen detailed pages covering various aspects of our technologies and enablers. This wiki serves as a centralized repository for documentation, tutorials, and guidelines, facilitating collaboration and knowledge sharing among users. In addition to the wiki, public repositories on GitHub were created for the software and tools developed within the project. Each repository includes detailed README files with step-by-step instructions on setup, installation, and configuration, covering prerequisites, installation procedures, configuration settings, usage examples, troubleshooting tips, and contribution guidelines.

To enhance collaboration and streamline communication, we implemented GitHub Issues on all public repositories. This feature centralizes the tracking of issues, bugs, and suggestions, making it easier for users to report problems, request new features, and receive assistance. By assigning issues to specific team members, we ensure accountability and efficient resolution of user queries. This approach not only aids in the swift identification and fixing of bugs but also fosters community engagement and transparency in our development process.

Support for Open Call Winners

Personalized technical assistance was provided to various OC1 winners, helping them navigate technical challenges and effectively integrate enablers into their projects. We established strong communication channels, fostering trust and collaboration. To gain insights into the effectiveness of our technical support services, we developed and distributed a comprehensive feedback form to all OC1 winners. The form was designed to capture detailed information about their experiences, including usability of resources, quality of support, resource effectiveness, and areas for improvement.

Valuable suggestions from the feedback were analyzed and taken into consideration for future enhancements to the technical wiki, repositories, and support mechanisms.

Although OC2 winners have not yet been announced, we have begun offering technical support to potential participants. Recognizing the importance of early engagement and preparation, efforts are focused on assisting these potential applicants in understanding and utilizing our enablers effectively, thereby enhancing the quality of their proposals and readiness for the upcoming call. We have proactively reached out to interested parties, providing resources to help them familiarize themselves with our technologies. Virtual information sessions have been organized, and consultations are available to address specific questions and provide guidance.

3.4 NEXT STEPS

Several key lessons have emerged from our efforts. Actively seeking and implementing user feedback is crucial for resource effectiveness. Tailoring support to meet specific user needs enhances satisfaction and outcomes. The value of clear, detailed documentation is essential for enabling users to adopt new technologies confidently. Providing multiple formats, such as written guides, video tutorials, and interactive sessions, caters to diverse learning preferences.

The importance of early and proactive support is evident. Initiating support for potential participants fosters preparedness and can lead to better project proposals.

Proactive engagement helps identify and address challenges before they escalate. Community engagement enhances success, as building a collaborative community encourages knowledge sharing and collective problem-solving. Open communication channels strengthen relationships between users and support teams, contributing to a supportive environment that benefits all participants.

Feedback

In response to the feedback, we outlined the following future improvements:

- *Expanded Content*: develop additional examples, tutorials, and case studies to provide users with a broader understanding of how to apply the enablers in various contexts.
- *Improved Navigation*: restructure the technical wiki to include an intuitive menu system, categorization of topics, and a search function to enhance user experience.
- *Update Notifications*: establish a notification system to inform users of updates, including a changelog on the wiki and an opt-in mailing list for direct communications.

Furthermore, we are considering incorporating feedback mechanisms directly into our resources:

- *Feedback Sections*: Added dedicated sections in the wiki and repositories where users can leave comments or suggestions.
- *Community Engagement*: Encouraged users to participate in forums and discussion boards to share experiences and solutions with each other.

These enhancements are designed not only to address the immediate needs of the OC1 winners but also to benefit future users, including OC2 participants. By actively listening to our users and promptly implementing their suggestions, we can significantly improve the effectiveness and user-friendliness of our technical support services.

4 CONCLUSIONS

In this first of two deliverables, we have successfully developed a comprehensive educational framework and provided extensive technical support, significantly advancing our research project's objectives.

The educational framework serves as a foundational tool for educators and stakeholders to understand and integrate XR technologies into educational practices. It covers critical topics such as definitions of XR technologies, their impact on student learning, practical implementation strategies, and integration into various learning environments.

Our technical support efforts, including the creation of a detailed technical wiki, public repositories with comprehensive documentation, and personalized assistance to Open Call winners, have empowered users to effectively utilize our enablers. The positive feedback received has enabled us to refine our resources, ensuring they are user-friendly and effective. We have fostered a collaborative community, encouraging knowledge sharing and collective problem-solving among participants.

The successful execution of these tasks has resulted in valuable tools and resources that empower external users to confidently enter and explore the world of XR. By offering both an educational framework and robust technical support, we have lowered the barriers to adopting XR technologies in educational contexts. These developments not only fulfill our project's objectives but also contribute to the broader advancement of XR in education.

Looking ahead, we are committed to building upon these achievements. We plan to expand the educational framework with additional topics and continue refining our technical support to meet evolving user needs. Our ongoing efforts aim to contribute meaningfully to the advancement of XR technologies in education, enhancing learning experiences, and supporting educators and learners in embracing these innovative tools.