



D2.4 XR2LEARN MARKETPLACE, IPR TOOLS AND PLATFORM

XR2Learn Marketplace, IPR
Tools and Platform

WP2

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EXECUTIVE SUMMARY

XR2Learn aims to create an XR technology hub, providing support on two different levels: the business level and the technical level. To provide business support, XR2Learn introduces its platform, featuring a suite of tools and assets that pave the way for new business processes and elevated interactions within a community centred around XR and education.

The document provides an updated description of each component and new functionalities and outlines the integration work that unifies them under a common platform front end. In this way, Deliverable D2.4 demonstrates the continued alignment with the project's objectives while paving the way for sustained support of the XR community and the forthcoming piloting activities of the Open Call projects.

The enhancements presented in this deliverable have been shaped by the feedback collected from the first Open Call projects, ensuring that the platform responds directly to the needs of its early adopters. Collectively, the new elements promote transparent intellectual-property management, streamline the discovery and reuse of XR learning materials, and foster richer collaboration within the community. This document also highlights the added value of NFT-based asset handling, underscoring how blockchain technology enables flexible ownership models and fair revenue redistribution in the XR domain.

LIST OF ABBREVIATIONS

DoA	Description of Action
NFT	Non-Fungible-Token
API	Application Programming Interface
MOOC	Massive Open Online Courses
BE	Backend
FE	Frontend
UI	User Interface
UX	User Experience
SSO	Single Sign On
WP	Work Package
PoS	Proof of Stake
IPR	Intellectual Property Rights
CI/CD	Continuous Integration / Continuous Deployment
FSTP	Financial Support to Third Parties
OC	Open Call

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	VERENIGING VAN EUROPEAN DISTANCE TEACHING UNIVERSITIES
EITM	EIT MANUFACTURING SOUTH SRL

1 INTRODUCTION

1.1 PURPOSE AND CONTEXT OF THE DOCUMENT

The purpose of this document is to report the updated technical work of the business support branch of XR2Learn in months 13 to 30 of the project. It reports the results of the activities carried out under the context of tasks T2.3 “XR2Learn Marketplace and IPR handling tools” and T2.4 “XR2Learn platform integration”. One of the objectives is to showcase how the final version of the XR2Learn Platform and Marketplace was shaped, connecting the feedback from the first open call projects of XR2Learn as well as the internal consortium, and implementing them according to the latest technical advancements. Moreover, the ground is set to explain how XR2Learn leverages blockchain and NFTs to empower the community of XR technology. The rest of the document’s purpose is the description of the updated technical work carried out within the associated tasks, with a focus on the business processes enabled by the XR2Learn platform and marketplace.

Towards achieving the goals described above, the report starts with an analysis of Blockchain technology in XR2Learn, outlines the feedback received by the XR2Learn funded projects, continues with the description of the updated technical work and concludes with a description of the final integration activities. A detailed structure is provided in section 1.2.

1.2 DOCUMENT STRUCTURE

Following the executive summary, the introduction provides insights that first clarify the rationale of using NFTs in XR2Learn and the added value they provide for different stakeholders, and analyses the feedback gathered, which drove part of the changes to shape the last version of the platform. The document reports the technical work in three high-level sections, guiding the reader from the outer level components as the platform, to the most specific ones as the IPR Tool, and concludes the report with information on the status of the integration activities. More specifically, the chapters are the following:

- **Section 2** describes the updates performed on the level of the XR2learn platform, more specifically,
 - It reports the new functionalities of the catalogue, the forum, and the wiki
 - It introduces a new tool, the Learning Path
- **Section 3** outlines the final version of the XR2Learn Marketplace, which includes new features, functionalities, and a brand-new look
- **Section 4** includes the details of the blockchain realm, which consists of the implementations existing within or interacting with blockchain networks. It analyses the updates performed at the level of:
 - The IPR Tool, which enables the NFT interactions
 - The Smart Contract, which is the code that implements the NFTs and is deployed in the XR2Learn supported blockchain networks

- **Section 5** reports the current status of the integration activities of the platform and the infrastructure updates

1.3 BLOCKCHAIN AND NFTS IN XR2LEARN

The purpose of this subsection is to provide a clear rationale for employing blockchain technology, and specifically NFTs, in the context of the XR2Learn Platform and Marketplace. Additionally, it prepares the reader for understanding the infrastructure and decision-making on the platform features better.

Background

Blockchain is an emerging technology which, at its core, provides an immutable record of transactions within a network. Each participant in the network has immediate access to this record. This functionality unlocks several powerful features:

- **Transparency:** Everyone is able to view the current status of the network and any transaction that has ever happened on the network.
- **Decentralisation:** The control of the network is not in the hands of a single entity but is distributed among multiple participants. In cases of public networks as the ones employed in XR2Learn, for example, Ethereum, the network nodes (or participants) are around 25.700 across the globe at the time of writing [1]. This fact illustrates the power held by the network and ensures high decentralisation.
- **Immutability:** Information written on the blockchain cannot be removed or get tampered with.

These core features are what popularised blockchain applications in the first place. In its formative years, blockchain was employed mainly for financial applications, like tracking financial transactions in a network. As the technology evolved, the programmatic ability was introduced, which enabled a plethora of new abilities and dimensions that got unlocked. The first blockchain network to introduce the ability to create programs on the blockchain was Ethereum, and the programs are called Smart Contracts.

One of the most popular applications of Smart Contracts arrived in the form of a standard that defined a way to create non-fungible tokens. Two important definitions need to be introduced:

- **Token:** A token is considered any digital asset.
- **Fungibility:** Fungibility is the ability to exchange assets without the loss of value. For example, we consider fungible assets FIAT currency, gold or even corn. Any kilo of gold holds the exact same value as any other kilo of gold because they have the same properties.

Therefore, a non-fungible token or NFT is a digital asset with unique attributes. In the present era, any asset - digital or physical - can be wrapped as an NFT, the most popular example being art.

The unique attributes of NFTs are coded in the form of metadata. The metadata are formatted as a JSON file, which defines the properties of the NFT such as a title, a description or an image. The structure of the metadata is loosely defined in the Token Standards, such as ERC-721 and ERC-1155, which is the one implemented by the project [2]. They provide a required structure that can be expanded according to the needs of each application. NFT Marketplace platforms, such as OpenSea, often define their own

metadata standards built on top of the token-defined ones to ensure external NFTs are compatible for displaying them in their platforms [3]. The metadata are usually stored in a decentralised database (such as IPFS [4]) and directly attached to the NFT via a URI.

NFTs in XR2Learn

The XR2Learn marketplace is blockchain-enabled, as users are able to leverage its power to mint NFTs of their projects/applications or content in general. In the marketplace, users can explore a variety of content aiming to promote and support the evolution of XR technology, for example, software, 3D assets, datasets and even relevant educational materials as displayed in Figure 1.

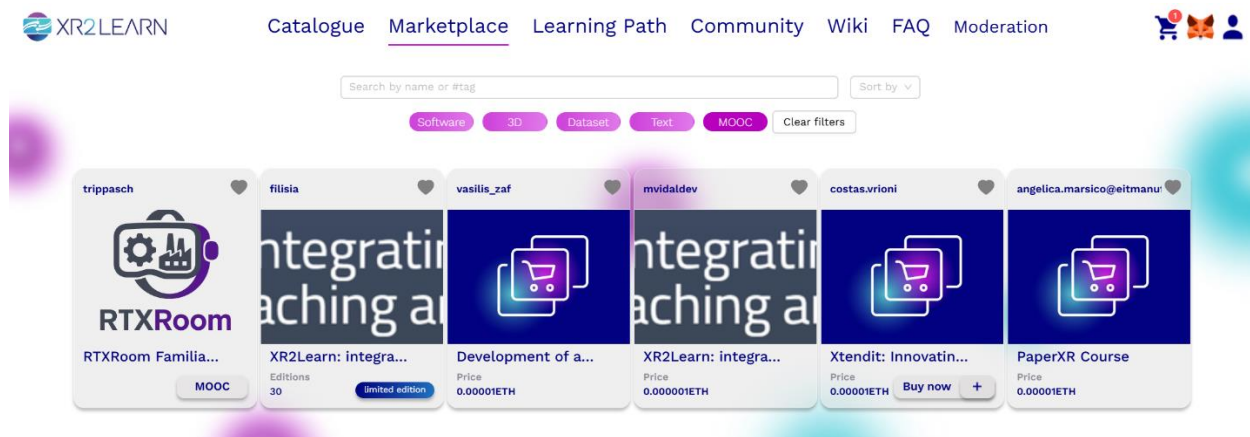


FIGURE 1 XR2LEARN MARKETPLACE

Each NFT is associated with a specific license (Figure 2), which creators select from a list of supported licenses.

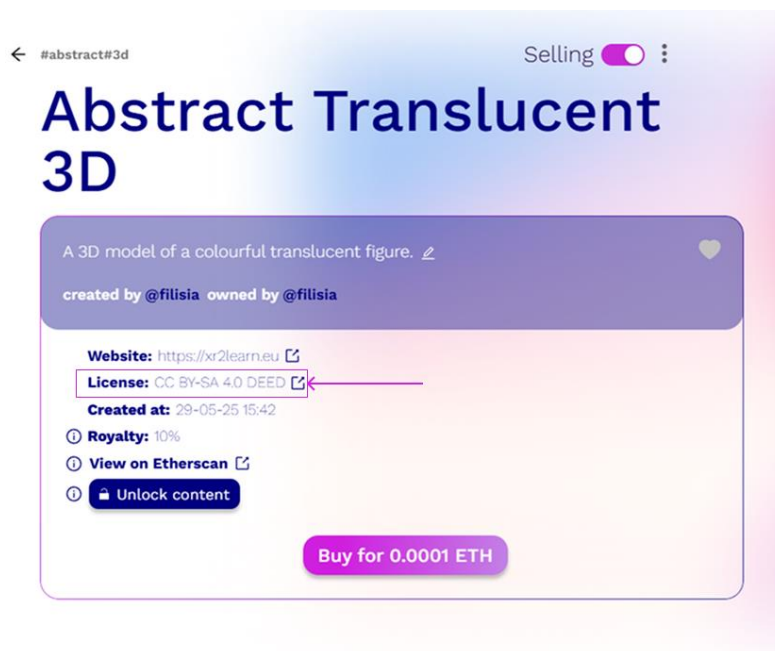


FIGURE 2 NFT DETAILS CARD HIGHLIGHTING THE LICENSE ATTACHED

By minting NFTs of XR-related content, the project ensures that:

- Creators retain control over their intellectual property

- b) Every creation of content and subsequent sale is traceable
- c) Transparent prices and remuneration mechanisms ensure fair transactions

These qualities unlock the potential for guaranteed and verifiable authenticity of assets and provenance, and automatic protection of IPR.

The added value of NFTs for different stakeholders

- **Content creators:** For people who produce content, whether **developers/innovators**, **startups** (software, datasets), **designers** (3D), or **educational institutions** (educational materials), NFTs unlock new business potential and uncover new revenue opportunities. Powered by blockchain, they are able to sell their content without any intermediaries and profit directly in a series of simple steps requiring no technical expertise. The value of their NFT content, as well as their IPR, is transparent and enforceable by the nature of smart contracts. Additionally, creators can leverage the royalty functionality to continue benefiting from the resells of their original works through automatic payments, retaining value from secondary markets.
- **Educators:** The marketplace offers novel materials of verified authenticity, provenance and clear status about the IPR, which is an important aspect when collecting materials to be used by established institutions and organisations.
- **Learners:** NFTs create a sense of quality and trust, allowing them to learn from materials they can verify the resources of and enabling them to resell after they have used them. This secures economically sustainable access to high-quality materials and appropriate crediting of original creators (royalties).
- **Buyers:** Unlike traditional marketplaces, where items bought cannot be easily (if at all) resold, using NFTs, XR2Learn ensures that buyers become true owners of assets and provides them with the ability to create a new layer of value: to monetise any purchase when no longer needed. Additionally, every item created in the NFT is guaranteed to exist in their wallet as long as the blockchain network exists (possibly forever), which means they retain control of their assets no matter what happens to the XR2Learn platform.

1.4 USER FEEDBACK AND NEW VERSION ALIGNMENT

This section provides an overview of the feedback received after the release of the first version, gathered by the OC projects, and analyses how they have been incorporated into the final version of the XR2Learn platform.

When the first set of FSTP-funded projects concluded their implementation phase, they enriched the XR2Learn platform with materials they had produced, mainly in the Marketplace. In total, they provided:

- 76 3D models
- 4 software applications
- 4 datasets

After using the platform, EITM collected feedback from 6 out of the 7 projects to examine the usability of the platform (in that version), gather insights into aspects that could be improved, establish features that could potentially be needed by potential

users of the platform (as the projects themselves) and assess the features that should be highlighted.

The feedback was gathered in an Excel document, and its analysis is provided below.

1. Which kind of material did you upload to the marketplace?

From the feedback gathered, which is also verified in the marketplace, around 83% contributed with software, while 66% contributed with 3D models. The percentages reflect that technical SMEs will most likely contribute to one of these categories or even both, as was the case in most of the projects.

2. Can you identify any challenges you faced when uploading your content?

One of the projects faced issues in uploading large files (around 100MB) and mentioned that they would prefer to see the maximum allowed sizes more explicitly. Another one faced some issues when registering for the platform, which were later fixed. One mentioned an extended loading time. And another one characterised the flow as “chunky” and preferred a smoother UI experience. The final two projects mentioned that for them, the experience was smooth, and they did not face any challenges.

From the analysis of this feedback, we extracted four requirements that would need to be added in the last version of the platform and are outlined in Table 1 below.

TABLE 1 FIRST SET OF REQUIREMENTS

Requirement ID	Description
REQ1	The maximum upload size in the marketplace must be increased to 100MB and must be made clearly visible in the content creation flow.
REQ2	The registration process must be updated for a smooth experience.
REQ3	The loading time of the marketplace must be decreased by investigating the infrastructure and performing optimisations on a software level.
REQ4	The UI/UX must be improved to offer a smoother experience to the users that is up to modern platforms’ standards.

3. How satisfied are you with the current support?

From a scale of 1-10, the average of the responses received was 7, which is considered satisfactory but with room for improvement in the second set of open call projects.

4. What does your ideal experience look like when uploading materials to the marketplace?

One mentioned that the process was already smooth, but would prefer higher file size limits, which reinforces the need for REQ1 in Table 1 to be satisfied. One mentioned their ideal experience would include being able to preview items before publishing and being able to edit the descriptions. Others reflected on the experience being “quick and painless” and “easy to identify and quick”, which can be addressed by REQ4. Lastly, one added that they would enjoy being able to use markup formatting in the item descriptions.

From this feedback, additional requirements have been extracted and outlined in Table 2.

TABLE 2 SECOND SET OF REQUIREMENTS

Requirement ID	Description
REQ5	The marketplace must allow users to edit the descriptions post publishing.
REQ6	The marketplace description must support markup formatting.

5. How do you think we could enhance the perceived value of uploading materials to the marketplace?

The analysis reflected feedback which had already been collected in previous sections of the questionnaire, such as the upload file size, the need for an improved user experience and a recognisable branding across the platform pages, and the loading time. However, new insights were also extracted. Some felt that larger user numbers would be sufficient to improve the perceived value of items, and others pointed toward being able to provide feedback on items.

From the analysis, one additional requirement could be extracted on a technical level, which is added to Table 3.

TABLE 3 THIRD LIST OF REQUIREMENTS

Requirement ID	Description
REQ7	The marketplace must enable users to provide feedback on marketplace items.

6. What goals or benefits do you hope to achieve?

All the participants mentioned Visibility, which reflects that potentially this could be the most important aspect for them. 83% of participants mentioned Networking, which aligns well with the goals of the platforms, as it provides a community forum and the new version of the marketplace incorporates networking features as well (“on-demand application creation”). The following are Direct Sales and Feedback, both mentioned by 33% of the participants, and lastly Licensing Opportunities, mentioned by 16%.

7. What features or tools would you like to see implemented in the marketplace to enhance your experience as a content uploader?

Most of the feedback under this section highlighted the need to enhance the branding of items in the marketplace (which is part of requirement REQ4) and provide an interactive display for 3D materials. Additionally, one mentioned an API specification, which exists but is not currently open to developers external to the XR2Learn consortium.

TABLE 4 FOURTH LIST OF REQUIREMENTS

Requirement ID	Description
REQ8	The marketplace must support interactive display for 3D materials.

8. What challenges have you encountered with the XR2Learn platform?

This section did not provide any new feedback as participants reflected issues they had already described, most of them mentioning the file restrictions on uploading materials. One participant mentioned that they would prefer the value of the different features and the benefits they provide to be more clearly outlined.

The feedback collected reflected the needs and issues that at least a group of potential users could face and can benefit from in the improvement of the XR2Learn as a platform that truly understands and satisfies the needs of the users. The feedback received shaped a list of technical requirements, outlined in Table 5, which was considered in shaping the last version of the platform.

TABLE 5 COMPLETE LIST OF REQUIREMENTS

Requirement ID	Description
REQ1	The maximum upload size in the marketplace must be increased to 100MB and must be made clearly visible in the content creation flow.
REQ2	The registration process must be updated for a smooth experience.
REQ3	The loading time of the marketplace must be decreased by investigating the infrastructure and performing optimisations on a software level.
REQ4	The UI/UX must be improved to offer a smoother experience to the users that is up to the modern platform standards.
REQ5	The marketplace must allow users to edit the descriptions post publishing.
REQ6	The marketplace description must support markup formatting.
REQ7	The marketplace must enable users to provide feedback on marketplace items.
REQ8	The marketplace must support interactive display for 3D materials.

2 PLATFORM

The XR2Learn platform acts as the central hub where users can have access to all the business and technical support services provided by the project. This section focuses on the updated version of the platform and interfaces, reflecting advancements and new features integration aimed at enhancing user engagement and platform utility.

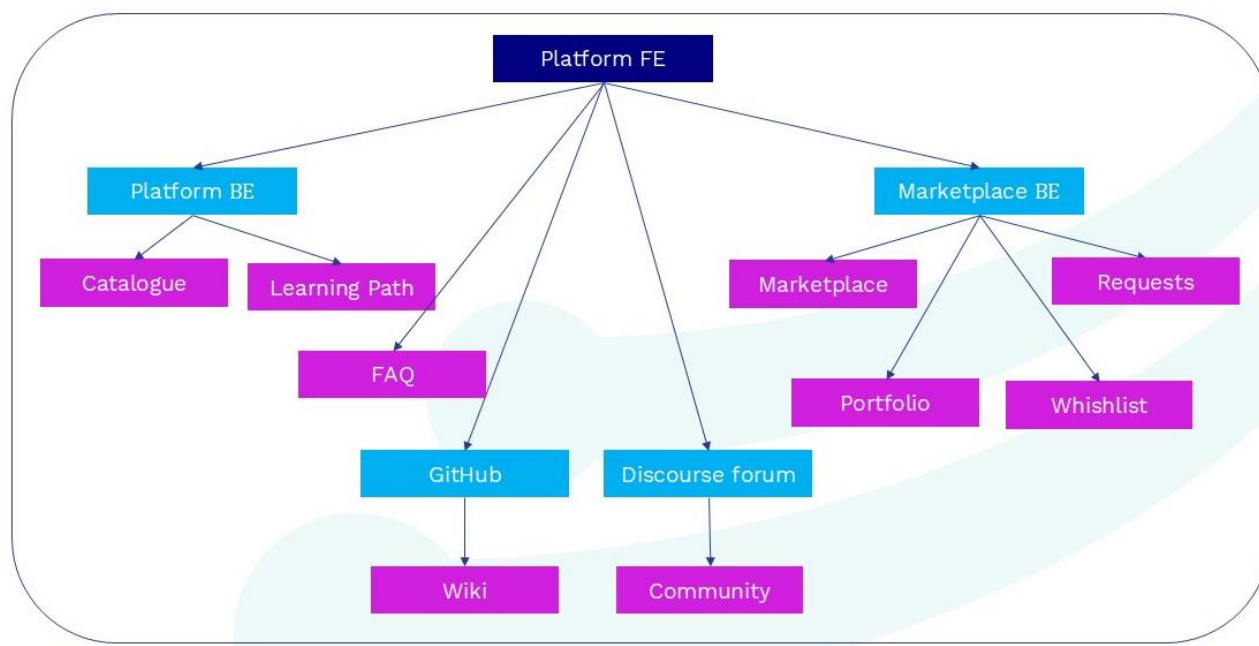


FIGURE 3 XR2LEARN PLATFORM ARCHITECTURAL DIAGRAM

Figure 3 provides an overview of the platform architecture as a whole and the relationships between the different components and services. On the highest level, directly accessible by the user is the **Platform FE** component, comprising a central Platform Frontend (FE) which serves as the unified user interface. This frontend interacts with several distinct backend systems, each responsible for specific domains of functionality:

- **Platform BE:** Manages core platform functionalities, including user profiles, and now, the new Learning Path feature (see section 2.4). It also provides access to the Catalogue.
- **Marketplace BE:** Handles all aspects of the XR2Learn Marketplace, including item listings, transactions (potentially via the IPR Tool), user Portfolio management, Wishlist functionality, and handling Requests. This component and its sub-components are analysed in dedicated sections.
- **GitHub Integration:** Provides access to code repositories and, importantly, serves as the foundation for the Wiki.
- **Discourse Forum Integration:** Powers the XR2Learn Community forum for user discussions and knowledge sharing.
- **FAQ:** Provides a centre where users can find quick answers to the most common questions related to the XR2Learn platform.

Each purple block in the diagram represents core pages or functionalities accessible through these backend systems via the Platform Frontend. The present section focuses on the updates on the Platform BE and its subcomponents, the Wiki (GitHub), and the Forum components.

Additionally, in the last period, significant activities have taken place to refine the platform's presentation and core functionalities. A key update includes a redesign of the website landing page to be more product-oriented. This initiative was driven by an extended study encompassing several aspects critical to user engagement and value communication, including (see **REQ4**):

- **Content Inventory:** Review and strategic organisation of testimonials, reviews, key metrics, product screenshots, and demos to highlight core features effectively.
- **Core Value Proposition:** Articulation through feature-benefit mapping and identification of Unique Selling Points (USPs) to clearly communicate what sets XR2Learn apart.
- **Stakeholder Alignment:** Ensuring the new design resonates with both internal teams (Marketing, Product, Sales) and external partners (institutes, designers, developers, industries) through clear communication plans and feedback loops.
- **Case-Study Development:** Planning for the creation of compelling case studies to showcase the platform's impact and benefits.

The outcome of this comprehensive study will be a new platform landing page featuring more user-friendly, attractive, and product-focused content, designed to better immerse users in the world of XR2Learn and clearly guide them towards the platform's diverse offerings. It will be reported in D5.6. The current version of the landing page has also been redesigned as part of the overall UI/UX update strategy across the platform and is displayed in Figure 4.

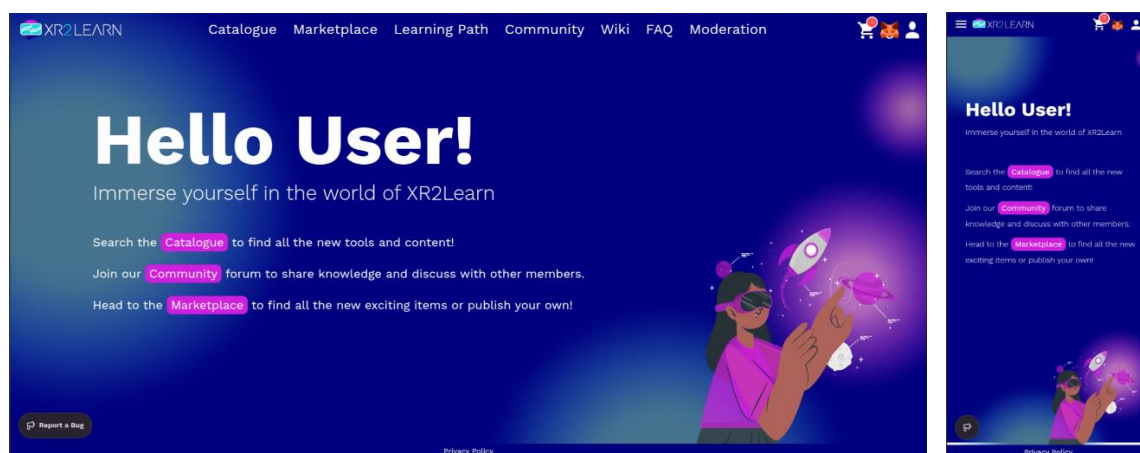


FIGURE 4 PLATFORM LANDING PAGE ON DESKTOP AND MOBILE

Furthermore, a major development in this period has been the successful integration and documentation of the new Learning Path tool. This innovative feature empowers instructional designers and educators to create structured, XR-based educational programmes by leveraging content from the XR2Learn Catalogue that has been labelled with specific, predefined learning outcomes. This method of content identification

significantly enhances the platform's capabilities for targeted educational content creation and delivery.

Additionally, significant effort has been invested in making the platform's user interface fully responsive, ensuring seamless access across a wide range of devices, including large desktop screens, laptops, tablets, and mobile devices. In the present document, the core pages of the platform are showcased on a general desktop screen and a mobile device. This enhancement substantially improves the accessibility and usability of the XR2Learn platform for diverse user groups. However, certain platform functionalities, specifically those related to blockchain interactions, rely on web browser extensions such as MetaMask, which are not fully supported on mobile devices. Consequently, when users access XR2Learn via a mobile device, they are informed that a desktop web browser is required to leverage the platform's full capabilities (see Figure 5).

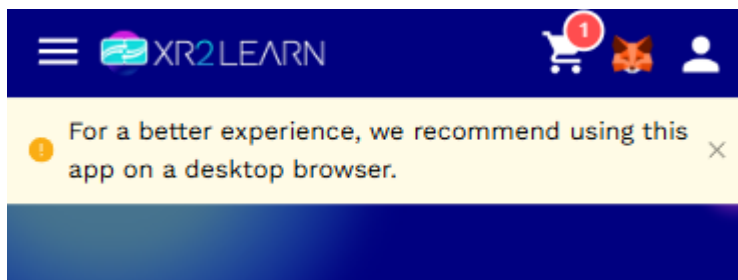


FIGURE 5 MOBILE RECOMMENDATION

Other key platform updates also include the integration of a new version of the marketplace, ongoing UI/UX enhancements across various components, resolution of Keycloak integration issues for smoother authentication, and updated web3 wallet (MetaMask) integration to improve interactions with the NFT and IPR tools. The following sub-sections will detail these updates and new features.

2.1 CATALOGUE

The XR2Learn Content Catalogue serves as a primary access point for all resources, assets, technology, and knowledge registered within the XR2Learn ecosystem. It provides a user-friendly interface for searching, filtering, and managing these items, which form the building blocks for both general discovery and structured educational programs created via the Learning Path tool.

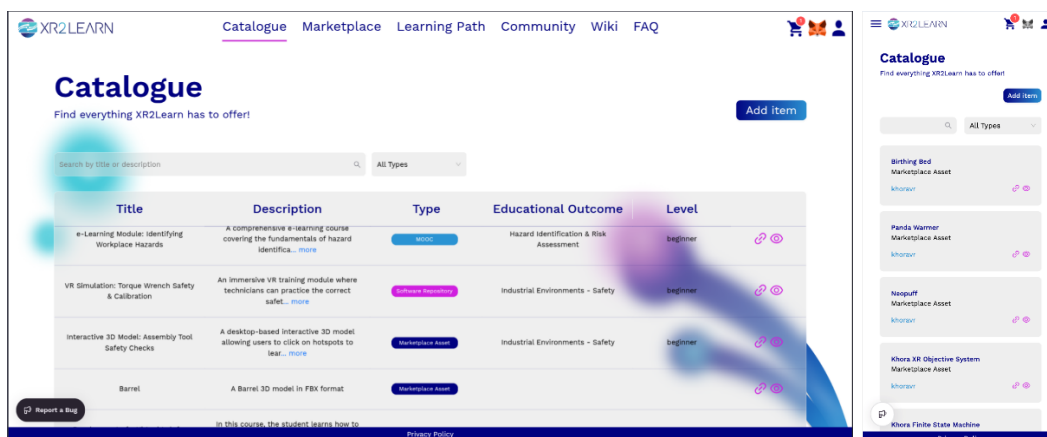


FIGURE 6 CATALOGUE PAGE ON DESKTOP AND MOBILE

2.1.1 Updates

In the last period, the following updates have been made to the Catalogue to enhance its functionality and support new platform features like the Learning Path Tool:

- **Introduction of Learning Outcome Labelling** for Catalogue Items: A significant enhancement has been the introduction of functionality to label Catalogue Items (i.e., Learning Materials) with specific, predefined learning outcomes (see Figure 7). This allows contributors to explicitly indicate the pedagogical purpose or skill that their content addresses. This labelling is crucial for the new Learning Path Tool, enabling instructional designers to accurately discover and link relevant Catalogue Items to the Learning Outcomes defined within their educational paths.

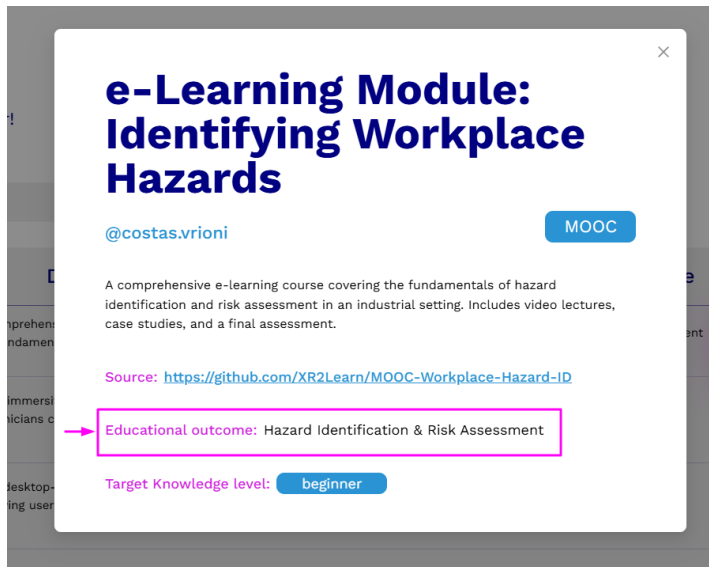


FIGURE 7 EDUCATIONAL OUTCOME ON CATALOGUE ITEM

- **Enhanced Search and Filtering:** The Catalogue's search functionality has been improved to allow more granular filtering. Users can now filter not only by item type (e.g., Marketplace Assets, Software Repositories, MOOCs), but also by general tags and other metadata. This makes it easier for users, especially those using the Learning Path Tool, to locate specific tools and content relevant to particular educational objectives. (See Figure 8)



FIGURE 8 ENHANCED SEARCH AND FILTER ON CATALOGUE

- **Improved Item Management:** The interface for adding, editing, and deleting registered items in the catalogue has been refined for better usability. Clearer forms and workflows simplify the process for contributors. (See Figure 9)

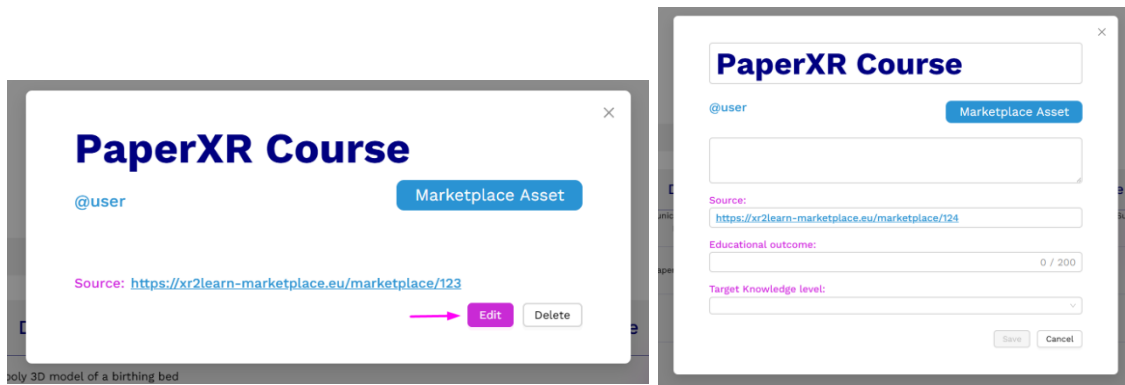


FIGURE 9 EDITING A CATALOGUE ITEM

- **UI/UX Enhancements:** The overall look and feel of the catalogue has been updated to align with the platform's branding and to provide a more intuitive browsing experience. This includes clearer visual distinction between item types and more accessible action buttons.

The Content Catalogue is part of the platform backend module (depicted in Figure 6), therefore, the technical configuration details and deployment guidelines will be reported at the end of this section.

2.2 COMMUNITY FORUM

The Community Forum has been set up since the first release of the platform, and its details have been analysed in D2.2 [5]. Since the first release, technical support has been continuously provided to the partners responsible for setting up the structure and engaging with the community. The technical effort in the forum has been mostly focused on maintenance and implementing the technical needs of the partners, as for example, the ability to host a webinar on the forum, while a redesign has been performed since the version reported in D2.2. The new design features key elements from the project branding to reinforce a recognisable identity of XR2Learn. Moreover, it provides a clearer aesthetic and experience and a modern approach (see Figure 10, Figure 11). In its current form, the forum has been populated with users interacting with each other and creating content, showcasing the potential of shaping a true XR community.

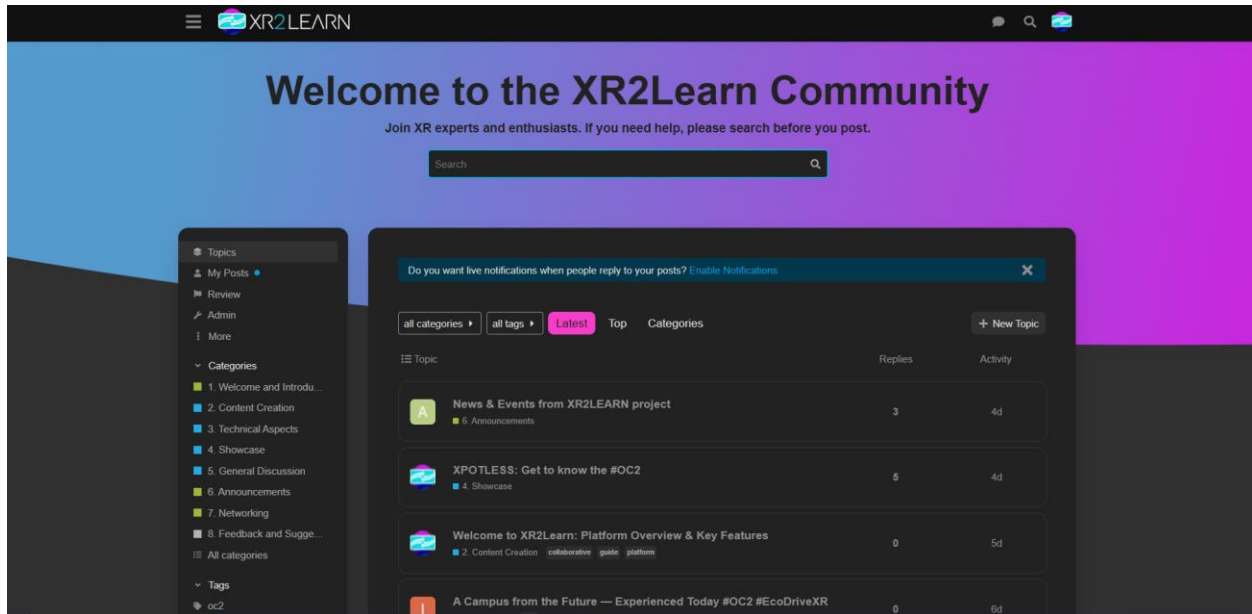


FIGURE 10 COMMUNITY FORUM – DARK THEME

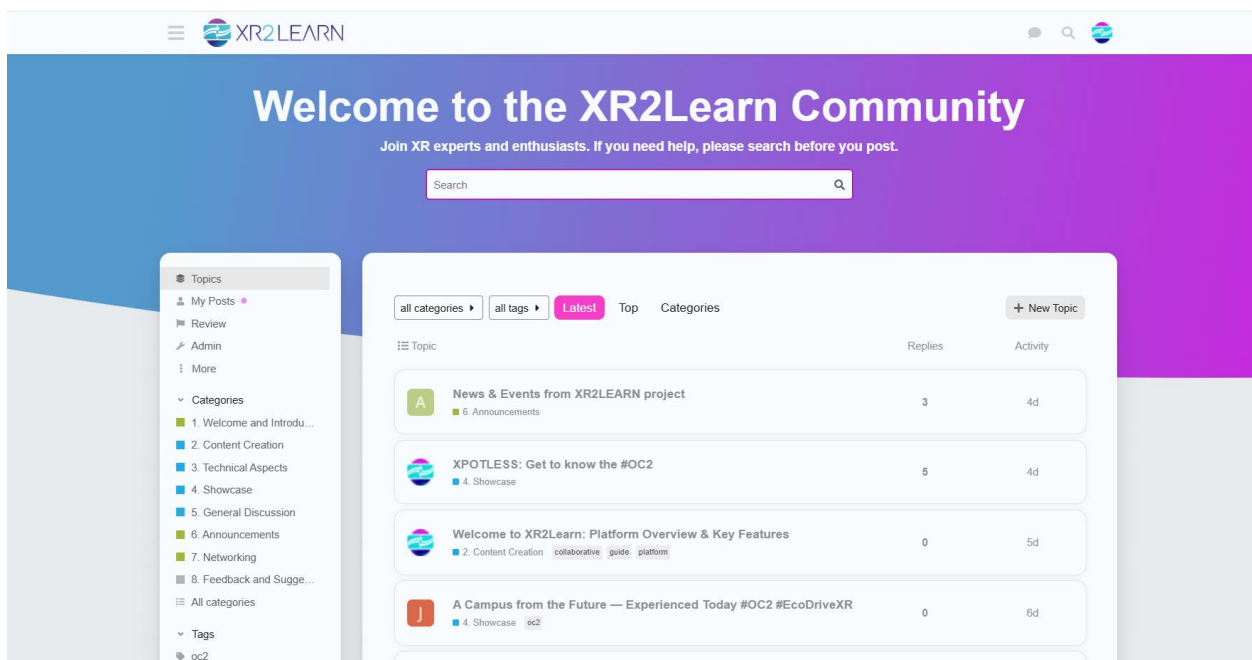


FIGURE 11 COMMUNITY FORUM - LIGHT THEME

2.2.1 Installation and Configuration

The forum is delivered as a self-hosted Discourse instance (See D2.2) and is packaged alongside a PostgreSQL database, a Redis database and a Sidekiq service in a docker-compose file [6].

To configure the service, a `.env` file must be created with the structure that is outlined in Table 1.

TABLE 6 FORUM CONFIGURATION

KEY	VALUE
POSTGRESQL_DATABASE	{Database name}
POSTGRESQL_USERNAME	{Database user}

POSTGRESQL_PASSWORD	{Database password}
DISCOURSE_CLIENT_CREATE_DATABASE_EXTENSION	hstore, pg_trgm
DISCOURSE_CLIENT_CREATE_DATABASE_NAME	{Database name}
DISCOURSE_CLIENT_POSTGRES_USER	{Database user}
DISCOURSE_CLIENT_POSTGRES_PASSWORD	{Database password}
DISCOURSE_DATABASE_HOST	postgresql
DISCOURSE_DATABASE_NAME	{Database name}
DISCOURSE_DATABASE_PORT_NUMBER	5432
DISCOURSE_DATABASE_USER	{Database user}
DISCOURSE_EMAIL	{Admin email}
DISCOURSE_FIRST_NAME	{Admin first name}
DISCOURSE_HOST	{The domain where the forum will be hosted}
DISCOURSE_LAST_NAME	{Admin last name}
DISCOURSE_PASSWORD	{Admin password}
DISCOURSE_REDIS_HOST	redis
DISCOURSE_REDIS_PORT_NUMBER	6379
DISCOURSE_USERNAME	{Admin username}

The forum can be installed by cloning the repository (available in the XR2Learn GitHub) and running the following command:

- `docker compose up -d --build`

2.3 WIKI

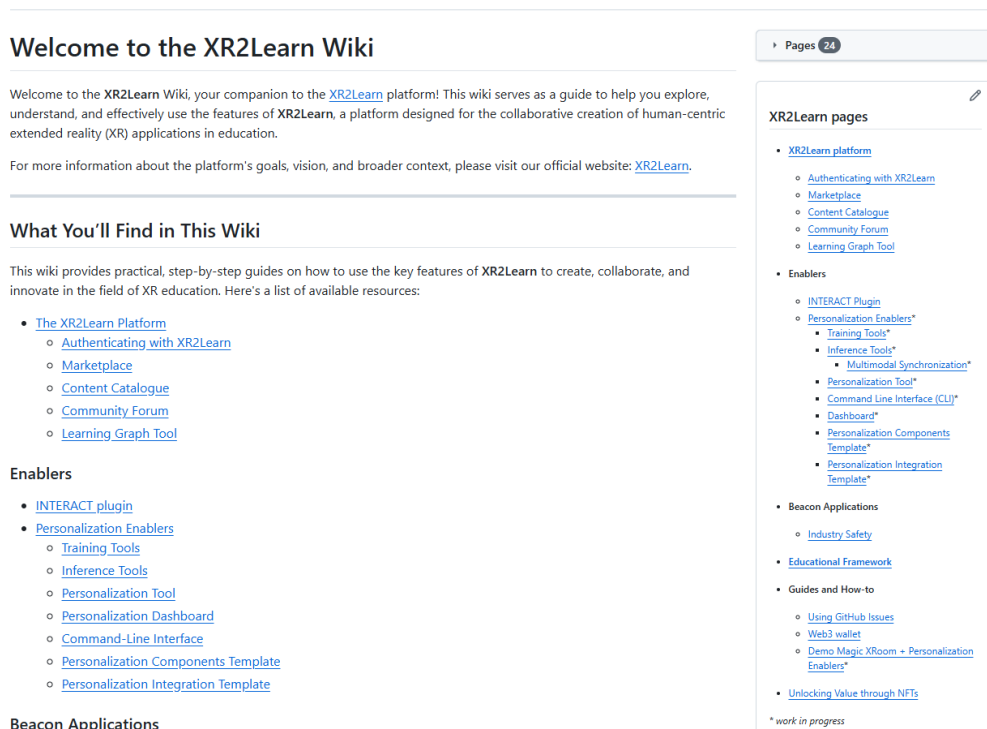
The XR2Learn Wiki (accessible via the platform and on GitHub under this link: <https://github.com/XR2Learn/.github/wiki>) serves as the central documentation hub for all platform components, tools, and services.

In the last period, the following updates have been made to the Wiki:

- **Integration of Learning Path tool Documentation:** Comprehensive guides for the newly released Learning Path tool have been completed and published. This includes:
 - Detailed explanations of the core concepts (Learning Topics, Learning Outcomes, Tag-based Material Linking).
 - Step-by-step instructions for instructional designers and educators on how to create, manage, and utilize Learning Paths.
 - Guidance on utilizing the predefined 'learning outcome' attributes of Catalogue items to define Learning Outcomes within the path and discover relevant XR Learning Materials.
- **Updated Platform Component Documentation:** Existing documentation for core platform services, including the Catalogue, Marketplace, and IPR Tool, has been revised to reflect the latest UI/UX enhancements, feature updates, and API changes. This ensures that users have access to the most current information.
- **Enhanced Navigation and Structure:** The overall structure and navigation of the Wiki have been improved to make it easier for users to find specific information. Content has been reorganized for better clarity and discoverability, with clear

sections for each major platform component, including the new Learning Path tool.

- **API Documentation Updates:** Where applicable, links to or embedded API documentation (e.g., Swagger/OpenAPI specifications) for platform services have been updated to reflect any modifications or additions to endpoints, particularly those supporting the new Learning Path tool functionalities.
- **Installation and Configuration Guides:** Instructions for setting up and configuring different components of the XR2Learn platform have been reviewed and updated to ensure accuracy and completeness, considering any changes in dependencies or procedures.



The screenshot shows the 'Welcome to the XR2Learn Wiki' page. It includes a welcome message, a link to the official website, and a list of resources. A sidebar on the right lists various pages and enablers.

Welcome to the XR2Learn Wiki

Welcome to the XR2Learn Wiki, your companion to the [XR2Learn](#) platform! This wiki serves as a guide to help you explore, understand, and effectively use the features of XR2Learn, a platform designed for the collaborative creation of human-centric extended reality (XR) applications in education.

For more information about the platform's goals, vision, and broader context, please visit our official website: [XR2Learn](#).

What You'll Find in This Wiki

This wiki provides practical, step-by-step guides on how to use the key features of XR2Learn to create, collaborate, and innovate in the field of XR education. Here's a list of available resources:

- [The XR2Learn Platform](#)
 - [Authenticating with XR2Learn](#)
 - [Marketplace](#)
 - [Content Catalogue](#)
 - [Community Forum](#)
 - [Learning Graph Tool](#)

Enablers

- [INTERACT plugin](#)
- [Personalization Enablers](#)
 - [Training Tools](#)
 - [Inference Tools](#)
 - [Personalization Tool](#)
 - [Personalization Dashboard](#)
 - [Command-Line Interface](#)
 - [Personalization Components Template](#)
 - [Personalization Integration Template](#)

Beacon Applications

XR2Learn pages

- [XR2Learn platform](#)
 - [Authenticating with XR2Learn](#)
 - [Marketplace](#)
 - [Content Catalogue](#)
 - [Community Forum](#)
 - [Learning Graph Tool](#)
- **Enablers**
 - [INTERACT Plugin](#)
 - [Personalization Enablers*](#)
 - [Training Tools*](#)
 - [Inference Tools*](#)
 - [Multimodal Synchronization*](#)
 - [Personalization Tool*](#)
 - [Command Line Interface \(CLI\)*](#)
 - [Dashboard*](#)
 - [Personalization Components Template*](#)
 - [Personalization Integration Template*](#)
- **Beacon Applications**
 - [Industry Safety](#)
- **Educational Framework**
- **Guides and How-to**
 - [Using GitHub Issues](#)
 - [Web3 wallet](#)
 - [Demo Magic XRoom + Personalization Enablers*](#)
- [Unlocking Value through NFTs](#)

* work in progress

FIGURE 12 THE XR2LEARN WIKI

2.4 LEARNING PATH

This section describes the Learning Path, which has been added in the new release of the platform. The Learning Path is envisioned as a core component of the XR2Learn ecosystem, designed to streamline the creation, discovery, and deployment of XR-based educational and training programmes. Inspired by prior research on modular educational toolboxes [7], this tool adapts the concept of a structured learning path (linking Topics, Outcomes, and Materials) specifically for the domain of XR learning content hosted within the XR2Learn Catalogue. Its central innovation lies in using a community-driven labelling system based on educational outcomes to facilitate the effective search, selection, and integration of reusable XR learning materials contributed by the XR2Learn community. The primary objective is to reduce design effort, promote pedagogical best practices, enhance content reusability, and ultimately foster a more vibrant and efficient ecosystem for XR education and training.

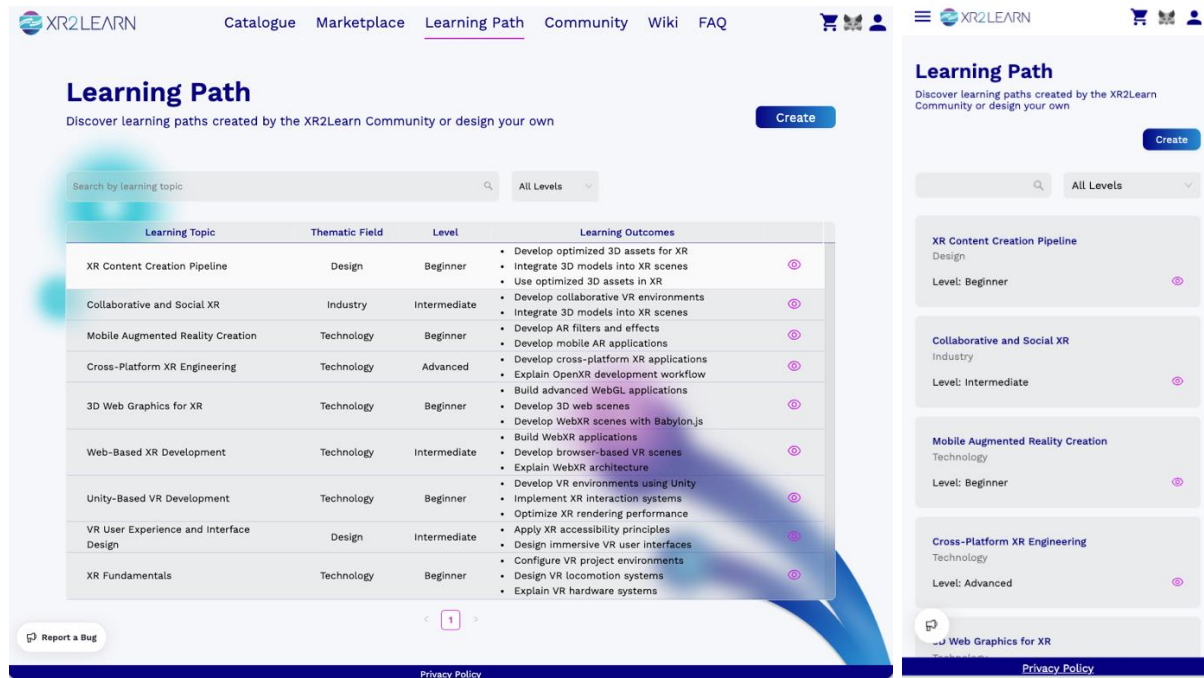


FIGURE 13 THE LEARNING PATH PAGE ON DESKTOP AND MOBILE

2.4.1 Core Concept and Objectives

The Learning Path Tool enables users to visually construct learning programs (represented as paths as displayed in Figure 14) by:

1. Defining a high-level Learning Topic, which includes a Title, a Thematic Field (e.g., Industry, Healthcare, Education), and a Level (e.g., Beginner, Intermediate, Advanced).
2. Breaking this topic down into specific, measurable Learning Outcomes. Each Learning Outcome is defined with a Title.
3. Searching the integrated XR2Learn Catalogue for XR Learning Materials that have been explicitly attributed by contributors with a matching predefined learning outcome value (e.g., "Industrial Environments," "Safety," "Patient Diagnosis"). This attribute is optional for Catalogue items.
4. Linking selected XR Learning Materials directly to the appropriate Learning Outcomes within the path based on this shared, predefined "learning outcome" attribute.

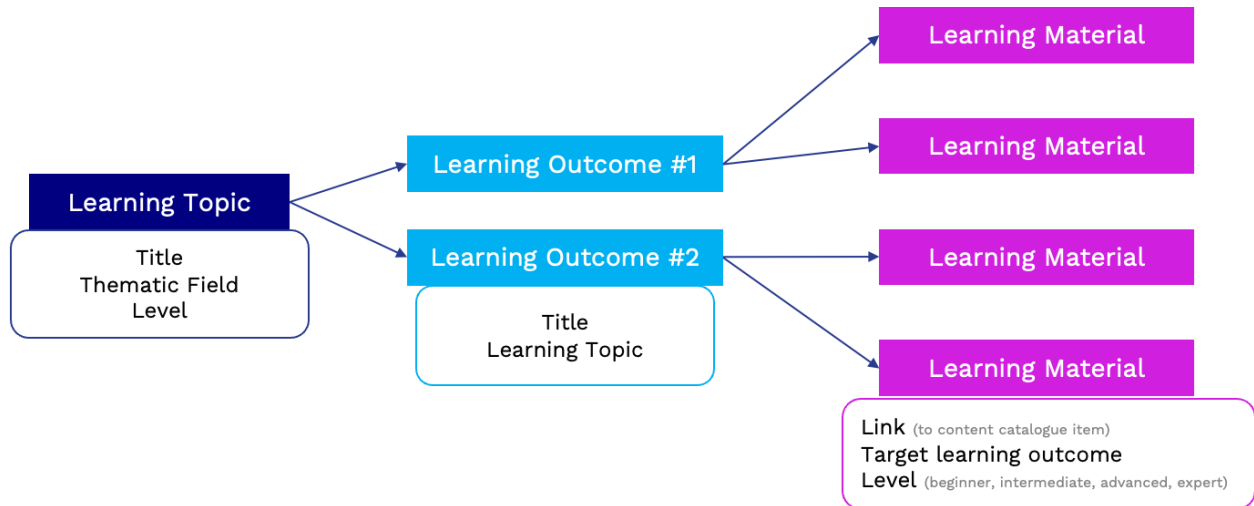


FIGURE 14 LEARNING PATH TOOL CONCEPTUAL MODEL DIAGRAM

Primary Objectives:

- To simplify and accelerate the design process for XR educational programs.
- To promote the reuse of existing XR learning materials available in the XR2Learn Catalogue.
- To establish a standardised method (via outcome labelling) for describing and discovering the pedagogical purpose of XR content.
- To facilitate the creation of structured, outcome-oriented learning paths using XR technologies.
- To empower the XR2Learn community to effectively share and leverage collective content creation efforts.
- To support the seamless integration of a widely recognised educational framework into the XR community.

2.4.2 Architecture

The Learning Path Tool is designed as an integrated feature within the broader XR2Learn platform architecture as displayed in Figure 3.

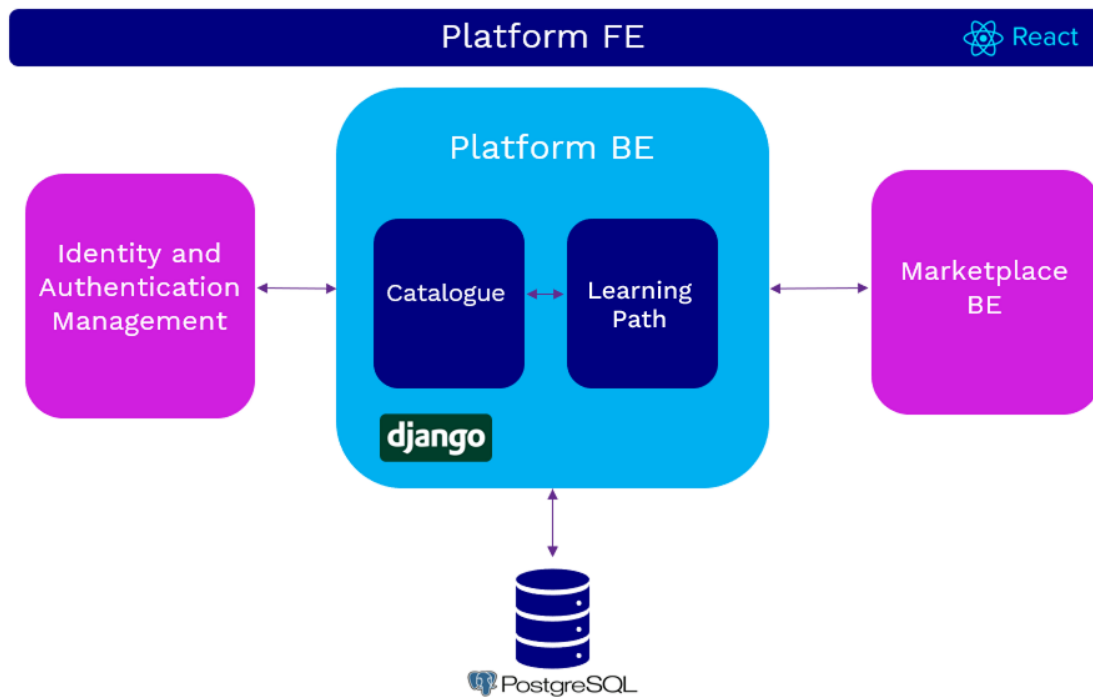


FIGURE 15 LEARNING PATH ARCHITECTURE

Focusing specifically on the Learning Path tool, its architecture, displayed in Figure 15 is designed for seamless integration and rapid development by leveraging existing platform infrastructure, particularly the XR2Learn Catalogue, and utilizing the platform's primary PostgreSQL database.

- **Frontend Integration:** The Learning Path tool UI (Figure 16) is a new, dedicated module within the existing XR2Learn Platform Frontend. This ensures a consistent user experience by using the same UI framework and design language. The UI module is responsible for displaying a dashboard for viewing, creating, and managing Learning Paths. Its design is consistent with the new look and feel and UX provided by the redesigned platform as a whole.
- **Backend Integration:** The backend logic for the Learning Path tool is implemented as new modules within the existing XR2Learn Platform Backend. This backend component handles:
 - New API endpoints (exposed via the main XR2Learn Platform API) for all Learning Path operations (Create, Read, Update, and Delete of topics, outcomes, and links).
 - Business logic for constructing, validating, and managing Learning Path data.
 - Interaction with the platform's main PostgreSQL database to store and retrieve Learning Path data.

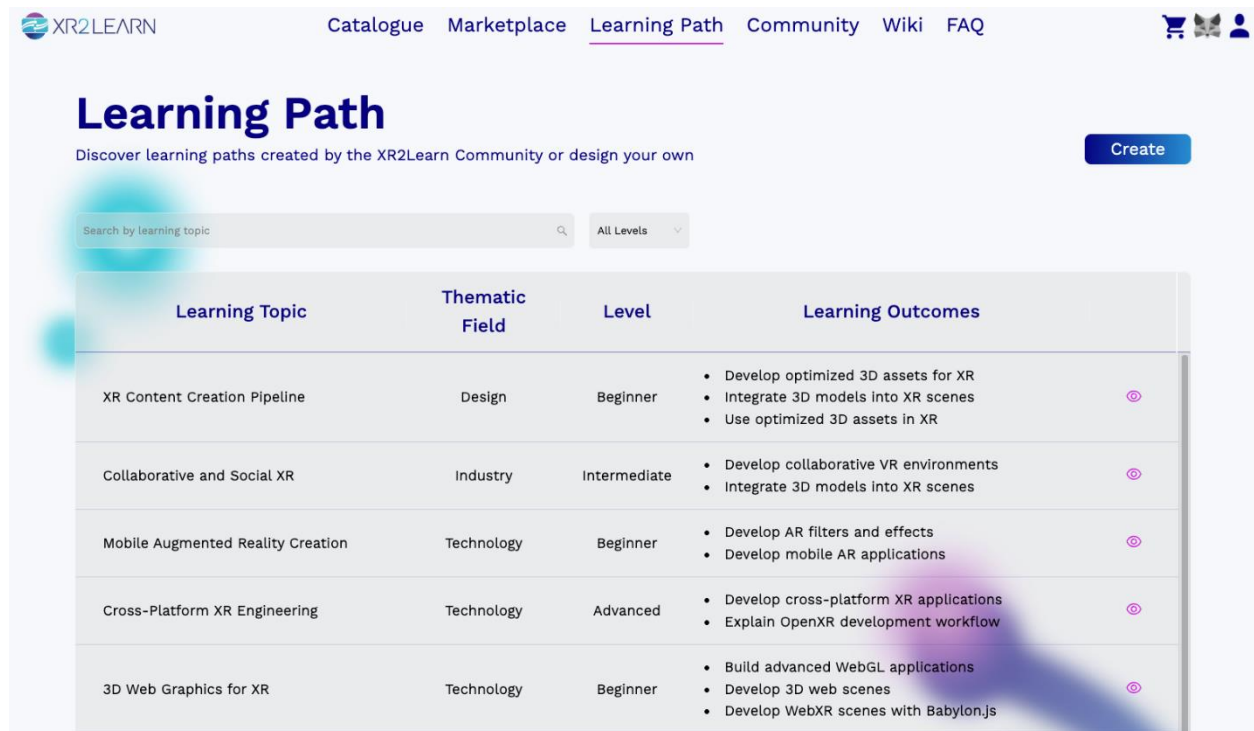


FIGURE 16 LEARNING PATH TOOL DASHBOARD EXAMPLE

2.4.3 Learning Path Creation Workflow

In the current version of the XR2Learn platform, the creation of Learning Paths has been redesigned from a multi-step wizard into a single-page form interface. This design simplifies the workflow by allowing instructional designers and educators to configure all elements of a Learning Path within one consolidated view.

Learning Path Metadata

At the top of the interface, users define the general information of the Learning Path. The required metadata fields include:

- **Learning Topic:** The title of the Learning Path that describes the overall educational objective (e.g., Safety Procedures in Industrial Environments).
- **Thematic Field:** The domain or category associated with the Learning Path (e.g., Industry, Healthcare, Education).
- **Level:** The Level attribute of the Learning Path is based on a simplified interpretation of Bloom's Taxonomy, a widely used educational framework for classifying cognitive learning objectives. The XR2Learn platform maps the learning levels to Bloom's cognitive process dimensions in order to support a structured progression of learner competencies.

The mapping used in the platform is the following:

XR2Learn Level	Bloom's Cognitive Processes
Beginner	Understand, Apply
Intermediate	Apply, Analyze
Advanced	Evaluate, Create

TABLE 7 BLOOM'S TAXONOMY MAPPING

This mapping enables instructional designers to categorise learning paths according to the expected cognitive complexity of the activities and materials included in the path. Beginner paths focus on understanding concepts and applying basic knowledge, intermediate paths involve deeper analysis and practical application, while advanced paths encourage evaluation, critical thinking, and the creation of new solutions or artefacts.

This metadata defines the general pedagogical context and facilitates the organisation and discoverability of learning paths within the platform.

×

Create Learning Path

* Learning Topic
XR tutorial

* Thematic Field
Industry

* Level
Beginner

To design your learning path, select the target learning outcomes and learning materials, then arrange the selected materials in the desired order.

Learning outcomes

Can't find the outcome you need? ⓘ

search outcomes...

- Apply XR accessibility principles
- Being able to deploy and evaluate emotion recognition models using multimodal inference tools
- Build advanced WebGL applications
- Build WebXR applications
- Configure VR project environments

Learning materials

Select one or more outcomes.

Selected and ordered Learning materials

No selected materials yet.

Submit

FIGURE 17 LEARNING PATH METADATA

Selecting Learning Outcomes

On the left side of the interface, users are presented with a searchable list of available predefined learning outcomes. These outcomes represent specific competencies or objectives that learning materials may address.

Users can:

1. Browse the available learning outcomes.
2. Search outcomes using the search field.
3. Select one or more outcomes that will form the structure of the Learning Path.

Once selected, the platform automatically filters and displays the corresponding learning materials associated with these outcomes.

×

Create Learning Path

* Learning Topic
XR tutorial

* Thematic Field
Industry

* Level
Beginner

To design your learning path, select the target learning outcomes and learning materials, then arrange the selected materials in the desired order.

Learning outcomes

Can't find the outcome you need? ⓘ

search outcomes...

Apply XR accessibility principles

Being able to deploy and evaluate emotion recognition models using multimodal inference tools

Build advanced WebGL applications

Build WebXR applications

Configure VR project environments

Learning materials

XR Accessibility Guidelines
Learning outcome: Apply XR accessibility principles

[XR2Learn Personalization Enablers] Inference Tools
Learning outcome: Being able to deploy and evaluate emotion recognition models using multimodal inference tools

Three.js Journey
Learning outcome: Build advanced WebGL applications

Selected and ordered Learning materials

No selected materials yet.

Submit

FIGURE 18 LEARNING PATH LEARNING OUTCOMES

Learning Materials Discovery

The central panel displays Learning Materials retrieved from the XR2Learn Catalogue. These materials are automatically filtered based on the selected learning outcomes.

Each learning material includes metadata such as:

- Title
- Associated learning outcome
- Quick access link to preview the material

Users can review the available materials and choose which resources should be included in the Learning Path.

Building the Learning Path

The right-hand panel displays the Selected and Ordered Learning Materials that will form the final Learning Path.

Using the provided interface controls, users can:

- Add selected materials to the Learning Path.
- Remove materials if necessary.
- Arrange the order of materials according to the desired instructional sequence.

This allows educators to structure the learning experience progressively, for example starting from foundational materials and advancing to more complex topics.

Saving the Learning Path

After selecting and organising the learning materials, users can submit the form to create and store the Learning Path within the XR2Learn platform. Once saved, the Learning Path becomes available for viewing, editing, Integration with XR2Learn educational resources

Create Learning Path ✕

* Learning Topic

* Thematic Field

* Level

To design your learning path, select the target learning outcomes and learning materials, then arrange the selected materials in the desired order.

Learning outcomes

Can't find the outcome you need? ⓘ

Apply XR accessibility principles

Being able to deploy and evaluate emotion recognition models using multimodal inference tools

Build advanced WebGL applications

Build WebXR applications

Configure VR project environments

Learning materials

XR Accessibility Guidelines

Learning outcome: Apply XR accessibility principles • already added

[XR2Learn Personalization Enablers] Inference Tools

Learning outcome: Being able to deploy and evaluate emotion recognition models using multimodal inference tools • already added

Selected and ordered Learning materials

1 **XR Accessibility Guidelines**

Apply XR accessibility principles

2 **[XR2Learn Personalization Enablers] Inference Tools**

Being able to deploy and evaluate emotion recognition models using multimodal inference tools

FIGURE 19 LEARNING PATH CREATION

2.5 INSTALLATION AND CONFIGURATION

This sub-section describes the installation and configuration steps of the Platform BE and the Platform FE components, which deploy the XR2Learn platform.

Prerequisites

System Requirements

The following set of requirements refers to technical requirements for the infrastructure where the platform intends to be installed:

- Docker installed
- Docker-compose installed

Software Dependencies

The following tools are considered as prerequisites since they allow exploring the full potential of the XR2Learn platform and are technically utilised in the Platform FE. The Platform BE component can be independently installed.

- IPR Tool installed
- NFT Marketplace installed
- Forum installed

Configuration and Deployment

The steps for deploying the Platform BE and Platform FE are identical and are the following:

1. Clone the respective repositories from the XR2Learn GitHub
2. Create an `.env` file in the same directory (different for each component) with the relevant structure outlined in tables:
3. Execute the following command: `docker compose up -d --build`

TABLE 8 PLATFORM BE CONFIGURATION

KEY	VALUE
POSTGRES_DATABASE	db
POSTGRES_HOST	Postgres-service
POSTGRES_PASSWORD	{Database password}
POSTGRES_USER	{The database user}
POSTGRES_PORT	5432
ADMIN_PASSWORD	{The Django admin password}
REDIS_HOST	Redis-service
REDIS_PORT	6379
KEYCLOAK_SERVER	{The URL to the Keycloak Realm}
LOGIN_REDIRECT_URI	{Platform base URL}/profile/auto
LOGIN_URL	{Platform base URL}/accounts/XR2Learn/login/?process=login
REALM	{The Keycloak realm}
CLIENT_ID	{The Keycloak client id}
CLIENT_SECRET	{The Keycloak client secret}
AUTHENTICATION_SERVER	{The URL of the Keycloak server}

TABLE 9 PLATFORM FE CONFIGURATION

KEY	VALUE
AUTH_URL	{The URL of the authentication and identity management}
AUTH_REALM	{The realm name}
AUTH_CLIENT	{The client_id}
AUTH_SECRET	{The client_secret}
API	{The URL of the marketplace backend API}
FORUM_URL	{The URL of the community forum}
PLATFORM	{The URL of the platform BE}

3 MARKETPLACE

XR2Learn is offering a marketplace for users to exchange their content and innovations. It works as a place where XR innovators and creators can advertise and sell their work, while being enumerated fairly. The marketplace has been updated to:

- Satisfy the requirements extracted from the OC feedback (see Table 5)
- Provide an updated look and experience that will be able to attract and retain users
- Provide a list of new, powerful capabilities and features

The overall architecture of the tool has remained mostly the same as the one reported in D2.2, as the new features were built on top of or improved the existing infrastructure of the marketplace. The high-level architecture of the marketplace, featuring its integrations with other XR2Learn components and services, is displayed in Figure 20.

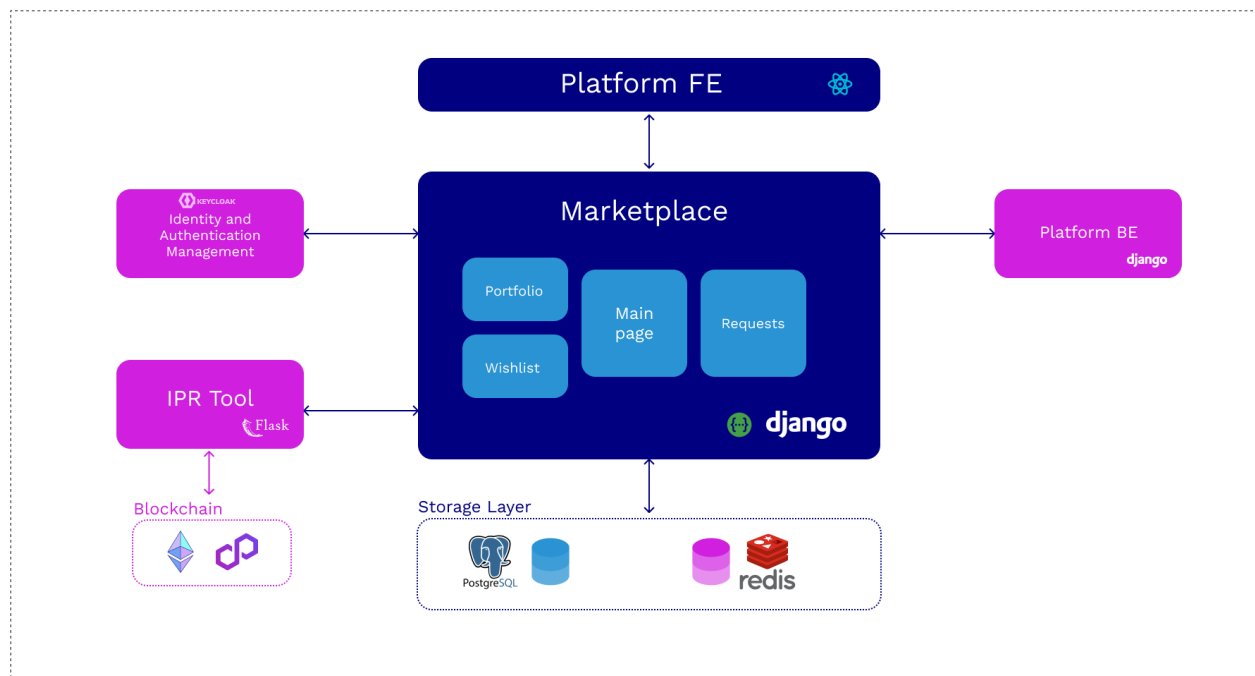


FIGURE 20 MARKETPLACE ARCHITECTURE

The following sections describe the improvements and new features added to the Marketplace.

3.1 UPDATES

The marketplace has been updated in three different axes:

- **UI/UX:** Updates on this level focused on improving the overall look of the marketplace to align with the XR2Learn branding and exude a clean and modern aesthetic that complements the functionalities provided. The redesign was guided by the relevant platform requirements presented in Table 5 Complete List of Requirements such as REQ4 and aimed to highlight the content displayed in the marketplace and the stories they carry, enhancing their perspective value and commercialisation.
- **Features and Functionalities:** Functionalities have been improved, informed by internal testing processes, partner feedback and the platform requirements extracted by the OC #1 questionnaires. Additionally, a multitude of features have been added, some that were already planned from the previous versions of the platform, such as the “on-demand application creation”, and others have been designed according to the list of requirements and internal suggestions. The new functionalities offer an array of possibilities which, along with the IPR Tool, are able to unlock new revenue streams, enhance the selling capabilities and offer better business support to sellers. Moreover, they enhance the intuitiveness of navigating the marketplace, offer clearer explanations on various features and complex terms, with the aim of delivering the most effective trade-off between simplicity and power.
- **Operational:** The underlying infrastructure has been optimised to be able to serve quickly and efficiently, laying the ground for potential scalability scenarios. The marketplace is now integrated with monitoring tools that proactively alert developers to potential issues and bugs and provide a continuous feed of information regarding the performance of the service and delivery times.

The present section presents the new version of the marketplace by navigating the reader through each of its pages and breaking down the different elements and components.

Marketplace Landing Page

Figure 21 displays the new version of the marketplace landing page (or main page).

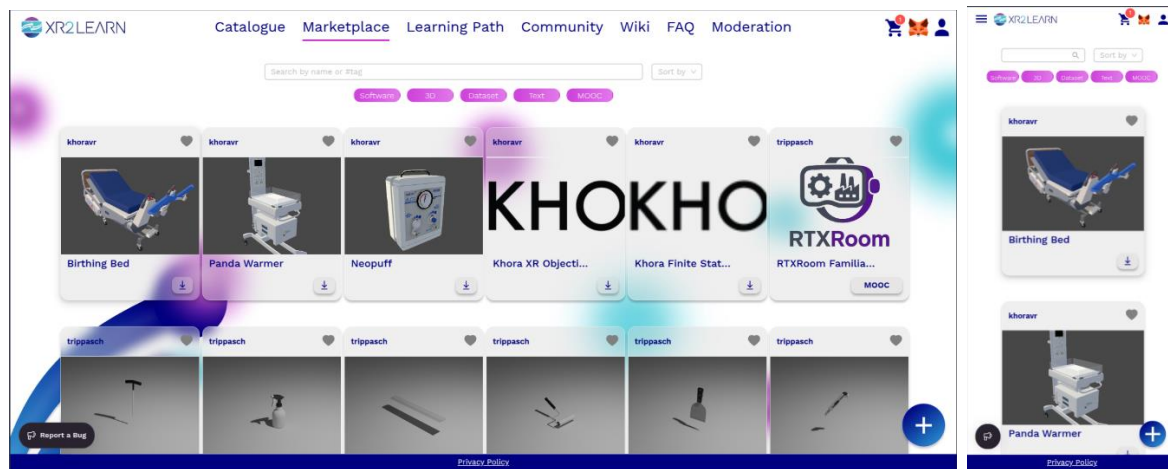


FIGURE 21 MARKETPLACE LANDING PAGE ON DESKTOP AND MOBILE

- **Searching and Filtering:** The searching and filtering capabilities have been improved to enable a smoother content discovery process. Users are now able to search either by any keyword in the title of the item, independent of case or the order of the keyword in the name, or by tags, using the “#” symbol in front of the word. Additionally, filtering and sorting have been improved in terms of efficiency in delivering results. Users are able to filter by selecting the type of items displayed in pink boxes or sorting the items by the time created or by the number of views, which is translated as popularity. (See Figure 22)

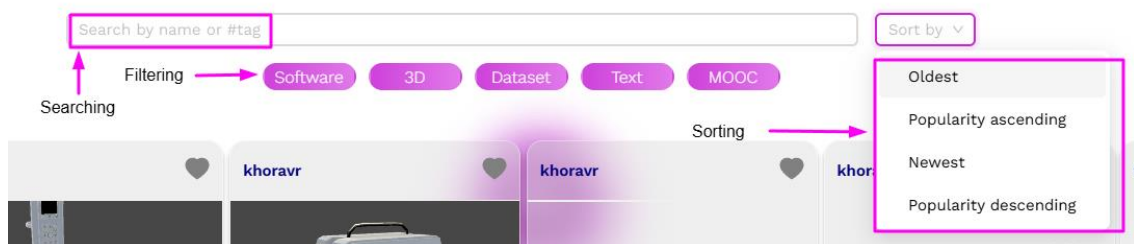


FIGURE 22 MARKETPLACE CONTENT DISCOVERY CAPABILITIES

- **Connection to MetaMask:** The Web3 wallet integration, specifically Metamask, has been improved to be more robust and secure. It now automatically configures the XR2Learn networks in case they are not already set-up in the wallet of the user, lifting the workload the user must take to connect to the marketplace heavily. On top of that, the connection button has been updated to reflect a more minimalist and clear approach. It features the logo of MetaMask which acts as a button to connect. The logo is in black and white spectrum if the user is not connected and in colour when they successfully connect.



FIGURE 23 LEFT: METAMASK NOT CONNECTED - RIGHT: METAMASK CONNECTED

- **Item card:** The marketplace item card has been updated to feature a sleeker look that focuses on providing essential information straightforwardly and with clarity. Important actions have been simplified and improved in terms of experience, for example, viewing a marketplace item's page, downloading, buying or adding to cart (a functionality that will be discussed later in this section) (see Figure 24). Users can also hover over the usernames of item owners or creators to view a glimpse of their basic details, and can click on the user to visit their portfolio.

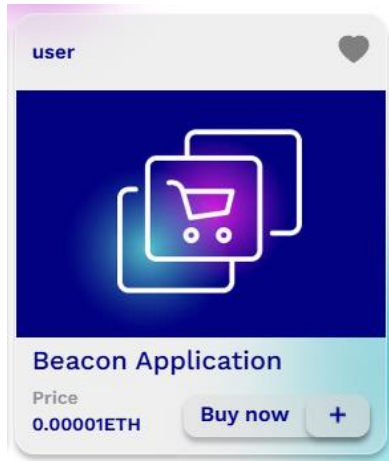


FIGURE 24 NEW MARKETPLACE ITEM CARD LOOK

- **Background:** The background features characteristic elements of the XR2Learn branding, which are also incorporated into the project's website (see Figure 25). This change not only enhances the identity of the project but also provides an essence of professionalism and leverages design trends such as the glass morphism style of the item card. These visual elements are expected to enhance the sense of trust and elevate the quality perception of the marketplace and its contents in the eyes of the users. Long-term, it could potentially lead to an increase in the user base and the activity levels.



FIGURE 25 LEFT: XR2LEARN WEBSITE CONCEPT, RIGHT: MARKETPLACE BACKGROUND CONCEPT

- **Menu:** The navigation menu of the marketplace has been grouped under the marketplace category, which can be expanded to enable the user to navigate the different components of the marketplace and provide a clearer view of the relationships between different XR2Learn services.

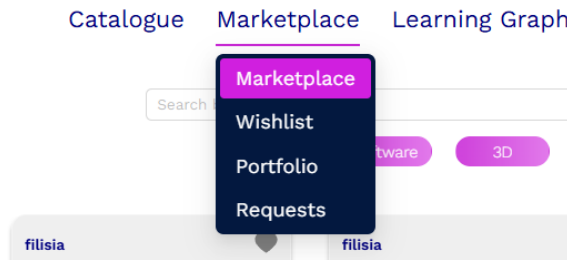


FIGURE 26 MARKETPLACE NAVIGATION MENU

- **Item creation workflow:** The basic steps for creating an item are consistent with the first versions of the platform, as they have proved efficient in guiding non-blockchain-savvy users into minting their own NFTs and publishing their content. However, details of the steps have been enhanced; size limitations of files have been increased and clearly defined (see REQ1 of Table 5) and a preview of the content is supported in most file types upon successful upload, even for 3D models.

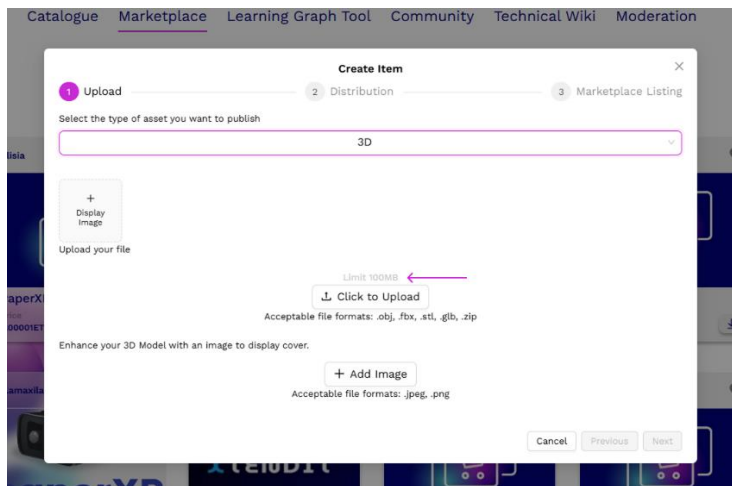


FIGURE 27 MARKETPLACE - FILE LIMITATIONS

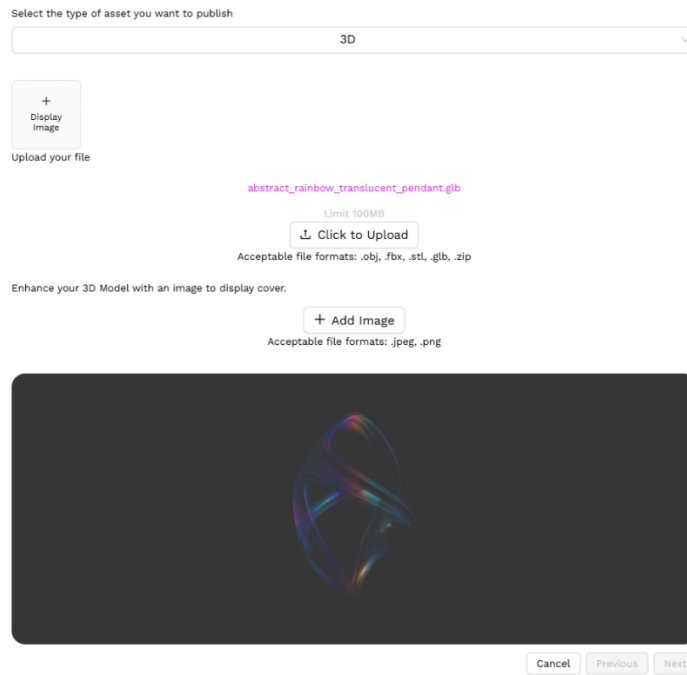
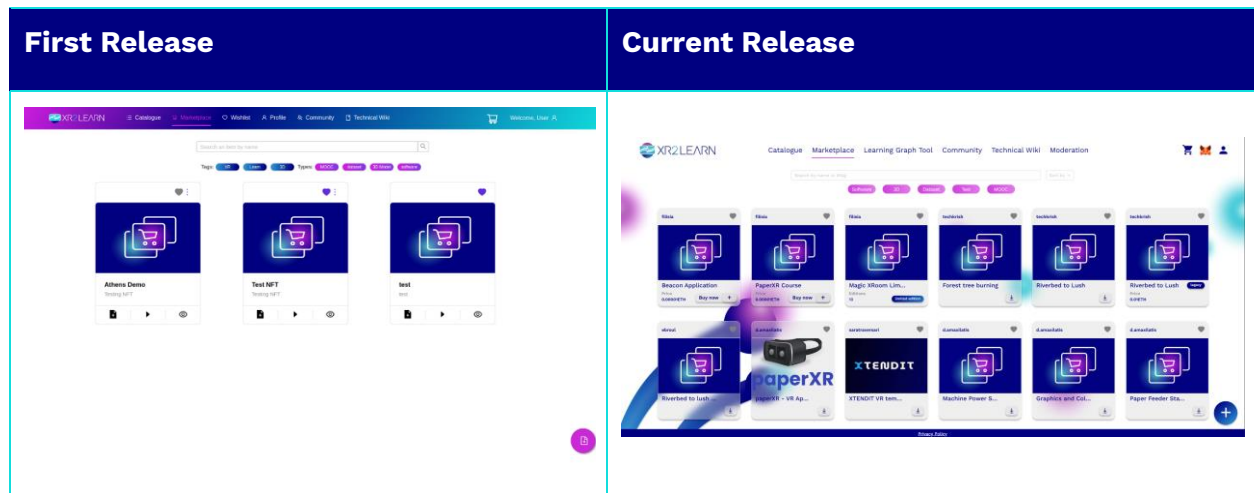


FIGURE 28 ITEM PREVIEW BEFORE PUBLISHING

- **Other:** Additional updates are evident in the marketplace landing page (Figure 21), for example, the different tags which are carried by marketplace items, such as “legacy” and “limited edition”, which are going to be analysed later in the document. To paint a clear picture of the visual and functional changes, Table 10 shows the first version of the marketplace compared to the current version.

TABLE 10 COMPARISON OF THE MARKETPLACE EVOLUTION



Marketplace Item Page

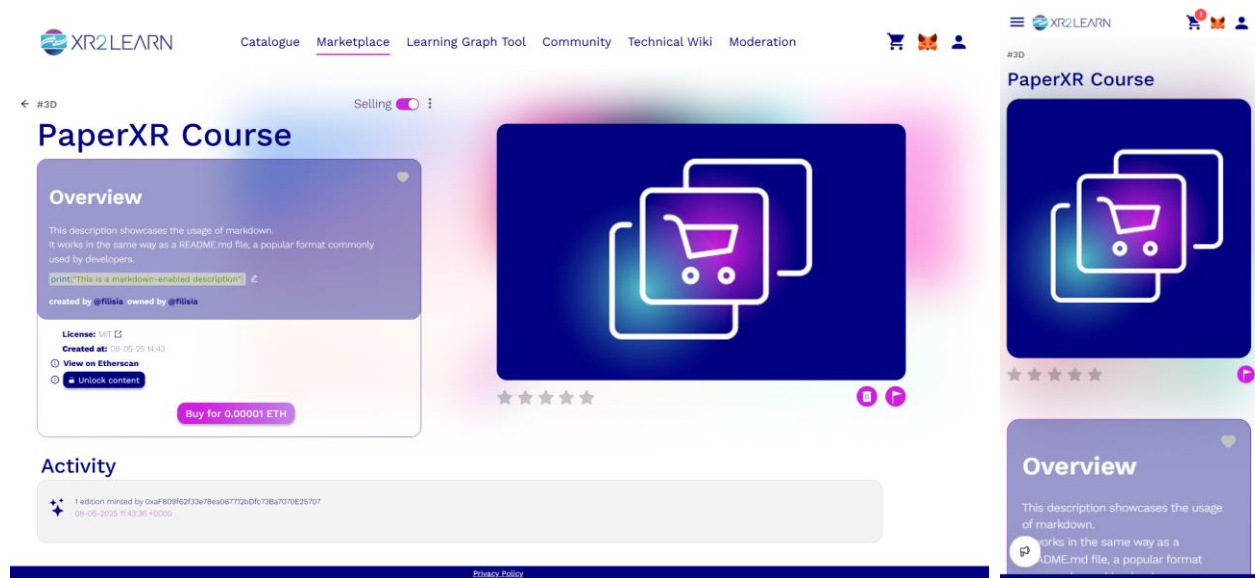


FIGURE 29 MARKETPLACE ITEM PAGE ON DESKTOP AND MOBILE

- **UI:** The graphic elements and design of the marketplace item page have been updated with an emphasis on a clearer but contemporary design, which highlights the visual elements of each item, as well as the story provided by the creators.
- **Back button:** A back button has been added on the top left corner, which enhances user experience by providing intuitive, seamless navigation and reducing frustration from getting lost. (see REQ4)
- **Rating system:** The users are now able to provide feedback on the quality of each item through a rating system, where they can vote 1-5 stars, and see the average rating of each item. This aligns with the requirements produced in Table 5, specifically REQ7.



FIGURE 30 MARKETPLACE RATING SYSTEM

- **Description:** The item's description is updated so that item publishers or owners are able to edit their description using the featured "edit" button. Additionally, the description is Markdown-enabled to support special formatting for potential blocks of code. This feature is able to provide better support and display for the description of software-related items and is also aligned with needs reflected by the users (REQ5, REQ6).

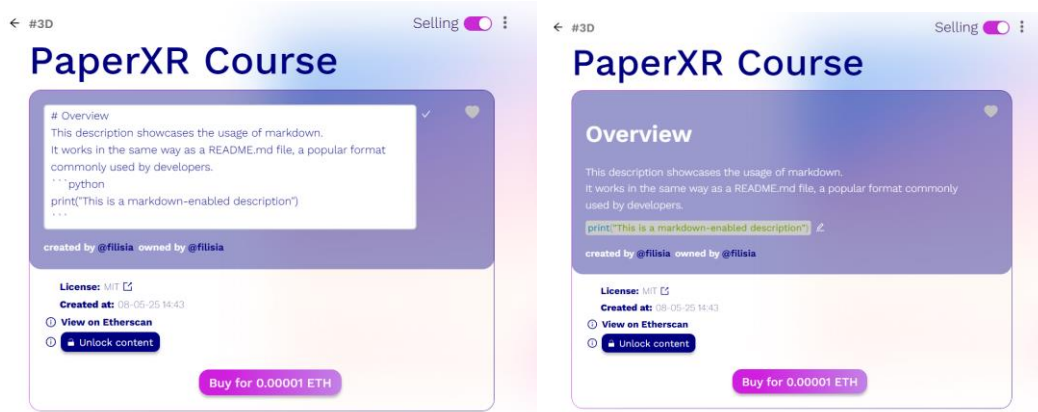


FIGURE 31 MARKETPLACE ITEM - EDITABLE MARKDOWN DESCRIPTION

- **Activity:** An activity panel has been created, which provides insight into the history of transactions for a specific item and enhances the sense of security and transparency. Users are able to see when an item was created/minted, and by which blockchain address, as well as all the subsequent transactions/sales. On top of that, they can visit the transactions in third-party applications called blockchain explorers [8] [9]. These applications monitor different blockchain networks and provide enhanced details for each transaction. This reinforces the transparency aspects while remaining optional for users to discover, keeping the balance of the information provided. Due to its nature, this section is included only in blockchain-enabled items and not free items. (see Figure 32)

Activity

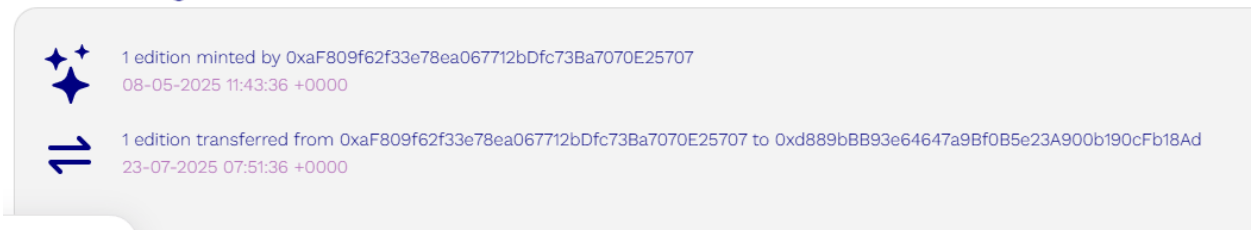


FIGURE 32 ACTIVITY SECTION OF MARKETPLACE ITEM

- **Selling options:** One of the newest features of the marketplace is the transfer of full control of the selling conditions to each NFT owner in the marketplace. Users can enable or disable selling, as well as update the selling parameters at any time. For example, they are able to update the price of the NFTs they sell.

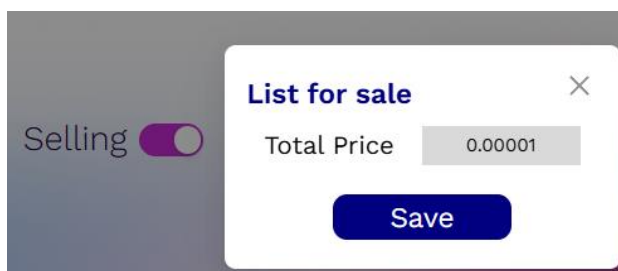


FIGURE 33 MARKETPLACE - SELLING OPTIONS

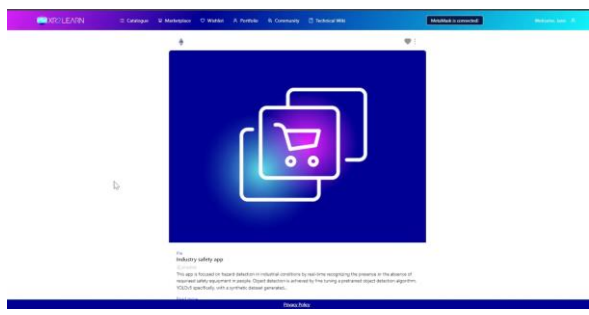
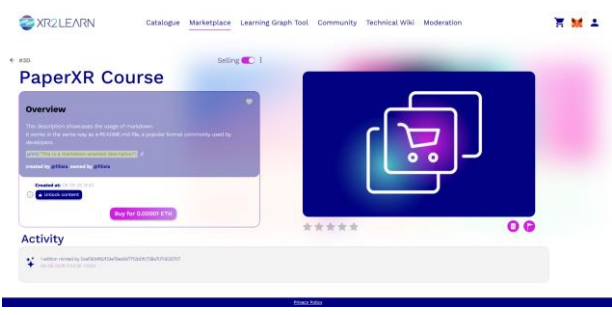
- **Unlockable content:** The unlockable content field, which is accessible only to NFT owners, has been updated as well to provide direct access to the content of the NFT stored in the decentralised database of the project (IPFS). Additionally, it has been redesigned to be more user-friendly and accessible.



FIGURE 34 MARKETPLACE ITEM - UNLOCK CONTENT

Table 11 provides a visual overview of the updates performed.

TABLE 11 MARKETPLACE ITEM PAGE EVOLUTION

First Release	Current Release
	

Wishlist

The Wishlist page has not been subject to change since the first release; however, it incorporates the new design of the marketplace items.

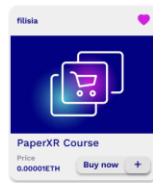


FIGURE 35 MARKETPLACE - WISHLIST PAGE

Portfolio

The user Portfolio (displayed in Figure 37) has been redesigned according to the direction followed by the rest of the platform and the marketplace. Additionally, the user information has been enriched with the option of featuring plenty of modern social media, networking and professional platforms as displayed in Figure 36.

Bio

Software Engineer@Synelxis Solutions

in https://linkedin.com/in/username

X/Twitter

Github

Mastodon

Facebook

Instagram

https://www.xr2learn.eu

Show less

Save

FIGURE 36 PORTFOLIO - EDIT INFO

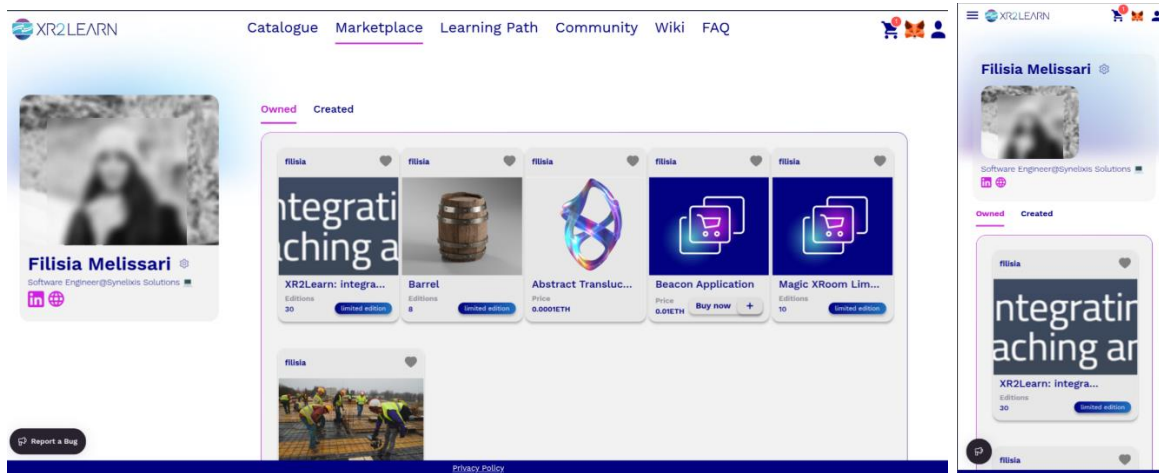


FIGURE 37 MARKETPLACE PORTFOLIO ON DESKTOP AND MOBILE

Moderation

This page is accessible only to XR2Learn users with the role of “moderator”. Currently, this list is restricted to a subset of the XR2Learn partners; however, in future exploitable versions of the platform, the role of moderator could be withheld and controlled by platform or community stakeholders. The purpose of the component is to enable marketplace owners to have moderation control over the marketplace content and the ability to enforce community guidelines when required. Users browsing content in the marketplace can use the report button on the item’s page and share their view of why that item is violating the rules. For example, violating IPR issues or offensive content. The report button and the relevant form are displayed in Figure 38.

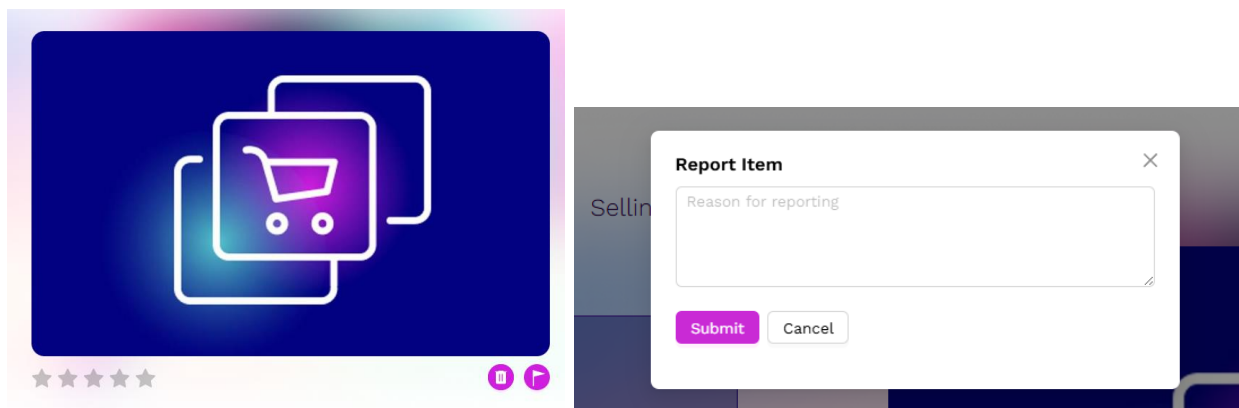


FIGURE 38 REPORT BUTTON AND FORM

Moderators can visit the Moderation System page available to them through the platform menu and handle the reports (Figure 39). They can visit the profile of the reporter, and the marketplace item reported, view the time the report was received and the status of the report. The default status of an unhandled item is “Action pending”. Many reports can be received for the same item, and they are handled in a group structure for each item.

- If the moderators think that the report is not violating any rules, they can press the “ignore” button from the action menu, and the report will be removed.
- If the moderators agree with the report’s reason, they can press the “warn” button. In that case, an email is automatically sent to the item owner, warning them to act within a specified timeframe. The action menu is updated with new options for moderators, specifically, a “Remove” and an “Ignore” button.

Additionally, the item is temporarily hidden from the marketplace main page until further action is taken.

- If the user has taken an action that satisfies the reporting requirements, then the moderators can ignore the report, and the item will become available in the marketplace.
- If the item still violates the rules, the moderators can permanently remove the item from the marketplace. If so, an automatic email is sent to the item owner, informing them of the deletion.

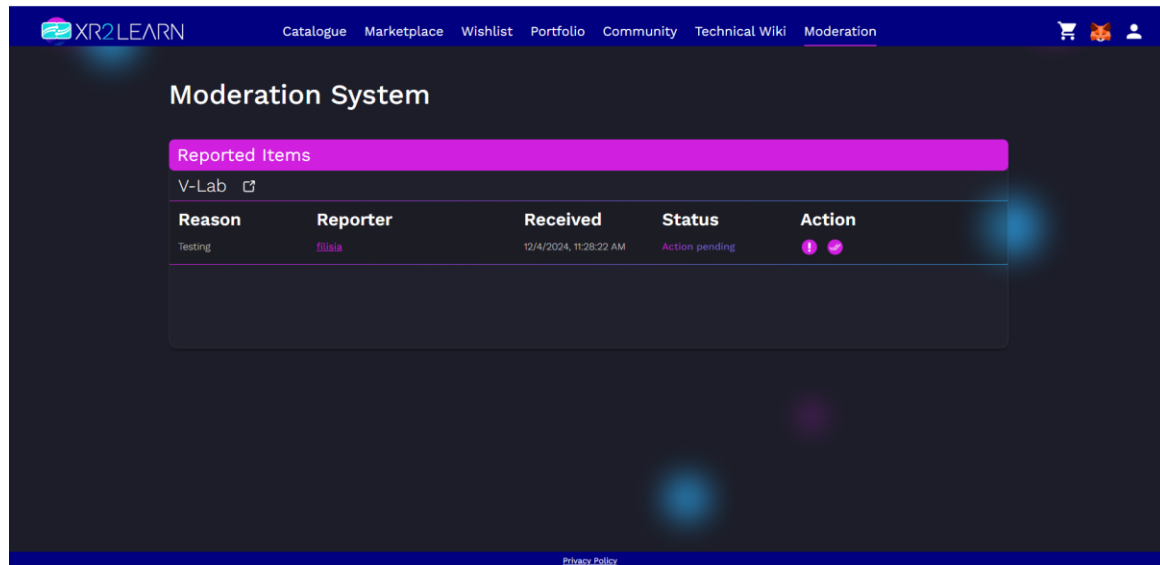


FIGURE 39 MODERATION SYSTEM

Requests

The requests page (see Figure 40) is a new addition to the pages of the marketplace. It has been included as the implementation of the “on-demand application creation” feature described in the grant agreement of the project. The purpose of this new tool is to unlock a networking dimension in the marketplace by connecting individuals, companies, or institutions who demand an asset, application, or service that is unavailable in the marketplace, to other individuals, companies, or institutions able to satisfy their requests.

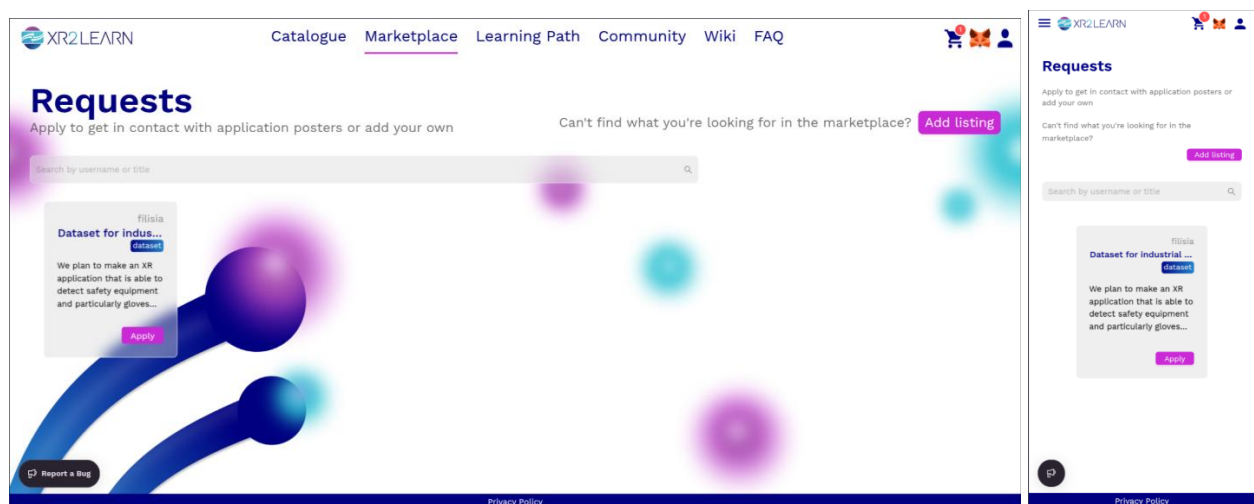


FIGURE 40 REQUESTS PAGE ON DESKTOP AND MOBILE

To use this tool, users can visit the “Requests” page from the Marketplace menu. Providers can browse the page to view listings relevant to their experience and expertise. To aid this process, they can employ the content discovery tools provided, such as searching by title or poster and filtering by content type. For example, software providers can narrow down their search by filtering for listings of the “Software” type. If they find listings, they consider interesting, they can apply to connect with the posters, either directly from the main page or by visiting the specific listing’s page.

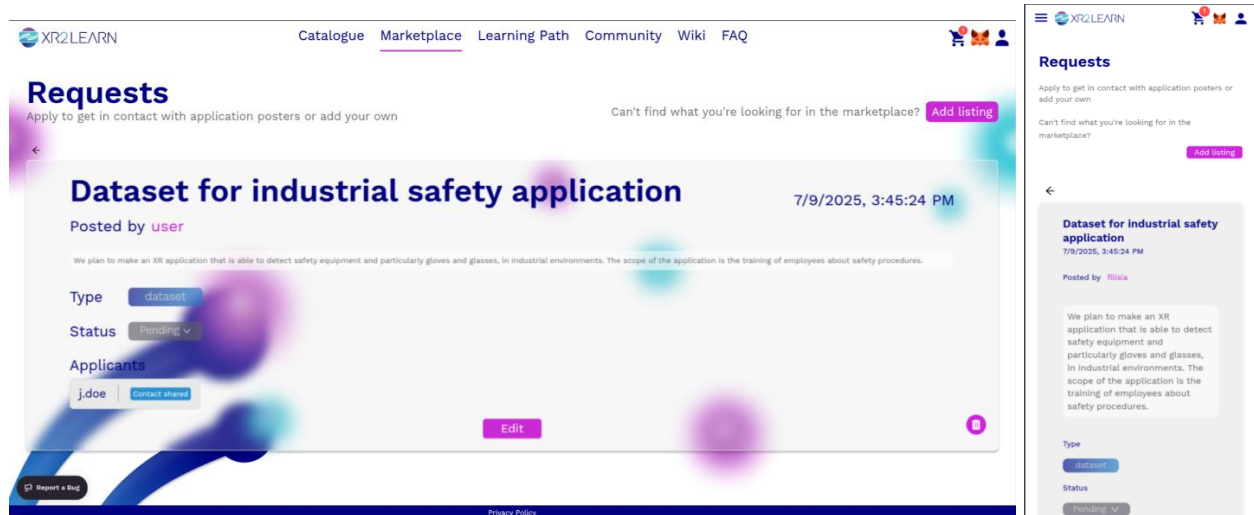


FIGURE 41 LISTING PAGE FROM THE POSTER’S VIEW ON DESKTOP AND MOBILE

Visiting the listing page, they are provided with more information and details, such as a full description, the time the listing was created and its current status. And they can also apply to retrieve the contact information of the poster. If the poster accepts their request, they get informed via email that the poster has agreed to share their contact information and expects them to reach out. In that case, the user can contact the poster via email to connect and find more details about their needs and potentially reach an agreement. If the poster rejects the request, they are also informed via email of the rejection and the contact information of the poster is not shared. The listing page from the view of the poster is displayed in Figure 41.

Add listing
×

* Title:

* Description:

* Type:

* Contact information:

Create

FIGURE 42 CREATE A REQUEST LISTING FORM

To use this tool as an entity in demand of a solution or specific content, the user visits the request page and can use the “Add listing” button to insert the details of their application (see Figure 42). Specifically, they can add:

- Title: A short descriptive name
- Description: A longer description of what they require

- **Type:** The type of asset they require from the main categories supported in the marketplace (software, 3D, dataset, text, MOOC).
- **Email:** The email address they wish to be contacted at by accepted applicants.

Pressing “Create”, the listing is created in the Requests page, and providers can now apply using the previously described steps. Visiting the page of their listing, they are provided with enhanced control, including the ability to:

- Edit the description
- Delete the listing
- View the received requests and accept or reject applicants
- Change the status of their listing:
 - **Pending:** This is the status assigned by default and reflects that the applicant is waiting for applications to be received or is in the process of receiving applications.
 - **Processing:** This status can be used to establish that the poster has been in contact with an applicant or various applicants.
 - **Completed:** This status can be used in case the applicant has reached an agreement with someone, and they are no longer open to receiving applications.

3.1.1 Additional Features

This subsection presents some additional features whose scope is not restricted to specific marketplace pages.

- **Interactive 3D:** The marketplace enables the user to interact with 3D models, instead of just viewing a static picture of them. This dynamic viewing ability enables the user to make more informed decisions when browsing content and enhances the branding abilities of 3D model assets. This capability is supported for most (platform-supported) 3D model types. Depending on the file structure of the asset implemented by the creator, additional textures could also be supported. The interactive ability is implemented in two spaces, first inside the upload content form, where users uploading 3D models are able to interactively preview their items and see how they are going to look in the marketplace, and inside the marketplace item page. Item creators can still add a static display picture that is going to be used in the marketplace landing page. Figure 43 displays a 3D model asset contributed by one of the first open call projects of XR2Learn.

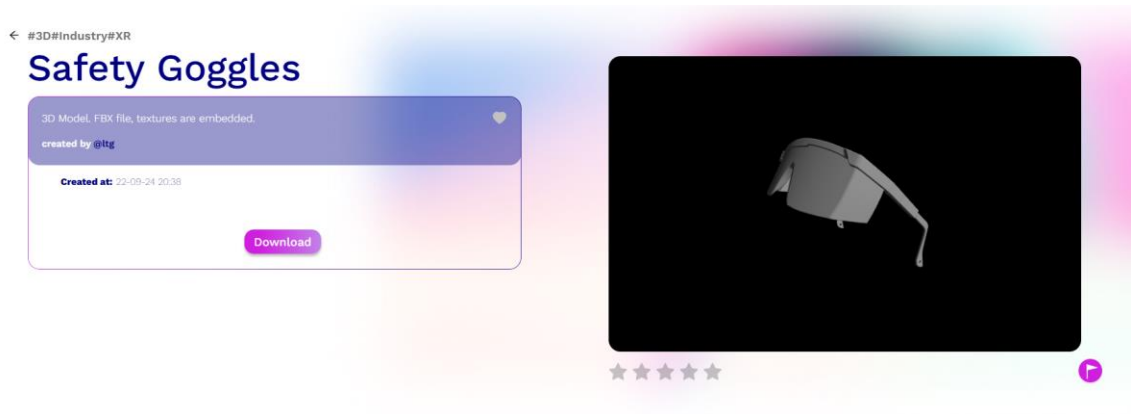


FIGURE 43 INTERACTIVE 3D MODEL

- NFT Royalties:** New NFTs now allow creators to profit from the resells of their assets, unlocking new revenue streams not existing in traditional marketplaces. In the item creation form, and specifically in the “NFT” step, they can fill the optional “Royalty” field with a percentage (0-99%). This percentage reflects the amount of any subsequent resell that they wish to retain. For users not familiar with this mechanism, they can find an information pin next to the field where they can hover to get to know how it works. More information about the technical details of this feature will be provided in section 4.2.1. The steps to create an NFT have been analysed in D2.2 [5].

Create Item

✓ Upload

✓ Distribution

3 NFT

4 Marketplace Listing

Name

Abstract Translucent 3D

Price (ETH)

0.0001

License

CC BY-SA 4.0 DEED

Amount

1

Royalty

10.0

Create NFT

Cancel

Previous

Next

FIGURE 44 SETTING ROYALTY INFO

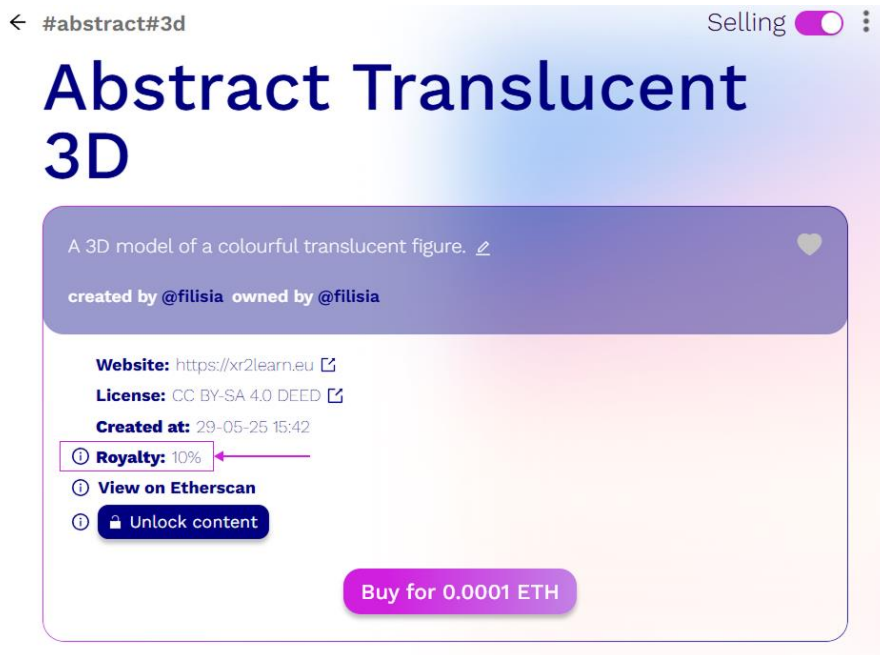


FIGURE 45 MARKETPLACE ITEM - ROYALTY INFORMATION

- Limited Edition NFTs:** Users are able to create limited editions of their NFTs. A “limited-edition” NFT is, in fact, several identical copies of the same digital item, which allows the item to be owned by possibly several different users. To create one, in the NFT creation form, users can specify the “Amount” field with a number greater than 1. In that case, the user, instead of creating an NFT, creates a semi-fungible collection of the NFT. The number they set is the number of editions that will be created. The item creation flow continues as with the single NFTs, and after accepting the transaction, a new item is created in the marketplace. In the landing page, this item carries a “limited edition” tag and specifies the number of editions instead of displaying the price, as seen in Figure 46. To buy any edition of this item, users must visit the item’s page. There, they can see all the current owners of the item and the number of editions they hold. They can see the starting price, which is the lowest available price for an NFT, and use the “Purchase options” button to view the available editions and the different prices. Users can add any number of editions from any seller they wish, view the total amount of their selections, and buy them all either directly or by adding them to their cart to purchase later. Edition owners can use the selling options feature to disable selling, select the number of editions they wish to sell and the total price for selling them.

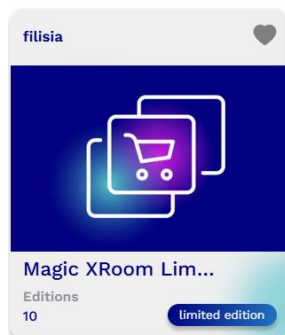


FIGURE 46 MARKETPLACE LANDING PAGE - LIMITED EDITION


[Catalogue](#)
[Marketplace](#)
[Learning Graph Tool](#)
[Community](#)
[Technical Wiki](#)
[Moderation](#)





Magic XRoom Limited Edition

created by @filisia owned by @filisia

License: CC BY-SA 4.0 DEED

Created at: 08-05-25 12:54

Editions: 10

View on Etherscan

Purchase options



★★★★★ 3.5 (2)




Activity


10 editions minted by 0xaF809f62f33a78ea067712bDfC73Ba7070E25707
08-05-2025 09:55:03 +0000

List for sale

Quantity

1

Total Price

0.000001

Save

Purchase options

Seller	Quantity	Price/Unit	Total Price
@filisia	10	0.00000 MATIC	0.000001 MATIC

Total

2 editions from @filisia

2e-7 MATIC

2 editions

2e-7 MATIC

Buy now

FIGURE 47 LIMITED EDITION NFT AND SELLING OPTIONS

- Cart:** A cart has been fully integrated in the marketplace, allowing users to add items to their cart and purchase them all in one transaction. This way, the user can reduce the operational costs. They are allowed to item NFTs that do not carry the “legacy” tag, which were created in earlier versions of the marketplace and do not support this functionality, and all items must belong to the same network. For example, if a user adds an NFT minted on the Ethereum blockchain, their ability to add NFTs from the Polygon network is disabled. They are able to add, however, both single NFTs and any combination of NFT editions they wish and purchase them (provided that all of them are minted on the same blockchain). As seen in Figure 48 the cart displays the total amount to pay, as well as basic information for all cart items, such as names, number of editions added, or royalty percentages.

52

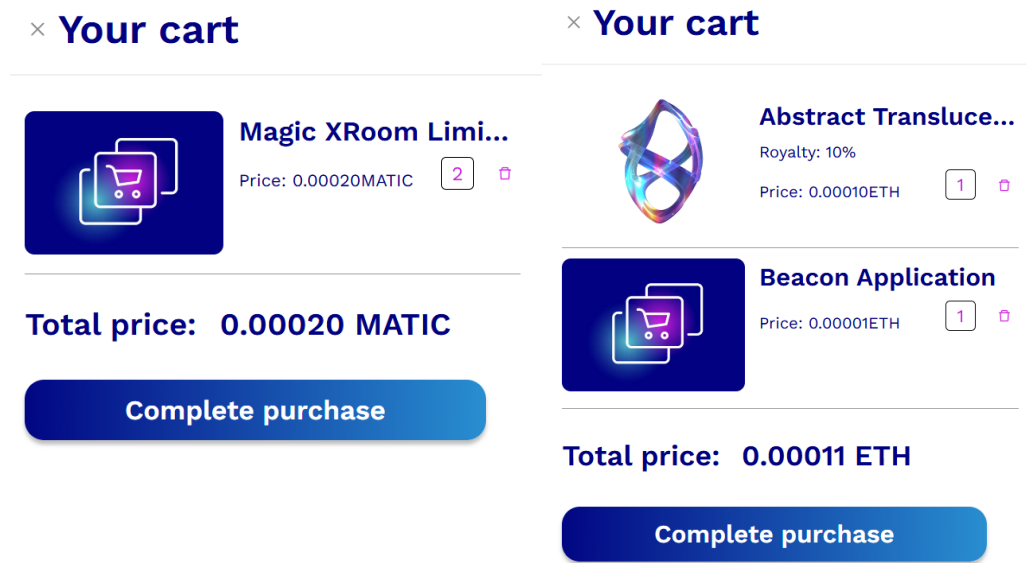


FIGURE 48 CART

3.2 SPECIFICATIONS AND INTERFACES

Chapter 3.1 presented the Marketplace updates through the graphical user interface, deployed as part of the overall Platform FE component. The functionalities described are enabled through the Marketplace backend component, which is delivered as a Django application, using a Gunicorn server to handle requests, employing a PostgreSQL database for storage and a Redis database for optimisations and concurrency. Furthermore, the application provides an API Documentation based on the Open API format using Swagger. This section provides an insight into the main interfaces of the component in this version, presented in Table 12. The complete API specification can be found in: <https://marketplace-api.xr2learn-marketplace.eu/api/schema/swagger-ui/>

TABLE 12 MARKETPLACE INTERFACE

NFT Marketplace		
Interfaces	cart/	
	Description	The interface allows the handling of the user's cart. It covers functionalities related to the creation and editing of the cart.
	Protocol(s) used	HTTPS
	Methods	POST, GET, PUT, PATCH
	Message	POST/PUT/PATCH: <pre>{ "items": [0], "purchase_info": [{ "listing": 0, "quantity": 1 }] }</pre>

		<pre> }] } GET: { "id": 0, "user": 0, "items": [0], "items_list": [{ "id": 0, "name": "string", "description": "string", "type": "MOOC", "owner": 0, "owner_name": "string", "tags": ["string"], "external_link": "string", "created": "2025-05- 29T11:59:59.112Z", "modified": "2025-05- 29T11:59:59.112Z", "views": 0, "display_image": "string", "source": 0, "source_media": "string", "nft": 0, "has_unlockable_content": true, "chainid": "string", "overall_rating": 0, "num_of_ratings": 0, "license": 0 }], "purchase_info": [{ "listing": 0, "quantity": 2147483647, "nft_id": "string", "royalty_value": "string", "available_quantity": "string" }] } </pre>
--	--	---

	nft/	
	Description	This endpoint handles the creation, editing and deletion of NFT objects.
	Protocol(s) used	HTTPS
	Methods	POST, GET, PUT, PATCH, DELETE
	Message	POST/PUT/PATCH: <pre>{ "name": "string", "price": 0, "license": 0, "supply": 1, "creator": "string", "chainid": 11155111, "legacy": true, "listed": true, "royalty_value": 0 }</pre> GET: <pre>[{ "id": 0, "name": "string", "price": 0, "license": 0, "supply": 1, "creator": "string", "chainid": 11155111, "creator_user": 0, "creator_name": "string", "legacy": true, "listed": true, "royalty_value": 0, "token_id": 0 }]</pre>
	marketplace-item/	
	Description	This interface exposes functionality related to the handling of items on the marketplace.
	Protocol(s) used	HTTPS
	Methods	POST, GET, PUT, PATCH, DELETE
	Message	POST/PUT/PATCH: <pre>{ "name": "string", "description": "string", "type": "MOOC", "owner": 0, "tags": ["string"], "external_link": "string", "display_image": "string", }</pre>

		<pre> "source": 0, "nft": 0, "unlockable_content": "string", "license": 0 } GET: [{ "id": 0, "name": "string", "description": "string", "type": "MOOC", "owner": 0, "owner_name": "string", "tags": ["string"], "external_link": "string", "created": "2025-05- 29T12:10:19.394Z", "modified": "2025-05- 29T12:10:19.394Z", "views": 0, "display_image": "string", "source": 0, "source_media": "string", "nft": 0, "has_unlockable_content": true, "chainid": "string", "overall_rating": 0, "num_of_ratings": 0, "license": 0 }] </pre>
--	--	---

3.2.1 Installation and configuration

The marketplace follows the same approach as the rest of the platform components and is delivered as a Dockerised application packaged alongside the PostgreSQL and Redis databases in a docker-compose file.

Prerequisites

System Requirements

- Docker installed
- Docker Compose installed

Software Dependencies

To enable the blockchain interactions and take advantage of the full spectrum of features of the marketplace, before installation, it requires the following:

- IPR Tool installed
- Marketplace smart contracts deployed (in Ethereum and Polygon or their Testnets)

Configuration and Deployment

To configure the marketplace, first, the repository must be cloned (available in the XR2Learn GitHub). Inside the cloned repository, a `.env` file must be created following the structure displayed in Table 13.

TABLE 13 MARKETPLACE CONFIGURATION

KEY	VALUE
POSTGRES_HOST	Marketplace-postgres
POSTGRES_DATABASE	db
POSTGRES_USER	user
POSTGRES_PASSWORD	{POSTGRES_PASSWORD}
GUNICORN_CMD_ARGS	"-c backend/gunicorn.py"
ADMIN_PASSWORD	{ADMIN_PASSWORD}
REDIS_HOST	marketplace-redis
REDIS_PORT	6379
AWS_SECRET_ACCESS_KEY	{S3_BUCKET_SECRET_KEY}
AWS_SECRET_KEY_ID	{S3_BUCKET_ACCESS_KEY_ID}
AWS_STORAGE_BUCKET_NAME	{S3_BUCKET_NAME}
MARKETPLACE_UI_URL	{The URL of Platform FE/Or a dedicated URL}
PLATFORM_URL	{The URL of Platform FE}
NFT_TOOL_URL	{The URL of the IPR Tool}
AUTHENTICATION_SERVER	{The URL of the Keycloak Server}
REALM	{The Keycloak Realm}
CLIENT_ID	{The Keycloak Client ID}
CLIENT_SECRET	{The Keycloak Client Secret}
MARKETPLACE_BACKEND_URL	{The present service intended URL}
PLATFORM_BACKEND_URL	{The platform BE URL}
EMAIL_PASSWORD	{The SMTP password}

After the creation of the file, the following command must be executed which will deploy the marketplace along with the required databases:

- `docker compose up -d`

4 BLOCKCHAIN REALM

This section is dedicated to updates relevant to the blockchain aspects of XR2Learn. These aspects are included in the IPR Tool, which enables the blockchain functionalities in the marketplace and interacts with the blockchain, as well as in the smart contracts of XR2Learn, which exist inside the supported networks. Several updates have been performed both in the smart contracts and the IPR Tool with the purpose of:

- Reducing the costs of minting new NFTs
- Improving the security aspects
- Enriching the transparency for blockchain operations in the marketplace
- Supporting new functionalities and features as the ones described in the marketplace sections, for example, limited edition NFTs and Royalties.

The updated architecture of the blockchain components is displayed in Figure 49.

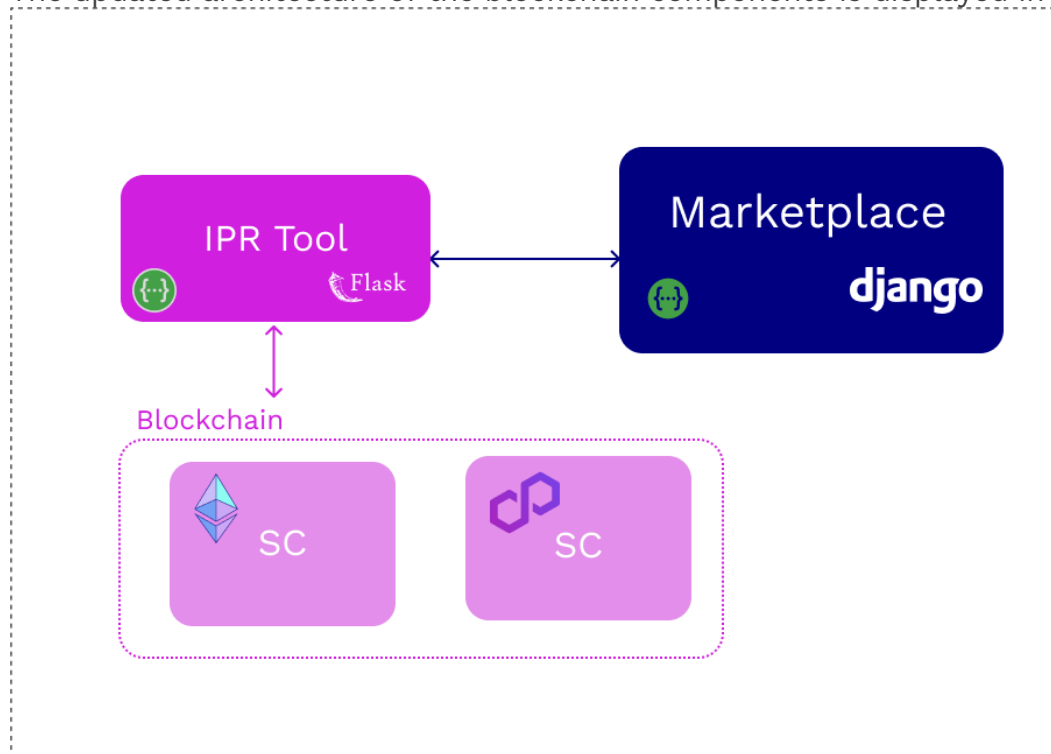


FIGURE 49 BLOCKCHAIN REALM ARCHITECTURE

The following sections present the updated versions of these components.

4.1 IPR TOOL

This section describes the final version of the IPR tool of XR2Learn, outlining the updates performed. The IPR tool is responsible for handling the wrapping and distribution of items as NFTs under specific IPR licenses. The scope of the tool has been expanded to enhance the transparency of blockchain operations and provide advanced selling interfaces and capabilities.

4.1.1 Updates

Several updates have been performed at the level of the IPR tool, in conjunction with updates of the Marketplace for the support of new features, as well as the smart contracts for updates on an operational level. One of the most notable updates is the implementation of a new workflow for the creation of NFTs.

In the previous version of the IPR Tool, in order to mint an NFT, a new contract had to be deployed in the appropriate network each time. In that version, each smart contract implemented an interface for a single NFT, which increases the computational complexity. Ethereum-compatible blockchain networks define a fundamental unit that describes the computational load of each transaction: gas.

A deployment of a contract, depending on its complexity, can be considered a computationally heavier action rather than a simple transaction, such as using a smart contract functionality. Therefore, the new workflow of the IPR Tool for creating NFTs leverages the fact that the XR2Learn Smart Contracts are pre-deployed by the component owner of XR2Learn, and the action of minting an NFT is reduced to a simple transaction.

This update required major changes in the smart contracts code, and along with further optimisations performed, it led to a significant reduction of gas costs. The comparison is evident in Table 14, using data of actual NFTs of the XR2Learn platform from the first version and the current version of the marketplace. One important parameter to display is the transaction fee applied to the creators of NFTs, which is the cost they must pay to mint it on the network. The transaction fee is calculated according to the formula below:

$$\text{Transaction Fee (ETH)} = \text{Gas Used} \times \text{Gas Price (ETH)}$$

The gas price reflects the cost of a gas unit at the blockchain network, in this case, Ethereum, and it is dynamic, so the price of gas varies across time depending on the “demand/traffic” of the network. To be able to make a comparison of the transaction fee, the gas price of the first transaction (~ 1.5 Gwei) was used in the calculations of both transactions. Moreover, we provide calculations of prices translated into EUR to highlight the comparison in easily comprehensible numbers. The prices are calculated using the exchange rate at the time of writing, specifically 1EUR=0.00043ETH.

TABLE 14 ESTIMATED REDUCTION OF GAS COSTS FOR MINTING

	First Version	Final Version	Result
Gas used	3,100,586	219,861	- 92.91%
Price in ETH	~0.00465088	~0.00032979 ETH	- 92.91%
Price in EUR	~€10.81	~€0.77	- 92.96%
Etherscan	<u>Old Transaction</u>	<u>New Transaction</u>	

Other notable updates performed include:

- The support of limited-edition NFTs as described in the Marketplace (section 3).
- Support for implementing NFT Royalties, which are described in detail in the following subsections.
- Implementation of a mechanism that provides historical information and allows the tracking of the activity for each NFT. For example, users can see the address on the blockchain, which is considered an account/user, who minted the NFT, how many editions were minted, as well as all subsequent sales of that NFT. These actions can also be verified by third-party applications, specifically Etherscan and Polygonscan, depending on the network. This feature increases the transparency and builds trust around the blockchain operations executed in the marketplace.
- Increased the security of NFT operations, supported by the smart contracts. When a user proceeds to create an NFT for the first time in the XR2Learn marketplace and selects the network, the tool requests explicit approval to allow the NFTs of the users to be sold in the XR2Learn marketplace. This is required by security mechanisms in the level of smart contracts and provides full control of the NFTs to their creators. The approval is requested as a blockchain transaction that the user must approve. They can reject it, but in this case, the ability to sell NFTs in XR2Learn will not be possible. If they approve it, they will not be asked again for this approval in the same network.

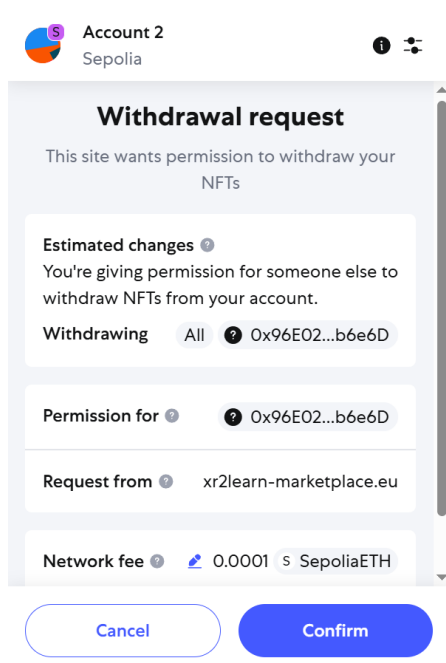


FIGURE 50 IPR TOOL - APPROVAL REQUEST IN NFT CREATION

4.1.2 Specifications and Interfaces

The IPR Tool is delivered as a service built on the Flask framework of Python and handles requests using the Gunicorn web server. It provides an API specification using Swagger. This section provides an insight into the main interfaces of the component in this version, presented in Table 15. The complete API specification can be found in: <https://nft.xr2learn-marketplace.eu/swagger>

TABLE 15 IPR TOOL INTERFACE

IPR Tool		
Interfaces	nft/	
	Description	The interface is used by other services, such as the marketplace, to create NFTs.
	Protocol(s) used	HTTPS
	Methods	POST
	Message	{ "payload": {}, "chainid": 0 }
	nft/buy/batch	
	Description	This interface allows the possibility to buy a single NFT.
	Protocol(s) used	HTTPS
	Methods	POST
	Message	{ "from": "string", "to": "string", "id": 0, "amount": 0, "abi": "string", "contract": "string", "price": 0, "chainid": 0 }
	nft/buy/	
	Description	This interface allows the possibility to buy multiple NFT in one transaction.
	Protocol(s) used	HTTPS
	Methods	POST
	Message	{ "from": ["string"], "to": "string", "ids": [0], "amounts": [0], "abi": "string", "contract": "string", "prices": [0], "chainid": 0 }

4.1.3 Installation and Configuration

To configure the IPR tool, first, the relevant repository must be cloned from the XR2Learn GitHub. Then an `.env` file must be created inside the repository with the following structure, as outlined in Table 16.

TABLE 16 IPR TOOL CONFIGURATION

KEY	VALUE
ADDRESS	The wallet address of XR2Learn
KEY	The wallet key of XR2Learn
ETHEREUM_CHAINID	The chain id of Ethereum, by default Sepolia Testnet chainid (11155111)
ETHEREUM_URL	The URL of the Ethereum RPC endpoint
GUNICORN_CMD_ARGS	"-c backend/gunicorn.py"
HOST	The address of the IPFS URL
POLYGON_CHAINID	The chain id of the Polygon network, by default Mumbai Testnet chainid (80001)
POLYGON_URL	The URL of the RPC endpoint of Polygon
PORT	The port of the IPFS URL for writing
IPFS_URL	The URL of the IPFS Gateway for retrieving files
ETHERSCAN	https://sepolia.etherscan.io (for Sepolia testnet)
POLYGONSCAN	https://amoy.polygonscan.com (for Amoy testnet)
ETHEREUM_ADDRESS	The NFT Contract address deployed on Ethereum (or testnet)
POLYGON_ADDRESS	The NFT Contract address deployed on Polygon (or testnet)

To deploy the tool the following command must be executed:

- `docker compose up -d`

4.2 SMART CONTRACTS

The smart contract of XR2Learn is an application which is executed on a blockchain network and allows the creation and management of assets of the XR2Learn marketplace. It implements the ERC-1155 standard, a standard defined in the Ethereum and Ethereum-compatible networks such as Polygon. It defines a way to create fungible, semi-fungible and non-fungible tokens and defines interactions like their transfer. In the context of XR2Learn, the smart contract is deployed on the Ethereum and Polygon networks and has been significantly updated to:

- Support some of the new features of the marketplace, for example, NFT Royalties and Limited-Edition NFTs
- Improve security of operations
- Reduce the cost of the transactions

As most of the features have been described in the previous sections, this subsection focuses on the updates performed at the smart contract level.

The next subsection describes the activities performed at a technical level for this component.

4.2.1 Updates

- **Reduction of costs:** The redesigned contract applies optimisation methods and best practices, which aim to reduce the computational complexity, which in turn reduces the cost and leads to more energy-efficient transactions. These optimisations take advantage of the low-level mechanics of Solidity, the programming language of the smart contract. For example, the order in which variables are stated has been carefully considered to optimise the memory storage of the smart contract. Additional techniques have been implemented according to more traditional programming principles for reducing computational complexity.
- **Increased security:** The new smart contract offers upgraded security by:
 - Implementing preventions against re-entrancy attacks [10]; a common attack in smart contracts, which allows malicious actors to exploit a vulnerability in which they are able to repeat actions like withdrawals and possibly drain a smart contract's funds or assets.
 - Implementing a mechanism where NFT owners must provide explicit approval to an address, which could represent other individuals or marketplaces, in order to transfer their assets.
 - Implementing access control inside the smart contract by defining the admin role and limiting access to certain sensitive actions. The admin role is linked to the web3 wallet (or address) of the XR2Learn admin.
- **NFT Royalty:** The smart contract integrates the NFT Royalty standard, ERC-2981 [11], which defines a way to retrieve royalty payments for NFTs. Since the mechanism is standardised, the royalty payments can also be supported by external marketplaces. NFT creators define the percentage of royalty they wish to retrieve from resells of their NFTs. When a resell is executed, payment is automatically received at the Web3 wallet of the creator, which is defined as the percentage of the total amount of the resell. For example, if an NFT is sold for 1ETH and the NFT has royalty at 10%, the original creator will receive 0.1ETH in their wallet.
- **Cart functionality:** The smart contract has extended the *batchTransfer* function of the ERC-1155 standard, which allows the creation of semi-fungible tokens, to allow the purchase of multiple different NFTs as well in the same transaction. This functionality has been described in more detail in the section 3.1.1.

The code of the smart contract is available in the GitHub repository of XR2Learn.

5 INTEGRATION

Since the initial platform integration detailed in Deliverable D2.2, the XR2Learn ecosystem has continued to evolve, with ongoing efforts focused on enhancing stability, performance, and the seamless interoperability of its expanding suite of components. The foundational CI/CD workflows and hosting infrastructure (Development, Stage, and Production environments) established earlier in the project remain robust and continue to underpin all development and deployment activities. This section highlights the progress and key integration activities undertaken in the recent period to support the platform's growth and improve the overall user experience.

A clear indicator of the project's sustained development activity and collaborative expansion is the growth observed within our GitHub ecosystem. The number of active repositories has increased from the 18 reported in D2.2 to 25 repositories, now encompassing 14 public and 11 private repositories. This expansion reflects ongoing work across the platform, including refinements to core services and the development of new functionalities. In concert with this, the core development team actively contributing to the platform has grown from 11 to 15 members, and we are pleased to note the continued engagement of 2 outside collaborators. This collective effort signifies a healthy and expanding development community dedicated to the XR2Learn mission.

The platform has experienced a notable increase in visitor traffic and overall usage in the recent period. This growth trend is actively tracked through our comprehensive monitoring system deployed in the production environment, which utilises tools such as Prometheus and Grafana. The insights derived from this continuous monitoring are vital for understanding user interaction patterns, assessing service performance under real-world conditions, and proactively managing resource allocation.

To ensure the platform continues to deliver a responsive and high-quality user experience despite increasing demand, proactive vertical scaling measures have been successfully implemented within the production infrastructure. This involved strategically upgrading the server specifications for key backend services. As detailed in Table 17, the production server flavour was enhanced:

TABLE 17 PRODUCTION SERVER FLAVOUR

Server flavour	OLD	NEW
vCPUs	2	4
RAM memory	8GB	16GB
IP address	40.66.55.229	Unchanged
Storage	60GB	Unchanged
OS	Ubuntu 22.04.3	Updated
Software	Docker/Docker Compose	Updated

These infrastructure improvements, particularly the doubling of vCPUs and RAM, were guided by data collected via monitoring tools and are essential for maintaining fast response times and stable performance across the platform.

In addition to hardware enhancements, critical updates to the operating system and containerization tools (Docker and Docker Compose) have been applied to ensure ongoing security, compatibility, and performance. Maintaining an up-to-date software

stack enables the platform to dynamically adjust resources as needed, reinforcing our commitment to delivering high Quality of Service (QoS).

6 CONCLUSIONS

The document described the final activities executed under tasks 2.3 “XR2Learn Marketplace and IPR handling tools” and 2.4 “XR2Learn platform integration” of WP2. It reports the final release of the Platform, including the new Learning Path tool, Marketplace with the on-demand application creation feature, and the IPR Tool, with the new version of the smart contract. The underlying infrastructure fulfils the technical objectives set for WP2. All user-driven requirements have been implemented, the platform components are seamlessly integrated under a common SSO, and the smart-contract refactor provides secure, low-cost royalty flows.

Although the platform has reached a stable and feature-complete state as planned for this phase, XR2Learn remains a dynamic and user-responsive environment. Any feedback or bug reports arising from the second Open Call will be addressed through dedicated maintenance activities. With an upgraded cloud environment and an expanding development community, XR2Learn is ready to support the second Open Call, large-scale pilots and the project’s forthcoming exploitation activities.

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