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E4E and E4L enablers, documentation, and software plug-in

By FBK

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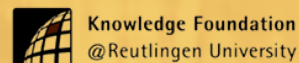


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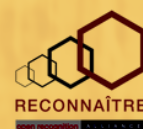


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E4E and E4L enablers, documentation, and software plug-in

Project result number D4.1 by FBK
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Executive Summary

This deliverable reports the achievements of Work Package 4 (WP4) in the development of Encore enablers, specialised digital tools designed to enhance the utilisation of resources generated within the ENCORE project, benefiting both educators and learners.

The deliverable presents the progress made in creating the Enabler for Educators and subsequently the Enabler for Learners, both integrating the accumulated developments from WP2 and WP3. The Enabler for Educators serves as an advanced learning design tool that seamlessly interfaces with the ENCORE database. This tool empowers educators to access Open Educational Resources (OERs) aligned with Green, Digital and Entrepreneurial (GDE) skills. Educators can assign resources to specific learning activities and structure these activities into coherent learning paths, delineated in a four-step process, namely: discover, collect, plan, and execute.

In parallel, the Enabler for Learners extends these pathways to learners, facilitating personalized learning experiences and promoting effective execution. This integration caters to learners' unique needs, enhancing engagement and outcomes.

This deliverable details the digital components and software plug-ins underpinning the implementation of the ENCORE Enabler approach. After the introduction, a dedicated section outlines the transformation of OER content into a conceptual map, derived from task T4.1. Subsequently, the Enabler for Educators (E4E) is expounded upon, informed by co-design activities and the resultant digital outcomes within the activities in task T4.2. The third section delves into the Enabler for Learners (E4L) from T4.3, offering students a tailored interface for accessing learning paths. Furthermore, the deliverable describes the supporting documentation for these enablers, stemming from T4.4. Lastly, insights into the plugin's development to facilitate seamless integration with external Learning Management Systems (LMS) such as Moodle, an outcome of T4.5, are also provided.

These digital outputs are positioned for ongoing refinement throughout the remaining duration of the project, where iterative enhancements will be applied. Subsequently, these refined outputs will undergo practical testing and validation within the activities outlined in Work Package 5 (WP5). This pivotal phase will provide valuable insights into the effectiveness, usability, and overall impact of the ENCORE Enablers, enabling necessary adjustments and optimizations before wider implementation.

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Acronyms & Abbreviations

Term	Description
API	Application Programming Interface, a set of defined rules that enable different software applications to communicate with each other
E4E	ENCORE Enabler for Educators
E4L	ENCORE Enabler for Learners
ESCO	The multilingual classification of European Skills, Competences, Qualifications and Occupations
GDE	Green, Digital and Entrepreneurial skills. Set of skills of highest priority as they are identified as key for the transformation in Europe.
GIT	Global Information Tracker, an open-source distributed version control system that tracks changes in any set of computer files.
JSON	JavaScript Object Notation, a language-independent data format that uses human-readable text.
OER	Open Educational Resources. OER are materials for teaching or learning that are either in the public domain or have been released under a licence that allows them to be freely used, changed, or shared with others.
UI	User Interface

Introduction: the ENCORE Enabler approach

The ENCORE project intends to address three main challenges in the current digitised educational world:

1. **Identify the skills most affected by the current macro-trend.** The educational sector is asked to change its perspective from traditional notion delivery to a more flexible and proactive approach, able to provide students with contemporary-relevant skills. Specifically, those skills are affected by macro-trends such as digitalization, climate change, and post-COVID economic recovery challenges. Three macro skills categories have been identified, to face current worldwide challenges, which are the focus of ENCORE: green, digital, and entrepreneurial skills, referred to as GDE skills.
2. **Favour the reuse of Open Educational Resources.** A great opportunity for the modernization of the educational sector is represented by the increased information and knowledge created and shared online. Open Educational Resources (OER) are any kind of educational material that can be freely used, adapted, and shared. The great availability of digital didactic material supports collaborative learning and constitutes a valuable asset to address the changes in education.
3. **Support the changing role of educators.** The changes occurring in the educational field are not solely limited to the adoption of new technologies or the wider distribution and access of educational materials, the role of educators is transforming as well. Teachers and educators are asked to transition into being education and experience designers.

ENCORE aims at empowering educators in creating courses and learning experiences that focus on Global Digital Economy (GDE) skills, utilising open and reusable content such as Open Educational Resources (OERs). To reach this goal, the project foresees two digital platforms - the Enabler for Educators (E4E) and the Enabler for Learners (E4L) - that are the main outputs of Work Package 4. These platforms are designed to facilitate seamless access to OERs centred around GDE skills, enabling educators to define customised learning activities and pathways, and effectively deliver these educational experiences to students.

As displayed in Figure 1, the work conducted in WP4 and reported in this deliverable is influenced by two previous WPs (WP2 and WP3), which played a crucial role in identifying the target skills and establishing a comprehensive database of Open Educational Resources (OERs).

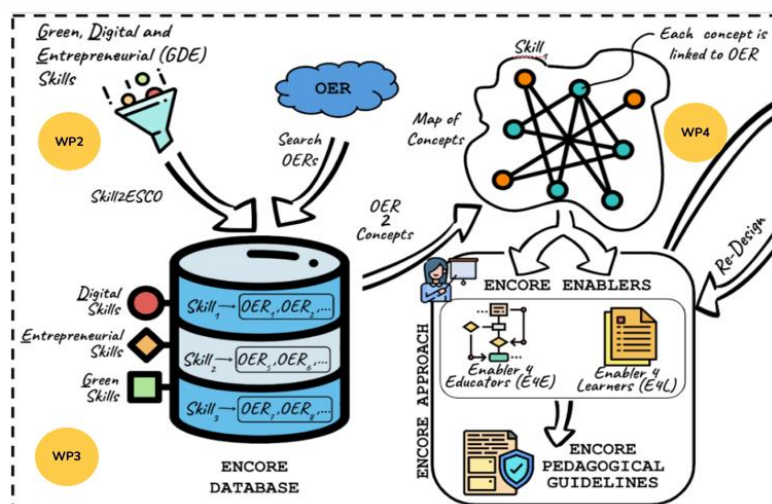


Figure 1. Diagram of the the interplay of outputs between WP2, WP3, and WP4

The activities of WP2 informed with the identification of green, digital and entrepreneurial (GDE) skills recognised to be essential to face macro challenges of digitization, climate change and post-COVID economic recovery. Scientific literature was exploited to automatically collect skills on the specified domains, which have subsequently been linked to the European Skills, Competences, Qualifications and Occupations (ESCO) framework. The outcome of WP2 is a list of skills categories by macro-area, including both knowledge and competencies. The majority of skills are shared by the three domains and focused on soft skills, examples include “think creatively” and “communication”. Green-specific competencies are associated with environmental issues (e.g.: “environmental engineering”, and “waste management”), economics and innovation (e.g.: “circular economy”). Digital skills address technological topics, including “computer technology”, “hardware testing methods”, and “computer programming”. Finally, examples of entrepreneurial competencies target economics and innovation, as well as soft skills focused on leadership: some examples are “marketing principles”, “innovation processes”, “communication” and “leadership principles”.

The ENCORE database is composed of OER connected to the identified GDE skills, creating a database of skills-related open resources. This was the objective of WP3. Firstly, open educational resources have been extracted from fifteen curated repositories of OER, including MERLOT¹ and OER Commons², and selected if compliant with quality guidelines. In a second step, associations between skills and resources have been identified. The final output is a searchable open database containing Open Educational Resources (OER) on green, digital, and entrepreneurial (GDE) skills.

All the developments presented so far have been considered and included in the creation of the Enabler for Educators, and subsequently in the Enabler for Learners. WP4 is in fact dedicated to the technical implementation of the two Enablers. The Enabler for Educators functions as a comprehensive learning design tool that seamlessly integrates with the ENCORE database. It empowers educators to effortlessly access OERs related to GDE skills, assign them to specific learning activities, and organise these activities into structured sequences known as learning paths. The Enabler for Learners makes such paths accessible to learners, by tailoring learning paths and promoting their executions.

To describe and organize the various stages of usage, the ENCORE Enablers approach comprises four distinct steps, as depicted in Figure 2. These steps delineate the overall objectives of the two ENCORE enablers. It is important to note that this process should be viewed as a preliminary framework for the development of the digital tools to be used by educators and learners, allowing for flexibility and adaptation depending on the educational and practical context. The process will undergo continuous refinement during the pilots in WP5 and through iterative improvements anticipated in the subsequent months.

¹MERLOT: <https://merlot.org/merlot/>

²OER Commons: <https://oercommons.org/>

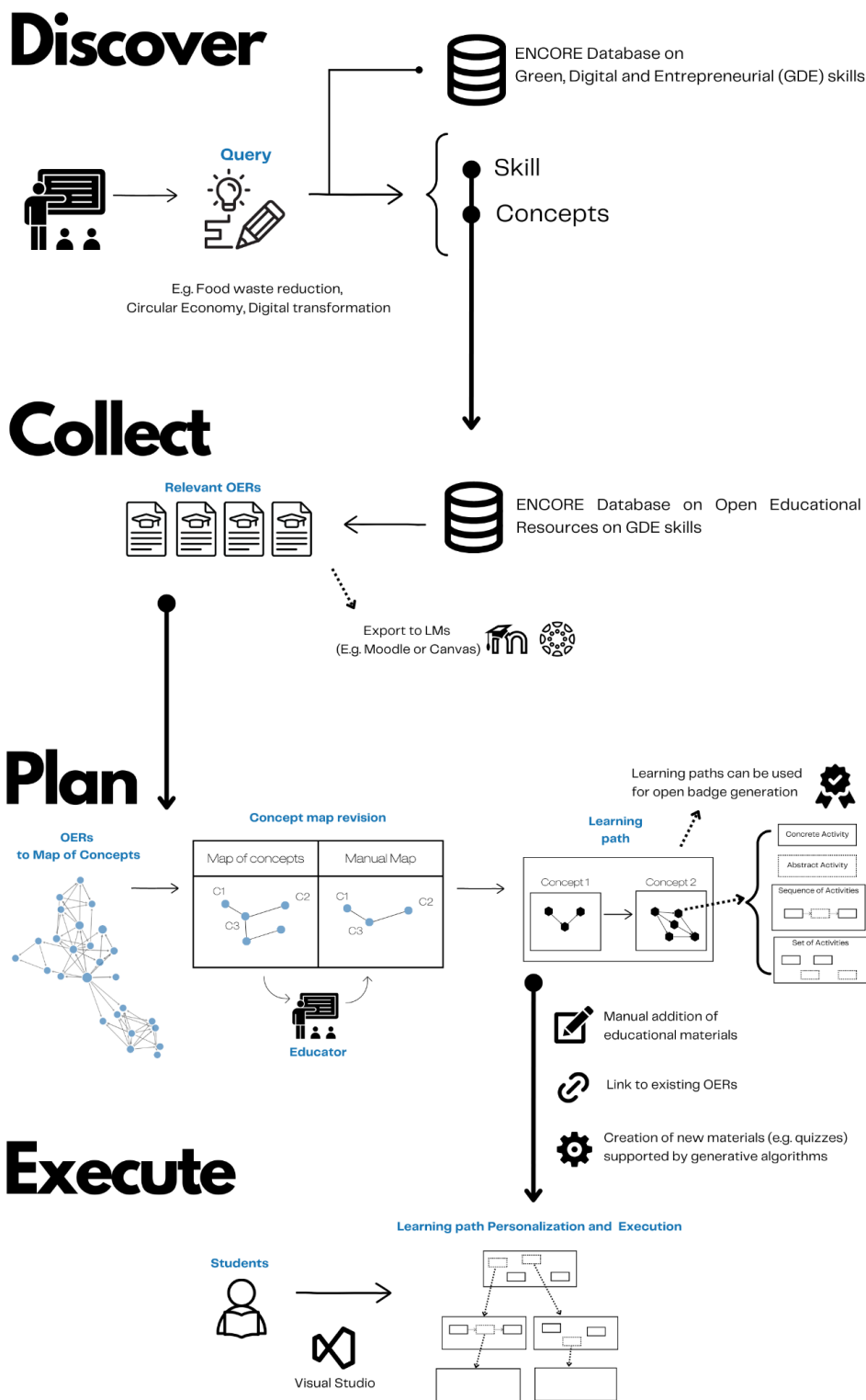


Figure 2. The four steps of the ENCORE enablers approach

The first step, **Discover**, involves educators delving into relevant concepts and skills that will serve as the foundation for their learning activities. These skills are identified within specific domains, namely Green, Digital, and Entrepreneurial (GDE), and are selected from the ENCORE database. This database comprises skills extracted from academic literature and

linked to the ESCO (European multilingual database of Skills, Competences, Qualifications, and Occupations). Educators identify pertinent skills and knowledge concepts within the domain, such as "circular economy" or "food waste reduction," in order to identify suitable Open Educational Resources (OERs).

Moving on to the second step, **Collect**, educators can review the extracted educational materials within the OERs and carefully select the most relevant ones. They have the flexibility to export these materials to other Learning Management Systems, such as [Moodle](#)³, or use them to enhance and refine a learning path based on the concepts covered in the OERs.

In the subsequent step, **Plan**, educators have the ability to convert the primary concepts from the collected OERs into a concept map using semantic similarity algorithms. They can then personalise the generated map by adding new concepts, making edits to existing ones, and arranging them as needed. The resulting concept map can be transformed into a learning path, where relevant educational resources and activities are associated with each node or concept. Educators have the freedom to determine the order of these resources and include various types of educational materials. These materials can be manually added, linked to existing OERs, or generated using generative models. Furthermore, the resulting learning path can be shared with students in the subsequent phase. Additionally, the learning paths can be utilized to validate the assignment of open badges, depending on the successful coverage of concepts and resources throughout the path.

Lastly, in the **Execute** phase, students gain access to the learning paths crafted by educators. They can utilise notebook interfaces to explore the learning activities presented within each node of the path, allowing them to personalise their learning experience by accessing different resources. These notebook interfaces enable students to engage with the materials in a flexible and personalised manner.

The following deliverable provides a description of the various digital components utilized to implement the ENCORE Enabler approach. The first part focuses on the process of translating Open Educational Resources (OERs) content into a map of concepts (T4.1). The second section covers the Enabler for Educators (T4.2), which encompasses the Discover, Collect, and Plan phases, and describes the co-design activities and the resulting digital outputs. The third section describes the Enabler for Learners (T4.3), which implements the final Execute phase.

Additionally, the supporting documentation for the Enablers (T4.4) is provided, along with a description of the plug-in developed to facilitate implementation with external Learning Management Systems (LMS) like Moodle (T4.5).

³ Moodle: <https://moodle.org/>

OER to map of concepts

This methodological note describes the processes done for task 4.1. The main purpose of this task was to identify concepts in OERs' description and the relations between them in order to create maps of concepts.

Methodology

The input data was the dataset of OERs produced in task 3.1, containing title, description, subject, and other features (e.g., creator, source, format, etc.) of 118,808 Open Educational Resources. The first operations were done in order to identify and extract concepts in the OERs' descriptions. We decided to adopt a lexicon-based information extraction approach. The process involves extracting concepts from the texts by searching for terms within a predetermined lexicon. When a specific term matches, the corresponding concept is considered discovered. Initially, we created a lexicon of concepts with a focus on aiding educational processes. Our approach involved gathering terms that could be considered essential for learning and teaching. To accomplish this, we used the European Skills, Competences, Qualifications, and Occupations - ESCO⁴ database and Wikipedia as sources. We began by using the 3,059 knowledge items from ESCO as a baseline. To expand this set of concepts, we conducted automated searches for all these knowledge items on Wikipedia. We recorded all the hyperlinks found on each Wikipedia page visited as part of our concept collection. This process was repeated for the new entities identified through these hyperlinks. We automatically visited their respective Wikipedia pages and gathered the hyperlinks present there. By combining the ESCO knowledge with the entities acquired through the two Wikipedia iterations, we finalised the lexicon of concepts, totaling 162,256 terms. With the completed lexicon, we were able to search for its terms within texts: each OER description has been automatically analysed through a Python script to match the concepts. We produced a dataset containing, for each OER, the list of the extracted concepts. To measure the reliability of this methodology and of the lexicon used, we randomly selected 500 different entities, among the ones extracted, and we read them to evaluate if they could be actually considered as a concept or not.

We then aimed to identify relations between the concepts identified in each OER description. The method we applied involved the usage of Wikipedia: we assumed that if a certain concept A appears on the Wikipedia page of another concept B as a hyperlink (redirecting to the Wikipedia page of concept A), it means that there exists a relation between them, in particular meaning that A is contained in B. The reason for this assumption is the fact that on Wikipedia pages it is common to mention concepts that are kindred to the main topic and to insert hyperlinks to redirect the user to their pages, if they exist. The relations identified on Wikipedia have a direction: if A is found on the page of B, but not vice versa, there exists a relation going from A to B, but not from B to A. This process has been performed through an R script which iterates over all the OERs: for each of them, it takes the concepts extracted and searches their corresponding Wikipedia page, through the R package WikipediR. Then, all the concepts are searched in the hyperlinks of the Wikipedia pages collected. The output was a

⁴ ESCO: <https://esco.ec.europa.eu/en>

dataset containing, for each OER, the combinations of all the concepts in pairs, and a flag to denote whether the Wikipedia relation exists or not.

The resulting dataset can be utilised to create graphs. We used the library networkD3⁵ to realise networks where the nodes are the concepts (nodes' size is proportional to the number of occurrences of a certain concept in the OER) and the edges represent the relations between them. We also set some parameters to filter the resulting graphs and show the most relevant concepts only: for each OER, we selected nodes whose degree centrality is higher than 1, and we took the main component of the graph only, in order to avoid having two or more separated clusters of concepts.

Figure 3 shows an example of a graph of concepts created from a single OER about AI and machine learning.

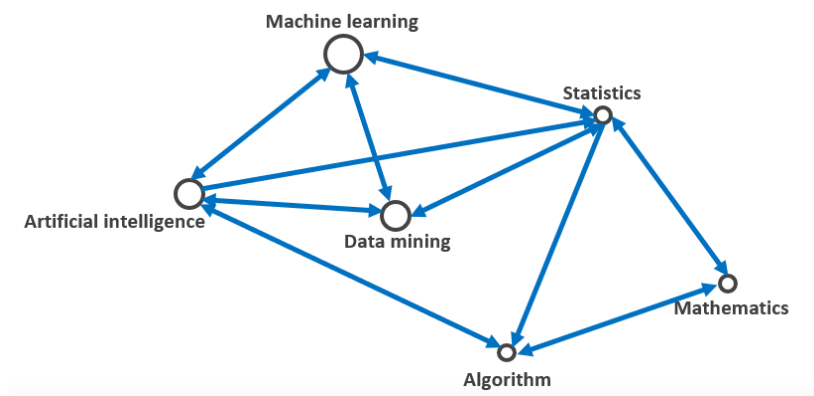


Figure 3. Graph of concepts created from a single OER.

It is possible to create conceptual maps also starting from a skill, rather than from single OERs. For this purpose, given a certain skill, we are able to filter the dataset of OERs in order to select only the subset of those which mention the skill. Hereafter, the concepts and relations used for the generation of the graph are then taken from all the OERs of the selected subset, and not from a single OER. In this way, we produce the graph of the relevant concepts of the OERs which cover the chosen skill in their program. Figure 4 demonstrates an example of these graphs, showing the concepts of the OERs which cover the skill of Virtual reality.

⁵ NetworkD3 library: <https://cran.r-project.org/web/packages/networkD3/networkD3.pdf>

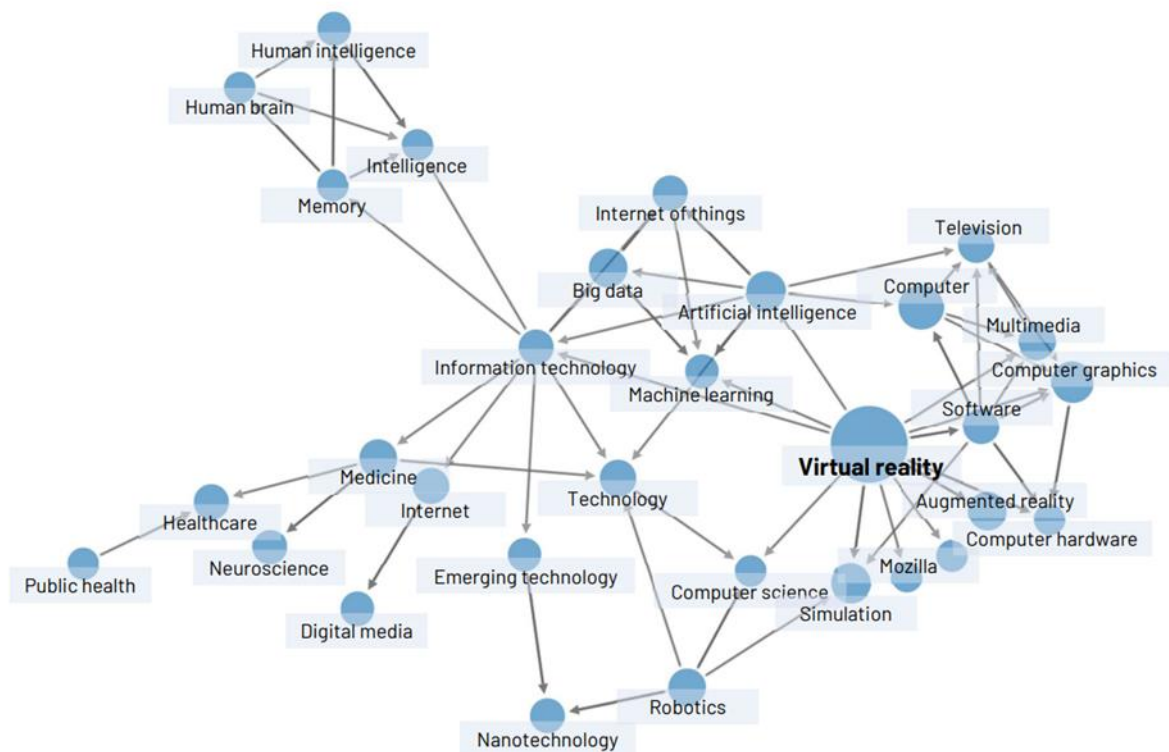


Figure 4. Graph of concepts related to the skill “Virtual Reality”

Graph of Concepts Generation APIs

The algorithm devised to underpin the methodology outlined earlier has been effectively implemented and is now offered as a collection of Application Programming Interfaces (APIs), designed to be harnessed by the Enabler for Educator (E4E). In the subsequent text, we provide an introduction to each of these APIs, outlining the parameters they accept and offering concise descriptions of their functionalities.

`/api/concept/genMapExt`

Accepted Parameters: extracted_concepts (list of concepts)

Description: This API generates a concept map by calculating the relationship between the provided extracted concepts.

`/api/concept/genMapSkill`

Accepted Parameters: skill

Description: Identifies a subset of OERs by filtering with the selected skill, and generates a concept map based on the relationship between filtered OERs’ concepts.

`/api/concept/genMapOers`

Accepted Parameters: oers_ids

Description: Generates a concept map based on the relationship between selected OERs' concepts.

`/api/concept/extract`

Accepted Parameters: text

Description: Extracts the concepts which are mentioned in an input text.

Enabler for Educators (E4E)

Instructional Design Tools

Instructional design is the process of creating learning experiences in such a way that knowledge and skills are acquired and applied. It involves assessing needs, devising a method, developing materials, and evaluating their usefulness (Reiser, 2001).

In this respect, instructional design tools are a set of resources and techniques that are used to create effective and efficient learning experiences for learners (Paquette, 2014; Pozzi et al., 2020). These tools are designed to assist instructional designers in developing instructional materials that are aligned with the learning objectives and goals of the course or program. Instructional design tools include a variety of resources, such as software applications, templates, frameworks, and models. These tools help instructional designers to organize, structure, and present content in a manner that is easy to comprehend and retain for learners. The use of instructional design tools is crucial for ensuring the effectiveness of instructional materials, as they help to ensure that the learning experience is optimized for the learner's needs and preferences. Moreover, the use of these tools allows for the creation of engaging and interactive learning experiences that enhance learners' motivation and engagement with the course material.

To ensure a comprehensive understanding of learning design tools, a thorough examination of current literature has been undertaken, serving two primary purposes. Firstly, to gain insights into the latest advancements in learning design, particularly regarding digital platforms dedicated to this domain. The focus was on comprehending how existing tools implement, support, and visually depict the learning design process. Secondly, the study aimed to determine whether the anticipated characteristics of this project offer genuine innovations to the field. A well-defined framework was utilized to evaluate ten of the most recent learning design tools, enabling a comprehensive assessment.

Based on previous research (Celik & Magoulas, 2016), a comprehensive analysis framework, tackling both current practices and elements of novelty, was created. The collected information regarding the tool, in terms of aim, technology and target users, the learning design phases supported, the information architecture, the presence of visual representations, and the presence of gamification, collaboration, personalization, and recommendation strategies. The reuse of open educational resources or general educational material was investigated as well.

A total of ten papers, published between 2012 and 2021, were reviewed, corresponding to 10 learning design tools: ILDE/edCrumble (Albó & Hernández-Leo, 2021), DEPIT (Laici & Pentucci, 2020), Pedagogical Planner (Pozzi et al., 2020), Learning Designer (Zalavra & Papanikolaou, 2019), CuVIS (Banerjee & Murthy, 2018), ILDE (Hernández-Leo et al., 2018), Learning Design Studio (Law et al., 2017), PeerLAND (Papanikolaou et al., 2016), OpenGLM (Derntl, 2015) and CADMOS (Katsamani et al., 2012).

The literature review reveals the current trends in learning design tools and the approaches employed in the learning design process. One noteworthy aspect is the dominant use of web-based applications. The preference for web-based tools can be attributed to recent technological advancements and the need for accessing materials seamlessly across various devices and locations.

The learning design process had been supported in different degrees and with different approaches by all the considered tools. The analysis highlights how learning design tools give more importance, and thus support, to the design aspects of the learning design process, namely the phases of conceptualization and authoring. The delivery phase is rarely included in these tools, perceived more as of secondary importance with respect to the whole process.

An additional feature emerging from the currently existing tools is the use of visual representations. Seven of the reviewed tools use a graphical representation to depict the learning design and to provide support to the educator-designers. The emerging suggestion from these findings appears to be to favour the use of graphical representation of learning designs to better support educators. The diversity among the representations proposed, suggests there is not a unique, nor a better, way to represent a design. For example, although four tools make use of a flow diagram, each of them is implemented differently. The use of graphical elements is positively supported by the current trends.

Apart from investigating current trends, an objective of the literature review was to identify potential areas of innovation in the realm of learning design tools. This exploration aimed to offer valuable insights for the development of E4E, the Enabler for Educators implemented in the ENCORE project. The analysis of recent tools has substantiated that the anticipated features of E4E indeed represent significant advancements. Specifically, the review revealed that only one tool, OpenGLM, supported the integration of Open Educational Resources for reuse. This finding suggests that the potential for incorporating pre-existing educational materials into learning design has been largely overlooked. Additionally, it is noteworthy that none of the existing tools make specific references to GDE skills, nor do they incorporate elements to support personalised and adaptive learning. These observations underscore the potential innovative contribution of the ENCORE enablers with respect to the prevailing tool landscape.

OER usage: challenges and opportunities

Open Educational Resources have become increasingly popular in recent years, as they offer a range of potential benefits, including cost savings, increased access to educational materials, and greater flexibility in course design (UNESCO, 2019). However, there are also several challenges associated with the use of OER that should be considered (Abri & Dabbagh, 2018; Luo et al., 2020; Wang & Towey, 2017).

One of the main benefits of OERs is that they can significantly reduce the cost of educational materials for students, especially in higher education (Luo et al., 2020; UNESCO, 2019). With the rising costs of textbooks and other course materials, OER can provide a more affordable alternative (Hilton, 2020). Additionally, OER can help to increase access to educational materials, particularly for learners in underprivileged or remote areas who may not have access to traditional educational resources (Perifanou & Economides, 2022; UNESCO, 2019). Furthermore, OER can offer greater flexibility in course design, as instructors can easily modify or adapt existing materials to meet the specific needs of their learners (Baas et al., 2019).

However, there are also several challenges associated with OER. One of the main challenges is the quality and reliability of the materials, as there is often little quality control or peer review for OER (Wang & Towey, 2017). This can make it difficult for instructors to determine

the appropriateness of the materials for their course and can lead to inconsistencies in the quality of the educational materials being used. Additionally, for practitioners familiar with the concept and existence of OER, discoverability has been recognized to be a major barrier to OER adoption: the large amount of available resources poses a challenge for the identification of adequate material (Luo et al., 2020). Finally, there can be issues related to copyright and licensing, as some OERs may not be licensed for commercial use or may have restrictions on their distribution (Abri & Dabbagh, 2018).

Co-design process and prototype development

Co-design methods are becoming increasingly popular in education, particularly in the design of educational resources and instructional design (Sanders & Stappers, 2008). These methods involve educators and other stakeholders in the design process, allowing for a collaborative approach to the development of educational materials (Roschelle & Penuel, 2006). Co-design methods involve a range of activities, such as workshops, focus groups, and online forums, which allow for the sharing of ideas and the co-creation of educational materials. This approach not only helps to ensure that the materials are tailored to the needs of the learners, but also increases the engagement and ownership of the educators in the design process (Cviko et al., 2014). Furthermore, co-design methods enable educators to share their expertise and experience, which can lead to the development of innovative and effective educational resources. Co-design methods can also help to ensure that the design process is more efficient, as educators are able to provide feedback and make changes to the materials in real-time (Roschelle & Penuel, 2006).

Considering the ENCORE project, the main objective of the Enabler for Educators (E4E) is to support educators in the creation of learning paths and re-using open educational resources (OER) on green, digital, and entrepreneurial skills.

The approach taken for the development process was co-design, which involved an iterative design approach. This approach included the validation and refinement of a referent prototype, which was reviewed by all project partners. To initiate this process, a first version of the prototype was tested during a co-design workshop held at a project meeting in Salamanca on February 24th, 2023. The workshop results were then analysed and further enhanced through a second round of validation conducted via a digital survey.

The valuable insights gathered from these validation rounds were incorporated into a re-designed prototype. This refined prototype served as the foundation for the enabler for educators, which underwent further advancements during the software development phase (Figure 5).

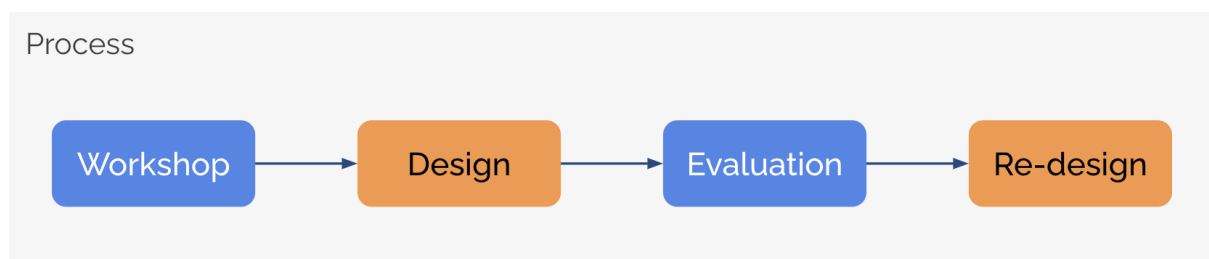


Figure 5. Design process adopted in the design of the ENCORE enablers

In the following sections, a detailed description of each step in this process is presented.

First design iteration

A collection of user interface elements (UI kit) was developed starting from the logo of the ENCORE project, specifying the main visual design aspects, and collecting ready-to-use interface elements.

The ENCORE logo was the starting point: the intention was to create an interface aligned with the logo, in order to create a fluent and unique visual experience. Visual consistency was achieved by choosing colour and fonts recalling the logo, and by constructing visual elements stylistically coherent. The complete UI kit is available in Appendix D, hereby the main components have been reported.

Two fonts have been selected (Figure 6): the primary font for titles and the secondary font for all the other textual elements. In order to select the typographic elements, the font present in the logo was taken as a reference. The selected primary font was Exo, characterised by soft curves and rounded shape. The secondary font chosen was Nunito as it matched well with the primary one, has a good readability, and is available in different weights.



Figure 6. ENCORE font and typeset

A colour palette has been constructed starting from the logo (see Figure 7), to create a visual experience consistent within the whole project. Six colours have been selected, including a primary colour for the most important interface elements, an accent colour to grab user attention when necessary, a secondary colour for less relevant components, and a three-colour grayscale for background and marginal elements.

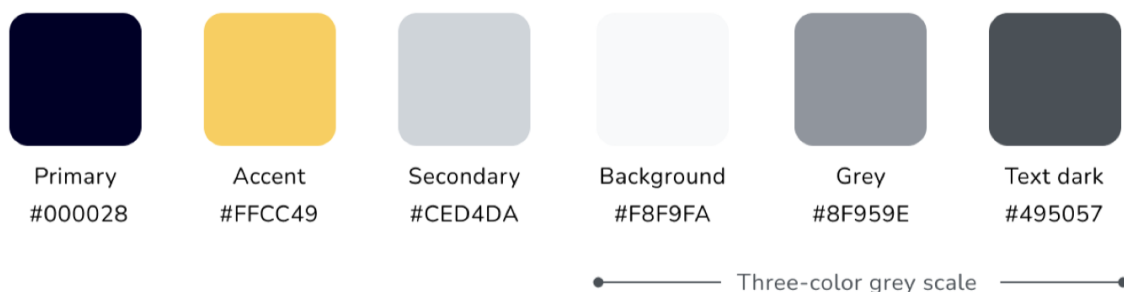


Figure 7. Colour palette for the ENCORE enablers

The most frequently used interface elements have been designed in order to have a minimal library of recurrent components available (Figure 8). These elements include a set of buttons with different states (eg. hovered, clicked, disabled), a search bar, a drop-down menu, the top

bar, and the lateral menu. Comprehensively rounded shapes and soft curves have been included in each element to recall the logo. In Figure 13 a portion of the button's design is depicted.

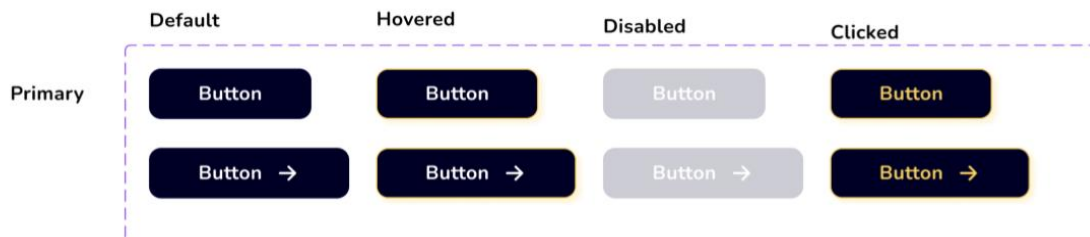


Figure 8. Button style for the ENCORE enablers

Co-design Workshop

In February 2023, a co-design workshop was organised in collaboration with the ENCORE partners during the consortium meeting. The primary objective of the workshop was to gather valuable input from educators for the design of the ENCORE's digital components that are intended to assist educators in navigating the ENCORE's Open Educational Resources (OER) database and selecting relevant OER based on targeted Global Digital Education (GDE) skills.

During the workshop, partners were given the opportunity to explore a prototype of the ENCORE Enabler4Educators (E4E) interface. This prototype featured four distinct approaches for searching Open Educational Resources (OER) within the tool (refer to Figure 9). The primary objective was to discern the participants' preferences among these options and to foster engaging discussions among them. A MIRO board was used during the workshop for collecting participants' feedback through the completion of different activities (See Figure 10). This provided a valuable opportunity to validate certain design choices and priorities while also stimulating discussions on the integration of the ENCORE Database in targeted learning scenarios.

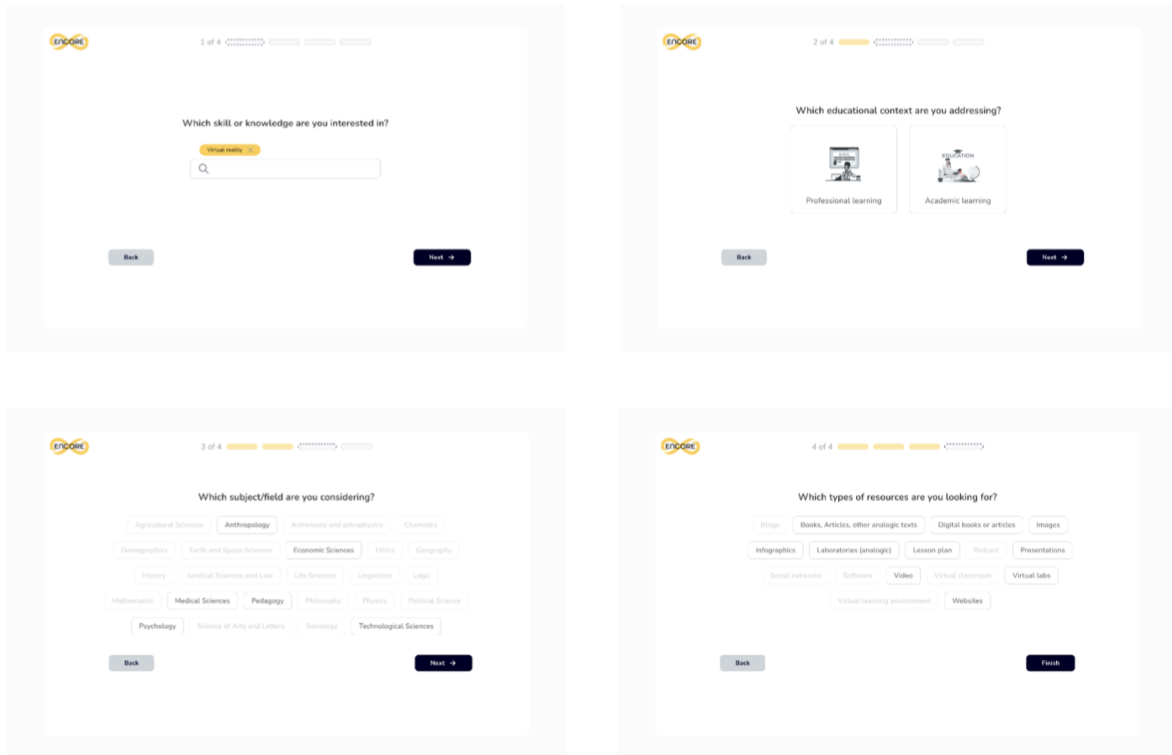


Figure 9. Prototypes used in the co-design workshop. The interactive prototype used during the workshop can be accessed via this [link](#)

All the participants (23 participants among the project partner institutions) provided insightful feedback, which is presently being analysed and incorporated into a revised version of the interactive prototype. The co-design workshop's output was critical in ensuring that the ENCORE components are tailored to meet the needs of educators, resulting in the more effective use of OER in teaching and learning. The outcomes of the workshop had far-reaching benefits for the entire educational community, enabling educators to better navigate OER and develop digital skills, ultimately resulting in more efficient and effective teaching and learning practices.

Activity 1: prototype hans-on

Try each different interaction options included in the prototype and report positive (green) or negative (red) aspects in the post-it below

[Click here to open the Prototype](#)



Activity 2: process validation

Using the blocks below represent the steps for recommending OERs based on your learning scenarios

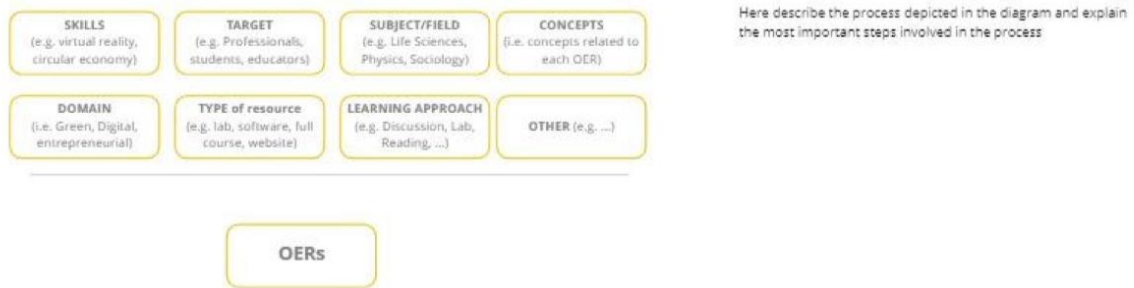


Figure 10. Examples of the activities used during the workshop. The MIRO board can be accessed via this [link](#)

Second design iteration

The workshop results were analysed through a thematic analysis of individual activities and have been translated into design guidelines. The main objective was to develop a platform that respects real needs and expectations. For this reason, the themes identified during the workshop encompass the primary concerns, suggestions, and considerations related to the tool. The resulting design guidelines express the key objectives to consider while advancing the design and development of the platform. Table 1 outlines the themes and their respective design guidelines.

Themes (15)	Design guidelines (9)
T 1.1 - Contextual information are relevant	DG 1 - Provide the option to specify contextual information (audience, subject/field)
T 1.2 - Maintain the number of "clicks"/steps low	DG 2 - Limit the number of pages the user is exposed to to complete a task

T 1.3 - Firstly, define the skill	DG 3 - Start the search process from the skill definition
T 1.4 - A well-defined search query to reduce results	DG 4 - Provide participants with the freedom to define the search query in as many details as desired
T 1.5 - Types of activities are interesting	No guidelines
T 1.6 - The concept map was appreciated	DG 5 - Consider visual representations to support the task completion
T 2.1 - The value of the tool resides in the GDE skills	DG 6 - Emphasise the role of GDE domains and skills
T 2.2 - Help users in positioning	DG 7 - Support the task of positioning: find resources that connect topics and domains
T 2.3 - Provide the information relevant to evaluate OER	DG 8 - Provide users with information relevant to evaluate OER
T 2.4 - Have a dynamic database	No guidelines
T 2.5 - Support flexibility	DG 9 - Try to support both direct search and explorative approaches
T 2.6 - Collect usage data	No guidelines
T 3.1 - Narrow down the search	DG 1 - Provide the option to specify contextual information (audience, subject/field) DG 3 - Start the search process from the skill definition
T 3.2 - Leave some information optional	DG 4 - Provide participants with the freedom to define the search query in as many details as desired
T 3.3 - Support various approaches	DG 9 - Try to support both direct search and explorative approaches

Table 1. Themes (T) and design guidelines (DG) resulted from the co-design workshop

In accordance with these guidelines, adjustments were made to the prototype employed in the workshop. As illustrated in Figure 11, the homepage of the enabler for educators underwent a revision, aligning with various pointers from the guidelines. For instance, to adhere to Design Guideline 1, advanced search options were incorporated, while Design Guideline 3 prompted a redesign of the interface to emphasise the pivotal importance of skills

and pertinent keywords that users could input into the search bar. Furthermore, enhancements were made to the results page, now featuring a more streamlined presentation of both the aggregated results and individual OER listings (Figure 12), while the representation of the concept maps was edited to enhance readability. (Figure 13).

In parallel, the results from the workshop were also shared with partners to further collect opinions and suggestions.

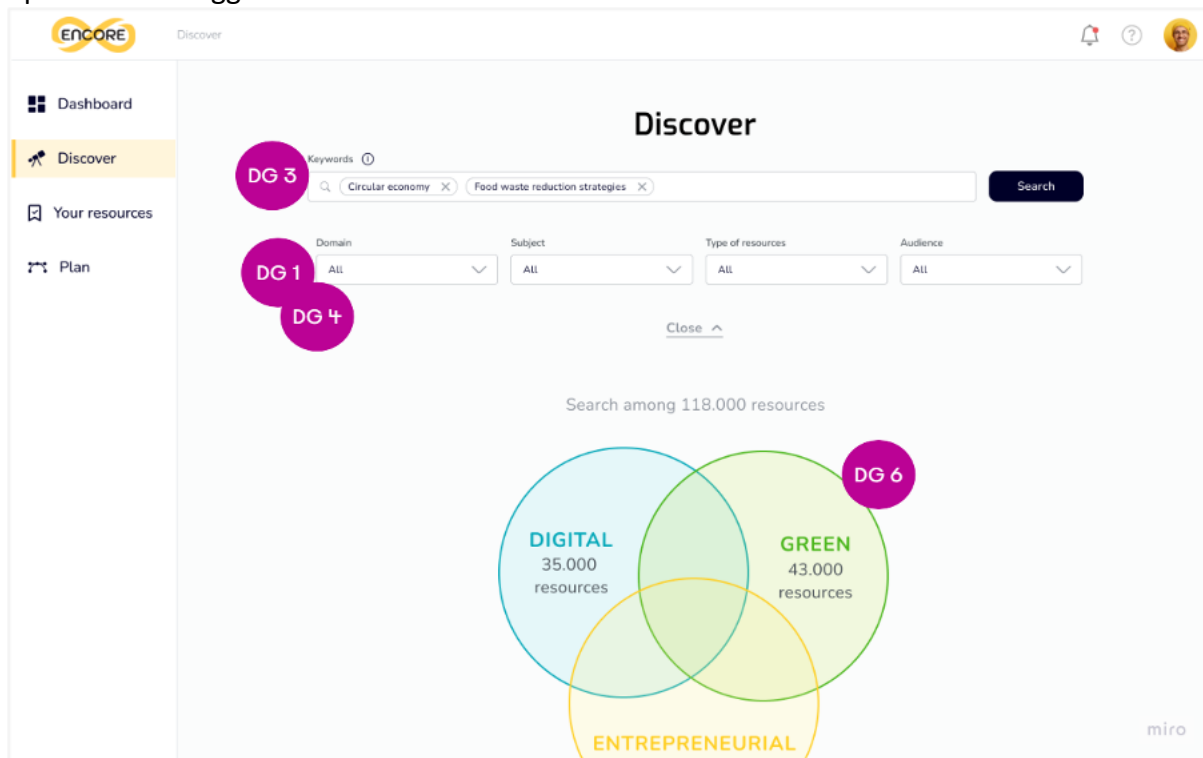


Figure 11. Revision of the homepage based on the design guidelines (DGs)

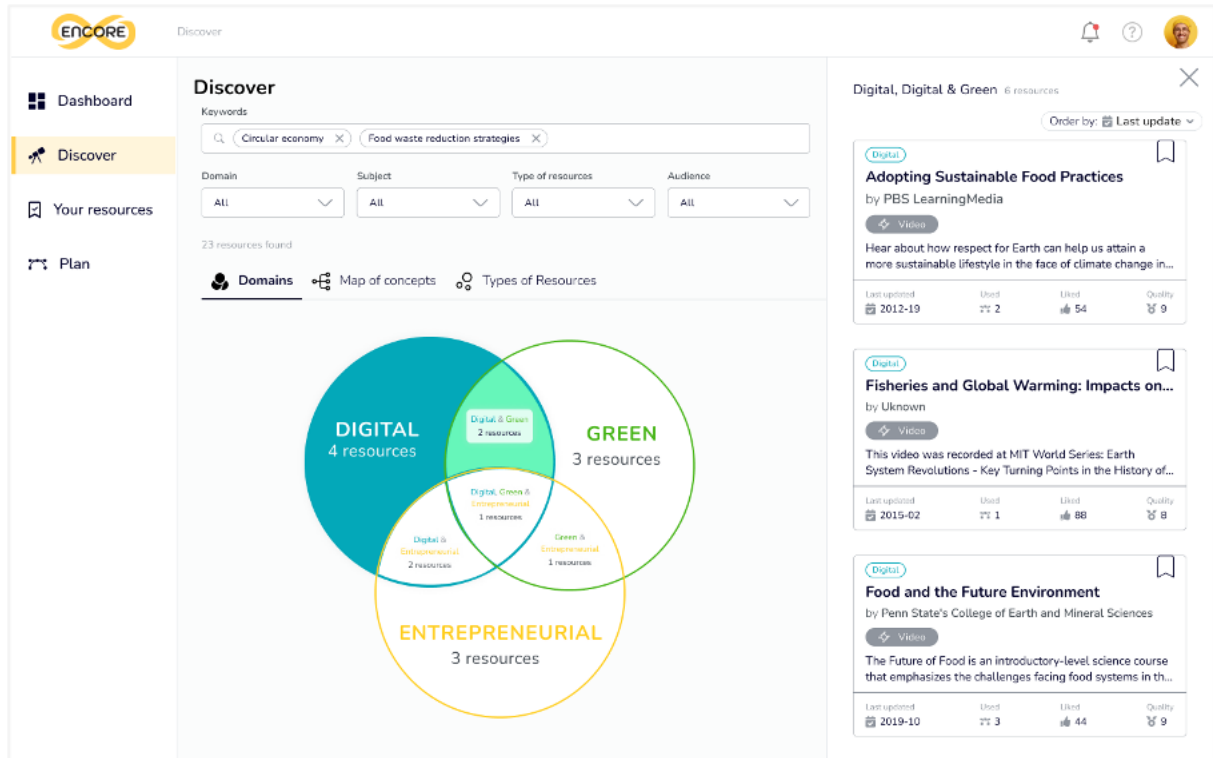


Figure 12. Revised interface for the search results

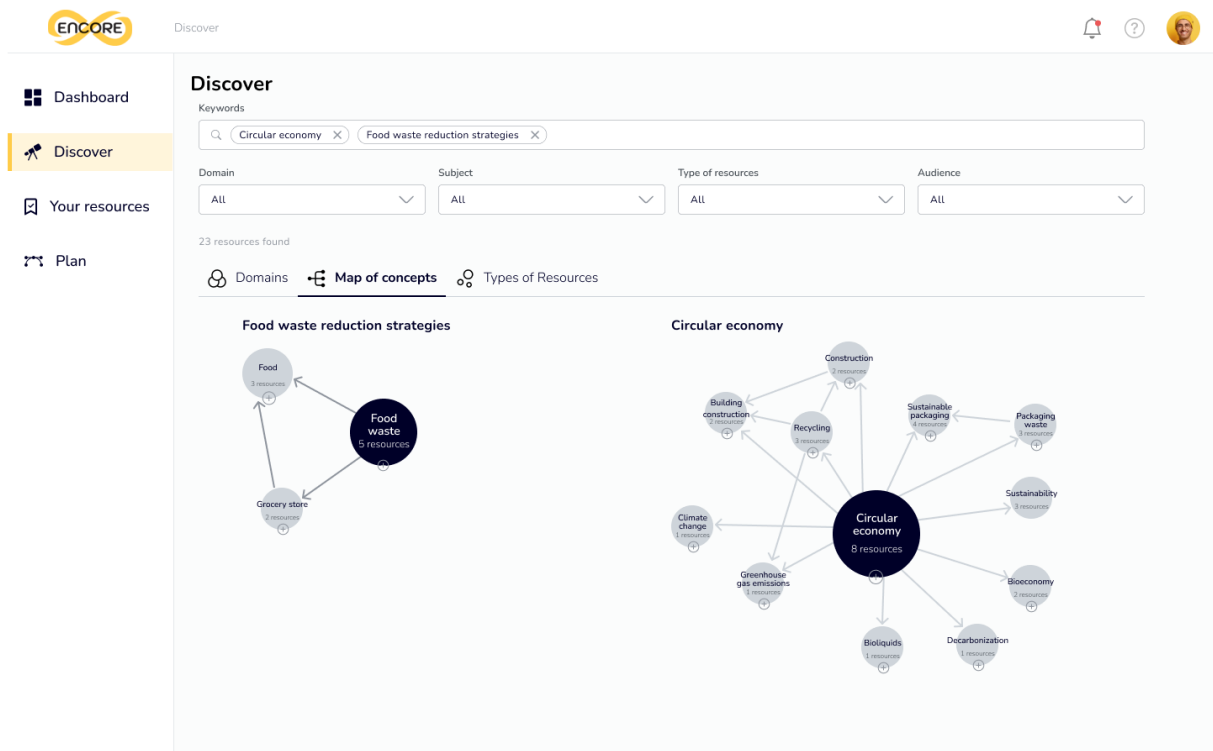


Figure 13. Revised representation of the map of concepts

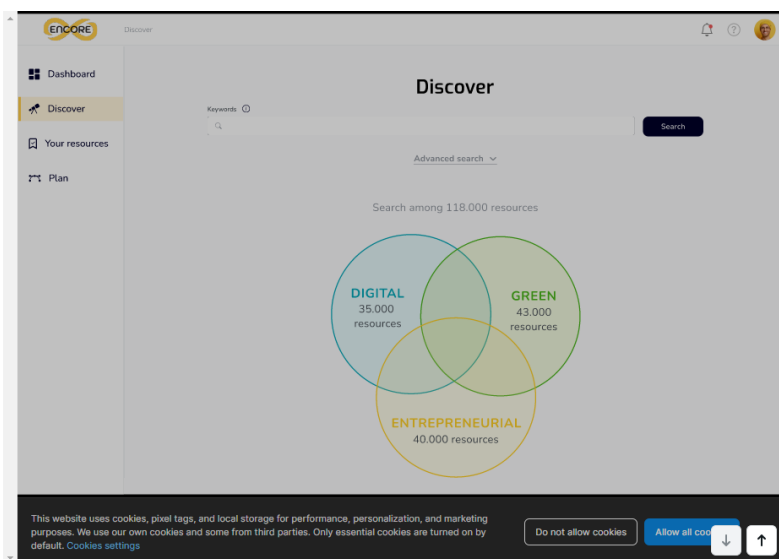
First prototype validation

The second version of the prototype was validated through a survey developed (Figure 14). This survey allowed participants to interact with the prototype and complete three different tasks:

Task 1: Participants were instructed to find resources related to the keywords "circular economy" and "food waste reduction strategies" specifically in the digital domain. Additionally, they were asked to locate resources that addressed both the digital and green domains.

Task 2: Using the map of concepts, participants were required to filter the Open Educational Resources (OERs) that contained the concepts of "food" and "sustainability." From the filtered results, they were instructed to save the resource titled "Adopting Sustainable Food Practices."

Task 3: Participants were asked to filter the OERs based on their type and select only videos and articles. Following this, they were directed to visualise the resources they had previously saved as "your resources."



The screenshot displays the ENCORE Discover interface. On the left, a sidebar shows navigation options: Dashboard, Discover (selected), Your resources, and Plan. A notification indicates '11/27 Required'. Below this, 'Task 1' is described: 'Find resources using the keywords "circular economy" and "food waste reduction strategies" that address the digital domain only, as well as those that address both the digital and green domains.' A 'Start' button is visible. The main content area shows a search bar with 'Keywords' and a 'Search' button. Below the search bar, it says 'Search among 118,000 resources'. A Venn diagram with three overlapping circles is shown: 'DIGITAL' (35,000 resources), 'GREEN' (43,000 resources), and 'ENTREPRENEURIAL' (40,000 resources). At the bottom, a cookie consent banner is visible with 'Do not allow cookies' and 'Allow all cookies' buttons.

Figure 14. The survey used for evaluating the revised prototype

Throughout the survey, participants were provided with the opportunity to engage with the prototype, perform the specified tasks, and provide feedback on their experience.

The survey was distributed among the project partners, resulting in a total of 24 responses. Participants were initially asked for some preliminary information (Figure 15). The majority of respondents (N=13, 54%) were from an academic education context, while a few participants represented vocational (2) and professional (2) training backgrounds. One respondent was from a Non-Governmental Organisation. Among the participants, the majority (N=17, 71%) reported having previous experience with Open Educational Resources (OER).

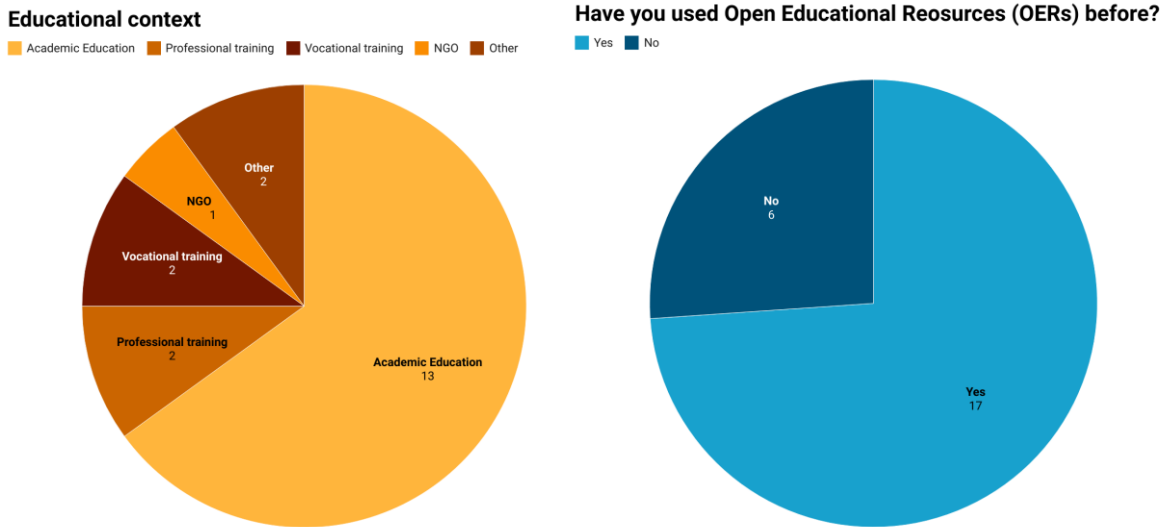


Figure 15. Respondent demographic information

However, only five participants stated that they used OER frequently or very frequently (Figure 16). Even fewer respondents reported frequent use of OER repositories, with only two participants indicating frequent usage. On the other hand, four participants reported rare usage, and six participants mentioned occasional usage.

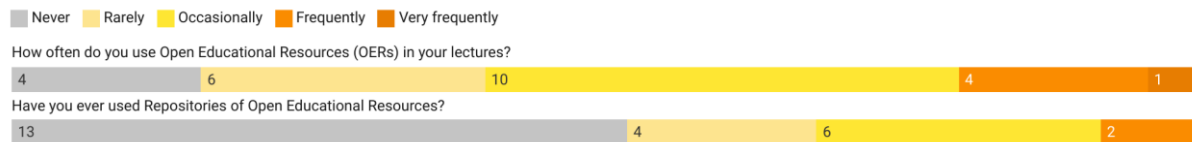


Figure 16. Respondent familiarity with OERs

When it comes to finding resources, the main methods reported by respondents were conducting searches on Google and YouTube, as well as exploring open learning object aggregators like OER Commons. Many participants mentioned searching for research articles, handbooks, videos, and TED Talks from scholars and professionals they know, even if those resources were not strictly classified as OERs. Browsing OER repositories was considered tedious and time-consuming by most participants.

Considering the three tasks, Figure 17 presents the success rates achieved for each task. Task 3, focused on identifying resources based on their type, received the highest score with a success rate of 74%. It was followed by Task 1, which involved identifying target OERs, with a success rate of 64%. Task 2, which required navigating the map of concepts, had a success rate of 52%.

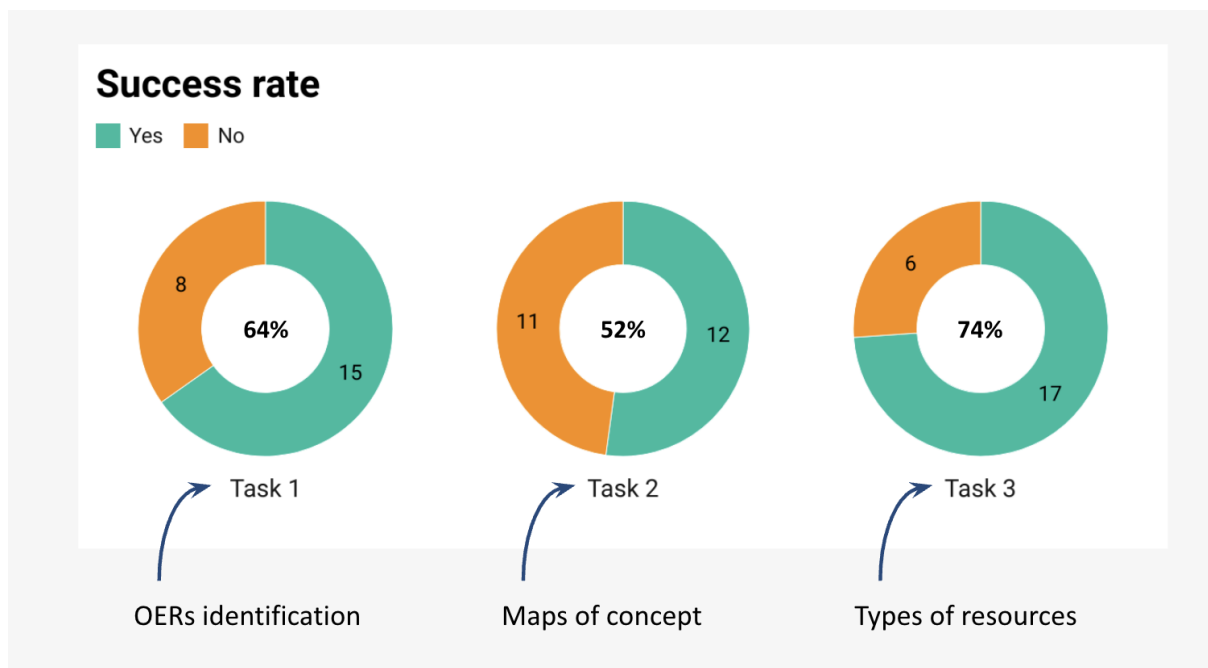


Figure 17. Results for the three tasks included in the survey

In addition to the tasks, the questionnaire also included questions from a usability scale called UMUX, as shown in Figure 18. The results from the scale indicate a generally high score in terms of usability, with an average score of 83 (on a scale from 0 to 100, SD= 18.7). The responses reflected positive feedback for both the Usefulness (M= 5.7, SD= 1.1) and Ease of Use (M= 5.8, SD= 1.3) aspects of the prototype.

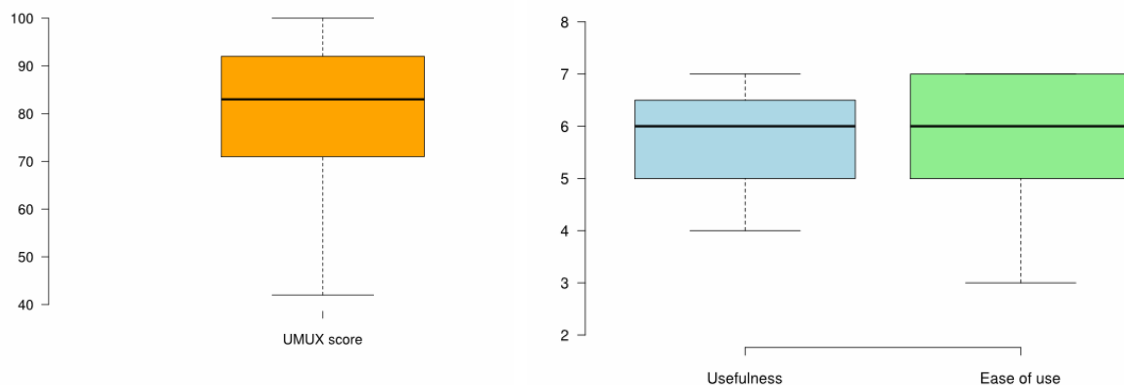


Figure 18. Results for the UMUX lite and usability scores

The final part of the survey focused on exploring instances of surprise and frustration within the interactive experience through open-ended inquiries. The incorporation of visualisation to enhance the search process was acknowledged as a source of surprise and innovation. The primary source of frustration stemmed from the prototype's constraints, which mandated users to follow a predetermined interaction path. Some participants conveyed a wish to thoroughly explore the tool within their own specialized domain to simulate real-world scenarios.

Second prototype validation

The survey validated that the use of visual representations was generally appreciated. The domain diagram and the bubble chart received more positive comments with respect to the map of concepts, which was perceived as complex (see Figure 19). These visualizations offer space for improvements, yet they demonstrate potential in supporting the task.

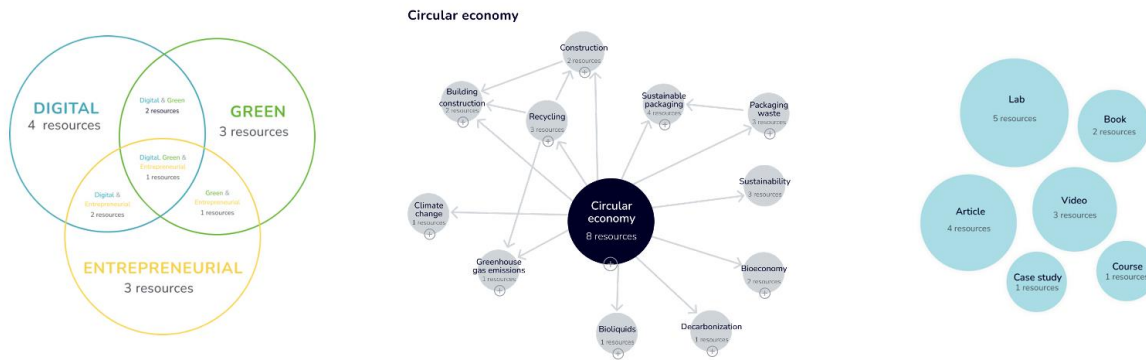


Figure 19. Graphical elements included in the prototype

The primary themes identified through the interface assessment encompassed (1) the focus on Open Educational Resources (OER), (2) potential enhancements for graphical representations, and (3) the need to provide access to the comprehensive results list. Across all three tasks, the feedback consistently underscored a deficiency in attention toward the resources themselves. The existing interface exhibited a disparity in the allocation of attention and prominence between OER and visualisations. Notably, the central screen area, where user focus is most concentrated, prioritised visualisations, relegating the list of OER to a peripheral space within the interface. This layout was acknowledged as a hindrance to effective task completion, potentially negatively impacting the perception of visual representations as limiting rather than beneficial. Subsequent design iterations of the prototype consider this insight and reorganise the interface accordingly (Figure 20).

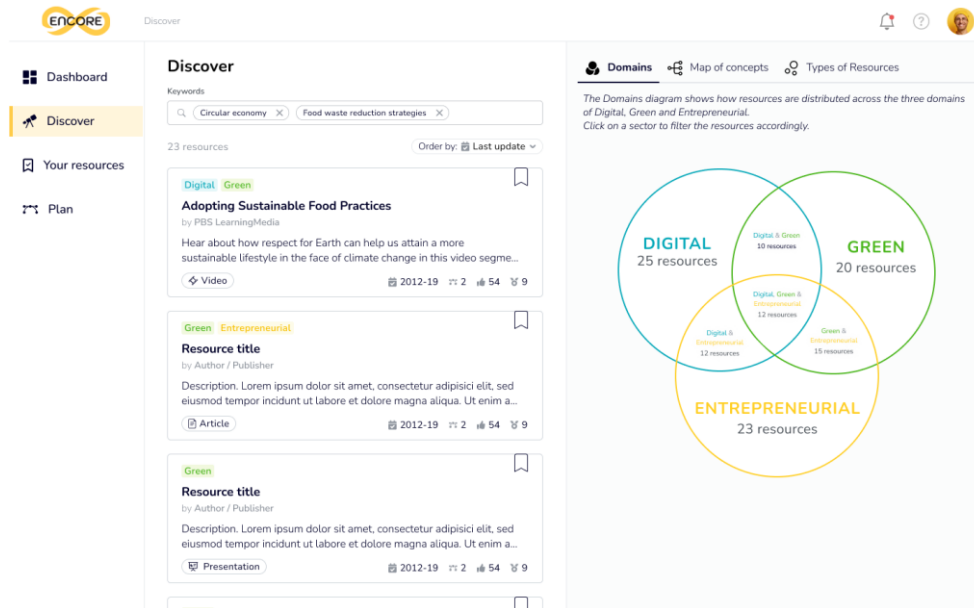


Figure 19. Revised interface for the result list

The second theme pertained to the visualizations, which encountered readability and clarity issues. Inconsistent text sizes and inadequate colour contrast occasionally impaired user experience. The concept map, in particular, generated higher confusion due to unclear elements such as arrows and plus symbols, leading to misinterpretation. A second revision has been developed for supporting the map readability (Figure 21).

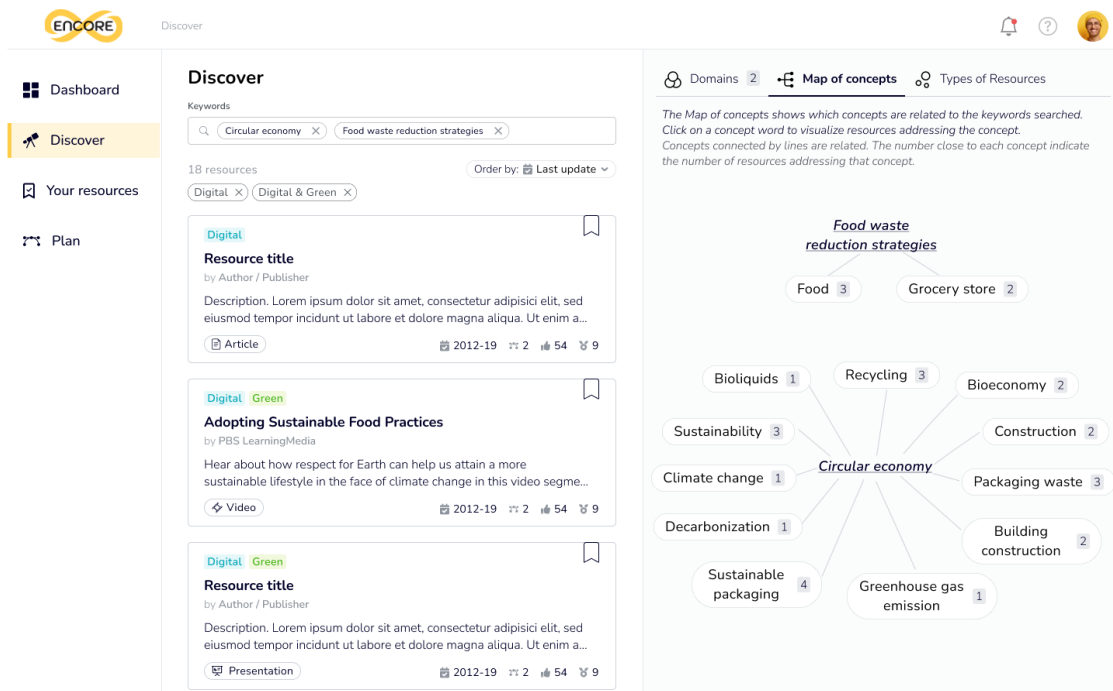


Figure 20. Revised interface for visualising the map of concepts

Lastly, the inability to access the complete results list has been deemed a drawback. Presently, the interface necessitates the selection of filters through visualisations to reveal the

corresponding resource list. However, educators utilising the platform in an exploratory manner might perceive this feature as limiting. This feedback calls for consideration in refining the interface to cater to diverse usage approaches. This information has been used in the development of the actual enabler, as presented in the following sections.

Enabler 4 Educators (E4E) Interface and Development

The E4E conceptual model (as depicted in Figure 21) is built around the concept of competence, acknowledging the significance of competences in both personal and professional growth. Each *Competence* is defined by its characteristics and represents a distinct set of abilities, knowledge, and behaviours that individuals can acquire and apply in various contexts. To better understand and assess competences, each *Competence Item* is structured and categorised into different *levels* of proficiency or expertise. These levels of proficiency help to measure a person's mastery of a particular competence, indicating the extent to which they have developed and applied it successfully. For instance, a competence item can be referred to as a competence at a specific proficiency level, such as beginner, intermediate, advanced, expert, or master. These proficiency levels serve as a guideline to evaluate and measure the depth of understanding and practical application of each competence.

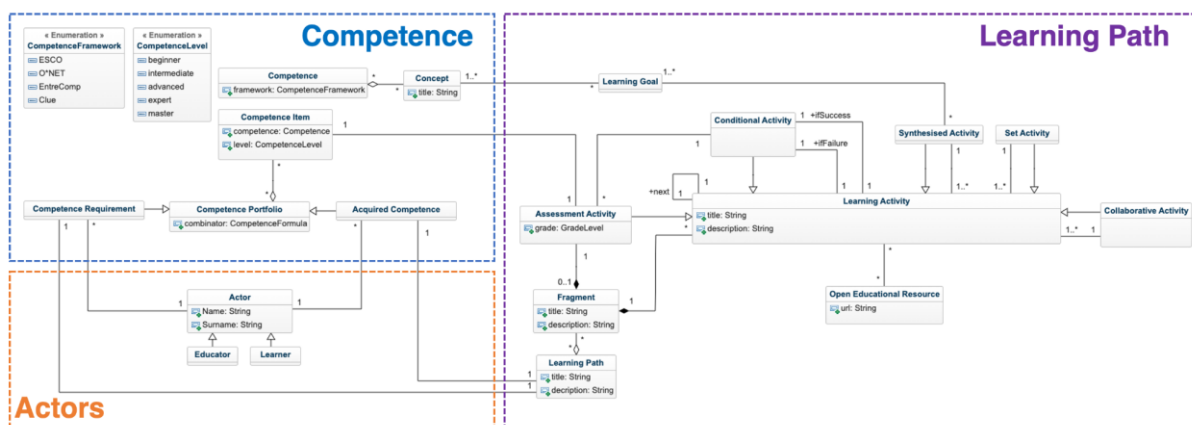


Figure 21. The conceptual model for the Enabler for Educators (E4E)

To establish a more comprehensive framework for competences, the E4E conceptual model explores potential links with existing *Frameworks*, such as O*NET⁶, ESCO⁷, EntreComp⁸, etc.. By connecting competences to these established frameworks, individuals can better align their skill development with recognized industry standards and qualifications, enabling them to make more informed decisions about their personal and professional growth.

A competence can be described as a set of *Concepts* that individuals must study, learn, and understand to develop specific skills and abilities. Competences are not isolated skills; instead,

⁶ O*NET (Occupational Information Network): <https://www.onetonline.org/>

⁷ ESCO (European Skills, Competences, Qualifications and Occupations): <https://esco.ec.europa.eu/>

⁸ EntreComp (European Entrepreneurship Competence Framework): <https://ec.europa.eu/social/main.jsp?catId=1317&langId=en>

they encompass a range of related knowledge, principles, and practices that work together to achieve a particular *Learning Goal*.

The *Competence Portfolio* serves as an aggregation of various competence items, representing a diverse range of skills, knowledge, and abilities that individuals possess or aspire to acquire. These competences are organised and structured within the portfolio to enable the identification of potential learning paths and progressions.

The *Combinator*, an essential component of the competence portfolio, plays a crucial role in guiding learners through their skill development journey. It is a logical formula that can incorporate both *Competence Requirements* and *Acquired Competences*. The requirements indicate which competencies should be acquired before progressing to others. This ensures a logical and coherent advancement in skill development, allowing learners to build a strong foundation before tackling more advanced topics.

On the other hand, the acquired competences represent the ultimate objectives or outcomes that learners aim to achieve after completing specific learning paths.

Each *Educator* has the autonomy to define *Learning Paths* for their learners. These learning paths are designed to be decomposed into a set of *Learning Fragments*, which are centred around the same topic or subject matter. These learning fragments allow for a more granular and focused approach to education, enabling learners to concentrate on specific aspects of a competence while gradually building a comprehensive understanding.

Learners can follow these paths, acquiring competences in a well-organised manner, and ultimately reach their desired end competences, which signify their mastery and proficiency in a particular domain. This approach fosters a systematic and efficient approach to skill development, empowering learners to achieve their learning goals and excel in their personal and professional endeavours.

Each learning fragment consists of a set of interconnected *Learning Activities* and serves as a guided process that helps learners achieve specific learning objectives. The activities within each fragment are designed to be executed in a particular order, facilitated by the *Progress Edge* entity.

As learners progress through each learning fragment, they follow a structured sequence of activities that build upon one another, providing a coherent learning experience. Each activity serves a unique purpose, contributing to the overall attainment of the learning objectives defined for that fragment.

The *Progress Edge* entity introduces the opportunity to have multiple outgoing outcomes from a learning activity. It guarantees a logical and structured flow of learning, ensuring a sequential order for completing activities.

With the *Progress Edge*, the learning journey becomes more dynamic and adaptive, accommodating various learning styles and preferences. Learners are empowered with

choices, enabling them to engage with the material and receive tailored feedback and validation methods based on their performance.

The *Progress Edge* enhances personalised learning experiences in several ways:

- **Diverse Outcomes:** The *Progress Edge* allows for multiple outgoing outcomes from a learning activity, such as unconditional progression, pass/fail assessment, exact value, and custom validation. This diversity in outcomes enables learners to receive feedback and recognition based on their individual performance and understanding of the material.
- **Tailored Learning Paths:** With the ability to choose from different outcomes, learners can take a more tailored approach to their learning journey. They can select the path that aligns with their learning goals and preferences, ensuring a personalised and engaging experience.
- **Adaptive Feedback:** The *Progress Edge* enables adaptive feedback mechanisms based on the chosen outcome. Learners receive specific feedback aligned with their performance, helping them identify areas of improvement and reinforcing their strengths.
- **Learning Flexibility:** Personalized learning experiences are all about flexibility. Learners can progress through the content at their own pace, diving deeper into topics that interest them or spending more time on challenging concepts.
- **Motivation and Engagement:** Personalization fosters motivation and engagement in learners. When learners feel that the learning experience caters to their specific needs and interests, they are more likely to stay motivated and committed to their studies.

By employing this systematic approach to learning, learners can effectively grasp complex concepts and develop their competences in a step-by-step manner.

A learning activity can take various forms, catering to different learning styles and objectives. These activities include:

- **Synthesised Activity:** It is not fully defined by the educator but is synthesised from a specific *learning goal* (i.e., a set of concepts to be mastered). By harnessing specific recommendation systems (da Silva et al., 2023) or generative AI techniques (Kasneci et al., 2023), the system can seamlessly propose learning activities that align with the designated learning objectives, utilising an existing set of learning fragments.
- **Set Activity:** Within this activity, learners have the freedom to select which activities they wish to engage with, based on their individual interests, learning preferences, and prior knowledge. By granting learners the autonomy to select their preferred sub-activities, the set activity promotes personalised learning experiences. Learners can focus on areas they find most challenging, delve deeper into topics they are passionate about, and apply their prior knowledge to build connections between different sub-activities.
- **Collaborative Activity:** It involves learners working together in a group setting to achieve shared learning goals. This type of activity promotes teamwork, communication, and cooperation, encouraging learners to exchange ideas, share perspectives, and collectively solve problems.

- **Assessment Activity:** It plays a crucial role in evaluating learners' achievement of specific competences within the overall learning path. The Assessment Activity is designed to measure learners' proficiency and understanding of the targeted competence. It may consist of quizzes, exams, practical exercises, or any other evaluative methods that measure learners' knowledge and skills related to the learning objectives. The Assessment Activity includes an attribute called "grade," representing the Grade Level defined for the specific competence being assessed. This grade corresponds to predefined criteria that align with the proficiency levels expected of learners at different stages of their learning journey. The grade serves as a quantitative measure of learners' performance, providing valuable feedback and insights into their competence development.

Open Educational Resources (OER) offer a valuable and versatile resource that can be utilised across all the learning activities mentioned previously. Whether in Set Activities, Collaborative Activities, Synthesised Activities, or even Assessment Activities, OER provides a wide array of freely accessible educational materials that can enrich the learning experience. By exploiting OERs across these learning activities, educators can enhance the quality and accessibility of education while promoting lifelong learning for a broader and more diverse audience.

Explore phase

The Enabler for Educators offers its primary service as access to an extensive collection of OERs, which have been curated through previous project activities. In accordance with the approach discussed in the preceding section, the interface has been designed using a co-design approach. This design empowers educators, as well as potential users, to effectively explore pertinent OERs by inputting specific skills or relevant concepts into the search function. This search capability can include all the terms (AND search) or at least one of them (OR search),

The database's contents are also visualised on the homepage (Figure 22). This is achieved through a Venn Diagram representation, visually categorising the OERs across the various GDE domains. Beyond this, users are provided with the opportunity to engage in advanced searches. They can fine-tune their results by applying filters based on domains, resource types (such as videos, datasets, comprehensive lectures, etc.), and target audience categories (ranging from academic and professional training to the general public, and more).

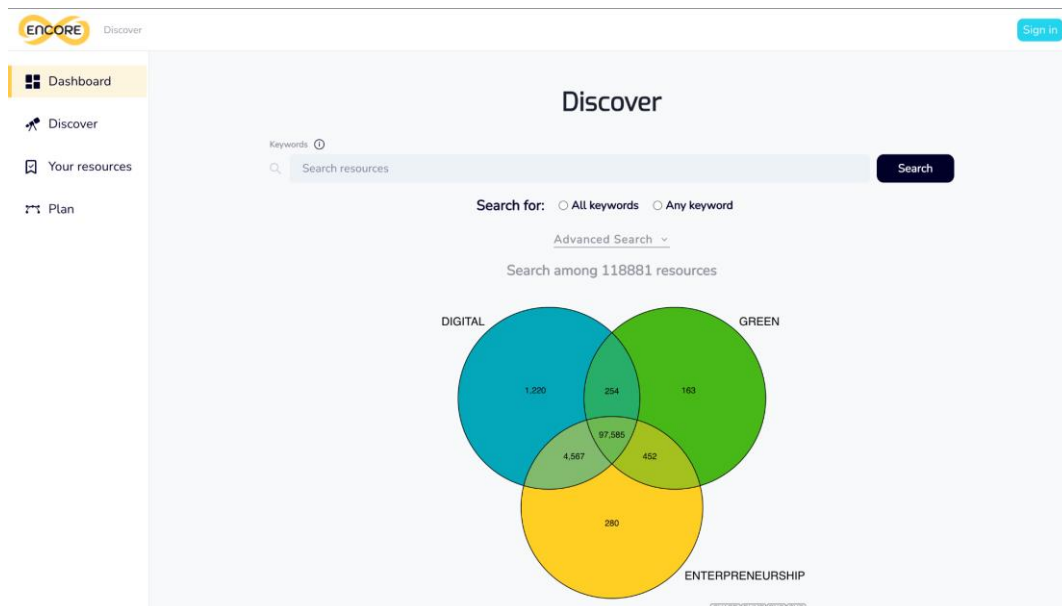


Figure 22. Homepage of the Enabler for Educators (E4E)

Once the search is conducted, users gain the ability to explore the results at their disposal (Figure 23). These results can be organised in multiple ways, such as sorting them by relevance, categorising them by the type of resources they are, or arranging them according to their ranking which is determined by quality metrics. Additionally, users are granted the option to seamlessly navigate through distinct OERs, each viewable in its own separate window.

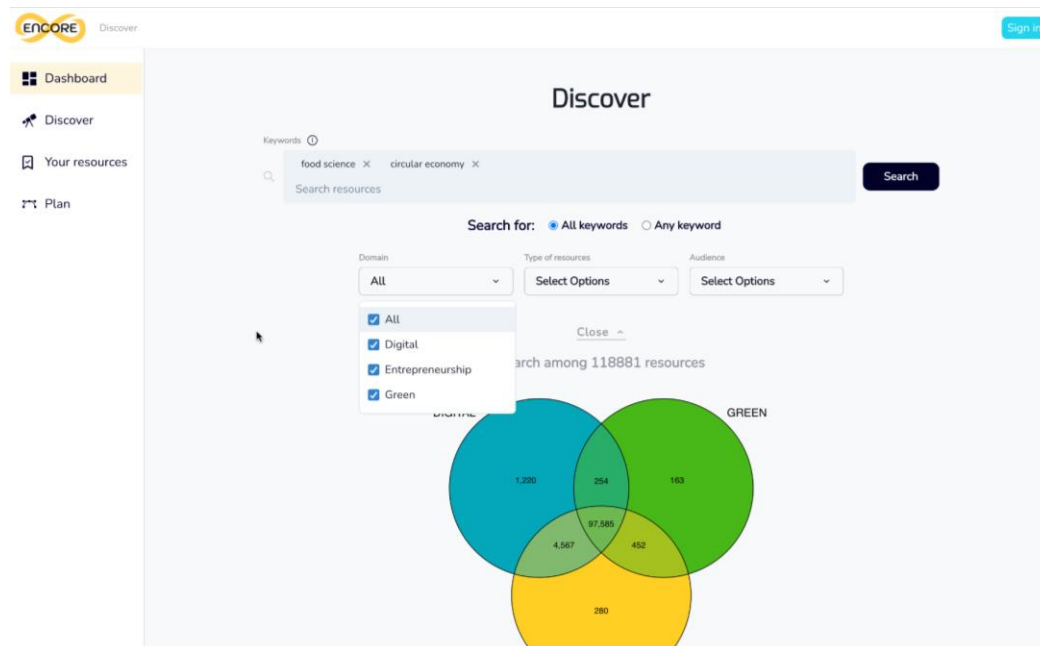


Figure 23. Advanced search

Furthermore, to enhance the analysis of these results, the platform offers interactive visualisations. These visual aids facilitate a comprehensive understanding of the outcomes, presenting various elements categorised by domain, concepts, or resource types (Figure 24).

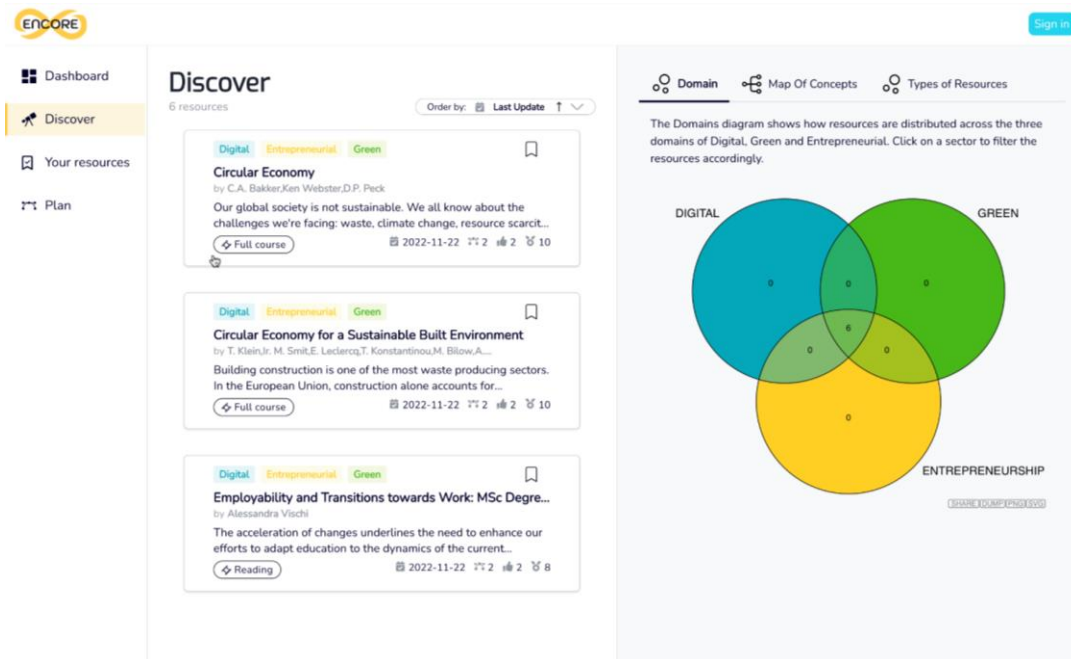


Figure 24. Result list

Collect Phase

The educational resources resulting from the search can be saved, permitting their later utilization within personalised categories (Figure 25). Users possess the capability to handpick pertinent OERs either directly from the search list or while reviewing individual resources. This functionality empowers them to construct bespoke collections of OERs (Figure 26), which subsequently prove valuable during the planning phase. Additionally, these personally curated categories can seamlessly integrate into Learning Management Platforms like Moodle, facilitated through the plugin expounded upon in the "LMS plug-in" section of this document.

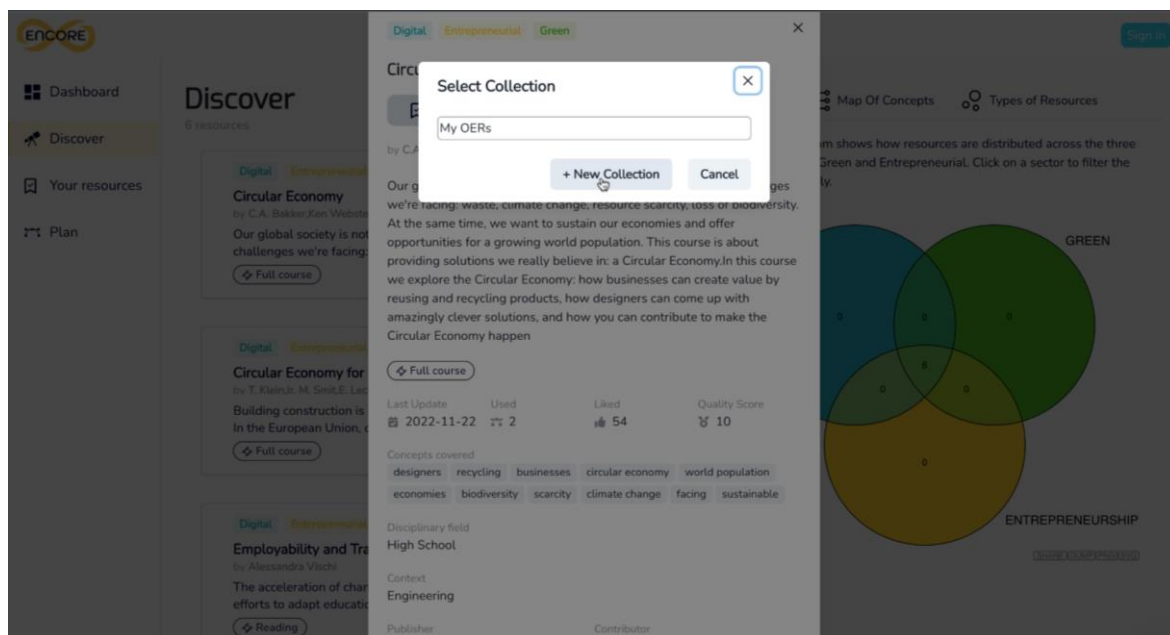


Figure 25. Add OER in a new collection

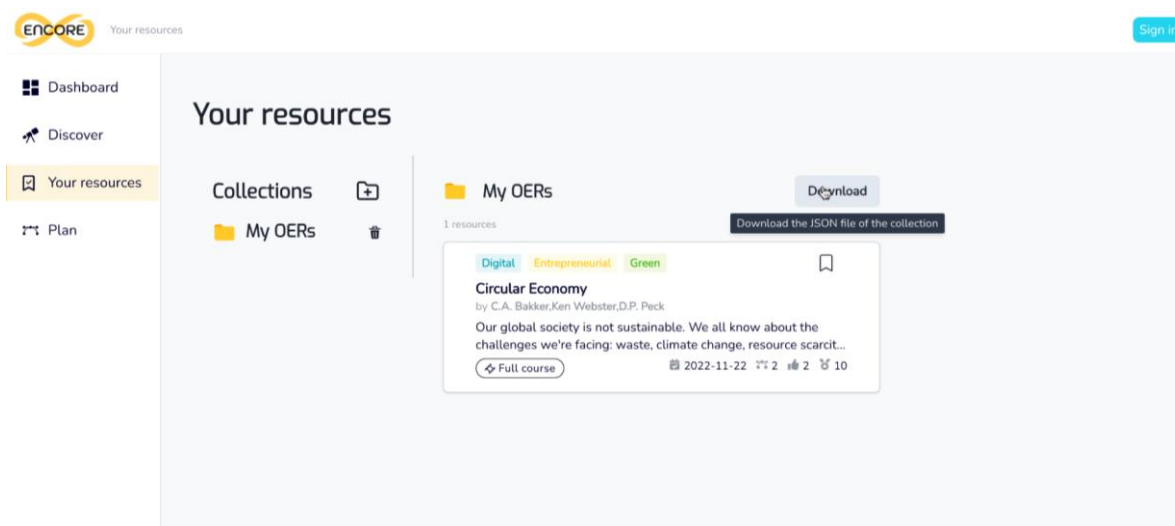


Figure 26. Personal collections

Implementing the E4E's Discovery and Collect phases

To engage in the exploration of Open Educational Resources (OERs) through the E4E platform, individuals are encouraged to experience its "Discovery" and "Collect" phases. To facilitate this, a dedicated GitHub repository⁹ has been established, providing essential resources including a comprehensive README file. This README provides clear and concise instructions for the seamless installation and local usage of the E4E platform. As part of our development process, rigorous internal testing is underway to ensure the platform's functionality and usability. Once these initial tests are successfully concluded, our roadmap entails transitioning the entire E4E platform into the public domain. This decision is driven by our commitment to serving the broader community of educators and trainers, allowing interested individuals

⁹OERs Discovery and Collect GIT repository: <https://github.com/ENCORE-OER/E4E>

worldwide to harness the power of E4E in enhancing their teaching practices and enriching the educational experience.

Plan Phase

Designing and realising learning paths for such a variegated learning experience might seem a daunting task at first. That is why E4E includes a Learning Path Editor heavily focused on the teachers' experience (see Figure 27). Its graph-like, visual-editing capabilities and integration with the rest of the framework allow the creation of ready-to-use learning paths with ease, thanks to the abstractions provided.

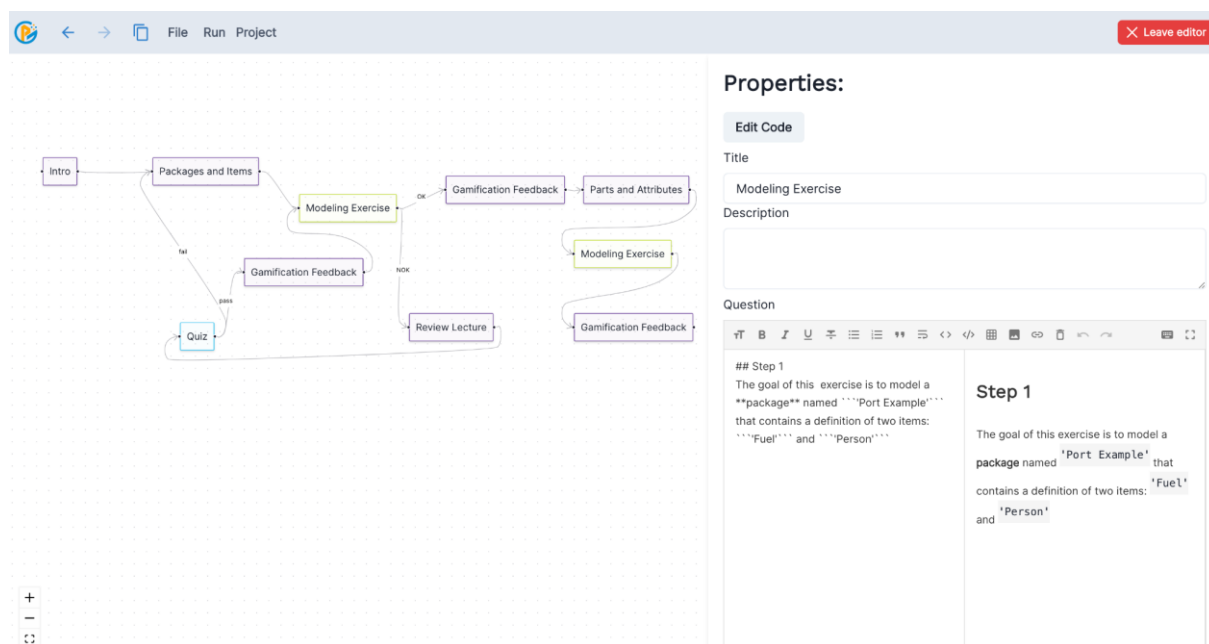


Figure 27. Learning Path Editor

The teacher design tool is composed of two main elements: the *drawing area* and the *properties panel*. The drawing area is the core of the visual editing experience. Nodes can be added, connected, and rearranged with simple clicks or drag-and-drop interactions. Nodes and edges themselves can be interactive components that augment the visual editing experience. The properties panel, instead, provides fine-tuning tools to define the activities and the links between them.

To define the learning path, a teacher can create new activities with a right-click on the canvas, change their type and parameters from the properties panel, and connect them by dragging from the handle on the source node to the handle on the destination node. By clicking on an edge, the teacher can edit the link condition by choosing from a list of existing abstractions or by writing their own validation code. The tool is implemented using web technologies with Next.js¹⁰ and TypeScript¹¹ with a particular focus on flexibility and extensibility. Its design

¹⁰ Next JS: <https://nextjs.org/>

¹¹ Typescript Language: <https://www.typescriptlang.org>

allows it to be part of a more comprehensive learning management tool. The drawing area and the properties panel are different abstract views that operate on the same data differently. Both components manipulate the same E4L elements (i.e. nodes and edges) by working on the shared state via Zustand¹² actions.

Gamification means creating a game narrative that guides players through complex challenges, keeping them engaged with social activities such as group work or competitions. It means providing immediate feedback (as expected from a game-like environment) and students making autonomous choices to progress down the individually decided path. Gamification mechanics are fundamental to the learning path personalization process in two ways. Not only do they keep the students engaged, but they can also be used as tools to gain insight into the student's behaviour from a different perspective and thus help generate a more personalised and engaging learning path. For this purpose, the editor provides a way to give specific `gamification feedback` to students throughout the advancement of the game narrative, via specific information defined in the edges of the learning path.

Implementation

The teacher design tool tries to achieve two opposite goals: providing useful abstraction to allow teachers to define the learning paths naturally while remaining concrete enough to allow students to consume them without further intervention. This dual goal is especially challenging to achieve with edges that allow teachers to define links abstractly with clauses such as "pass" or "fail", but not all activities are suitable for that abstract condition (e.g. a coding activity). Activities and connections must then undergo a programmable transformation phase to be converted into their executable counterparts. Implementation details can be generated behind the scenes to bridge the gap between the abstract world of activities and connections and its concrete executable form. Furthermore, some needed values may depend on the combination of others, so generating them guarantees consistency. For example, edges correspond to *Journey*¹³ rules in the execution phase. This correspondence is achieved by generating the validation code in this transformation phase.

Abstractly, a connection between two activities means that if a property on the source activity is satisfied, the student is allowed to pass to the destination activity. This process needs three components to work correctly: (1) information on the source activity; (2) information on the student submission, and (3) information on what property to enforce and how to do it. Suppose a quiz activity has an outgoing edge that enforces the property "pass". In this context, "pass" means that the student's answer must be among the correct solutions to the exercise.

Learning Path Definition

In E4E, a **Learning Path** is a graph composed of activities (i.e. nodes) and validation conditions (i.e. edges) to regulate the progression from one exercise to another. To exemplify the definition of a learning activity, we use a coding exercise. As can be seen in Listing below, to represent the node we use the JSON format.

¹² Zustand is a lightweight, unopinionated state-management library for React available at <https://github.com/pmndrs/zustand>

¹³ Journey is a .NET Interactive library for defining open-ended graphs of challenges

```
{
  "type": 'codingQuestionNode',
  "title": 'Intro to variables',

  ...    \\ other metadata attributes

  "data": {
    "question": 'Exercise text',
    "codeTemplate": 'var x = 1;',
    "language": 'csharp'
  },
  "reactFlow": {
    \\ element UI state in Polyglot Learning Path
    ↪ Editor
  },
  "runtimeData": {
    \\ the list of code submissions to prepare the
    ↪ environment for the current challenge
    "challengeSetup": [],

    \\ the list of notebook cells to display on the
    ↪ notebook
    "challengeContent": [
      {
        "type": 'markdown',
        \\ this is auto-filled from the
        ↪ data.question field
        "content": 'Exercise text'
      },
      {
        \\ this is auto-filled from the
        ↪ data.language field
        "type": 'csharp',
        \\ this is auto-filled from the
        ↪ data.codeTemplate field
        "content": 'var x=1;',
      }
    ]
  }
},
```

The node contains three important fields:

- The **data** field contains the raw inputs that can be edited using the properties panel (see Figure \ref{fig:teacherFrontend}).
- The **reactFlow** field contains the UI state of the node (e.g. the position of the node, its size, ...).
- The **runtimeData** field contains all the information required to interoperate with the E4L Runtime and .NET Interactive. It has two important subfields: **challengeSetup** and **challengeContent**. The former is a list of commands to set up the environment (e.g. to import or download a library, load a dataset, ...). They serve the same purpose as a list of hidden notebook cells to be executed before the exercise is shown to the student. The latter, instead, defines the content to be shown to the student as a list of editable notebook cells to display without having run them.

Note that this setup is not exclusive to VSCode as a frontend but it is a more generic form of learning activity delivery. The way (including form, modality, ...) how the content is delivered to the student is up to the specific frontend adapter. In the case of VSCode, the **challengeContent** is shown as a series of cells for the .NET Interactive kernel specified in the **type** subfield. If we were to execute a quiz node using Alexa as a frontend, the content to be

displayed would instead be spoken using a custom .NET Interactive content formatter registered by the Alexa adapter. The Alexa adapter could also introduce a preprocessing step to shorten the text to be suitable for the spoken modality, or decide to display the question or part of it onto an attached display.

```
{
  "type": 'passFailEdge',
  "title": 'pass',
  "data": {
    "conditionKind": 'pass'
  },
  ...    \\ other metadata attributes

  \\ auto-generated validation method for the
  ↪ specified edge type and data
  "code": 'async Task<(bool, string)>
  ↪ validate(PolyglotValidationContext context)
  ↪ {...}',

  "reactFlow": {
    \\ element UI state in Polyglot Learning Path
    ↪ Editor

    \\ the source node of this validation edge
    "source":
      ↪ '533c51ff-02ce-4dbe-9fa6-2ad787d1546e',

    \\ the target node to go to if the validation
    ↪ succeeds
    "target":
      ↪ '7306037d-8ada-4baa-ab9b-5c699a196238',
  }
},
```

Similarly to the Node, the Edge has a **data** field, and a **reactFlow** field for raw inputs and UI state respectively. In addition to those, a **code** field contains the generated validation code for the specified edge type abstraction and raw data.

Implementing the Learning Path Editor of the E4E

To install and try the Learning Path Editor, we have prepared a convenient and easy-to-install version which is available in a dedicated Git¹⁴ repository. This version is provided as a Docker application and GitHub Codespaces environment¹⁵, making the installation process very easy. By following the simple steps outlined in the README file users can quickly set up the tool for creating and executing personalised learning paths.

To begin, users can open the application in GitHub Codespaces or clone the repository and execute the provided Docker commands. The Docker container will take care of all the necessary configurations, enabling users to access the Polyglot editor through their web browser.

¹⁴ Learning path editor GIT Repository: <https://github.com/polyglot-edu/tryPolyGloT>

¹⁵ Video instructions: https://drive.google.com/file/d/1FDsC0cOIvaxQ-g2dMNIXsFLh42het1_/view?usp=sharing


```
# Clone this repository

git clone --recurse-submodules
https://github.com/polyglot-edu/
tryPolyGloT.git

# and then run
docker compose build
docker compose up

# Node editor will be
available at
http://localhost:3000 while
backend at
http://localhost:5000
```

Once inside the tool, users can effortlessly explore the intuitive interface and start crafting customised learning paths.

The heart of the editor UI resides on its home page (as depicted in Figure 28), where the list of available learning paths is provided. To facilitate the decision-making process, each learning path is tagged with relevant concepts and keywords. This not only provides a quick overview of the path's content but also enables you to make informed choices based on your learning goals.

Learning Paths

Search learning paths...

[My Learning Paths](#) [All](#)

- Introduction Applied Machine Learning**
ML APPLIED
Applied machine learning learning's example
- Epsilon Object Language**
MDE EOF
Intro Learning Path on EOL
- Food Science**
FOOD SCIENCE CIRCULAR ECONOMY
Food Science Intro Learning Path

Figure 28. Interface for the Learning Path editor

In this page educators gain the ability to seamlessly search for and access existing learning paths, making the process of finding tailored educational content effortless. Simultaneously,

the interface presents the "+" button located at the bottom right of the page, empowering educators to initiate the creation of entirely new learning paths.

In the Learning Path Editor, we have curated three distinct learning paths to provide users with a concrete experience of the tool's capabilities and the diverse range of learning activities it supports in its current implementation. Accessing these paths and exploring their nodes and edges is straightforward – a simple click on the desired learning path on the home page will suffice. Upon doing so, the editor interface will seamlessly open up, as depicted in Figure 29, where we have opted for the "Introduction to Applied Machine Learning" path for demonstration.

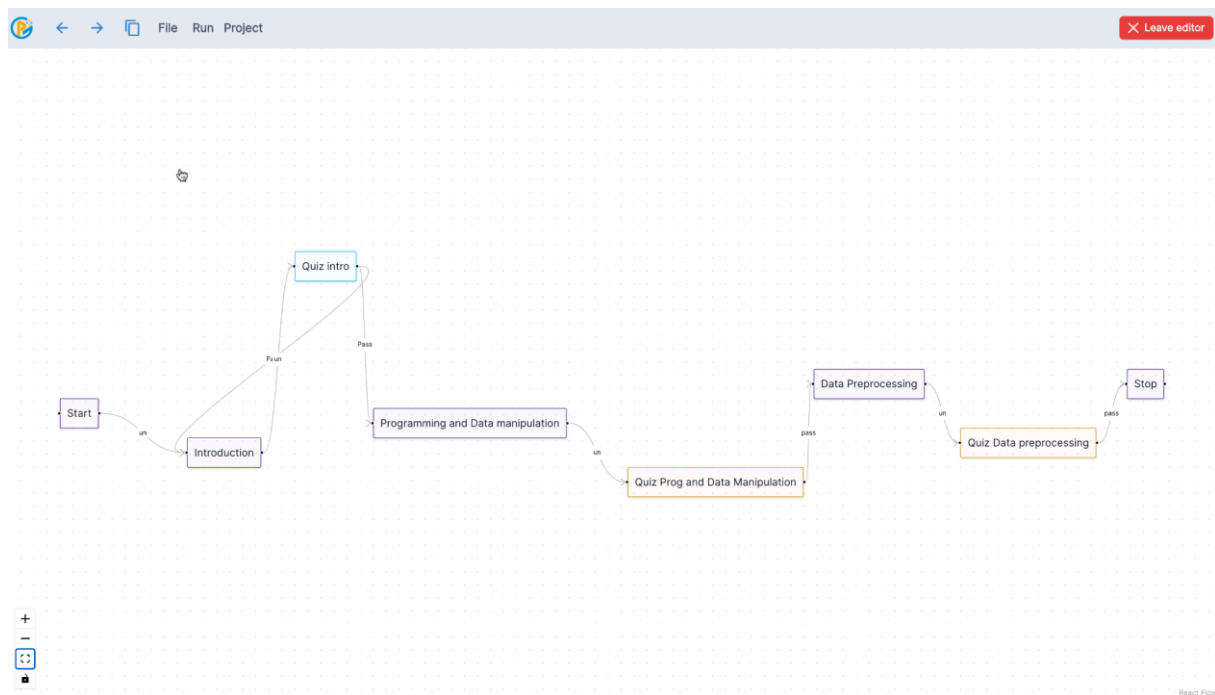


Figure 29. Example of a learning path

The editor offers a diverse set of node types and edges that facilitate the construction of comprehensive learning paths. Among these, the "lecture" nodes stand as pivotal elements, providing a platform to deliver textual content to students. At the same time it provides the "multiple choice question" nodes, designed to evaluate students' grasp of specific concepts. The dynamic interconnection of these nodes is established through a variety of edges, each endowed with its unique functionality. These connections can be unconditioned, representing sequential progression, or they can encapsulate the outcomes of assessments – portraying either success or failure in certain evaluation nodes. Examples of these nodes and edges are depicted in Figure 30, illustrating the dynamic orchestration of nodes and edges.

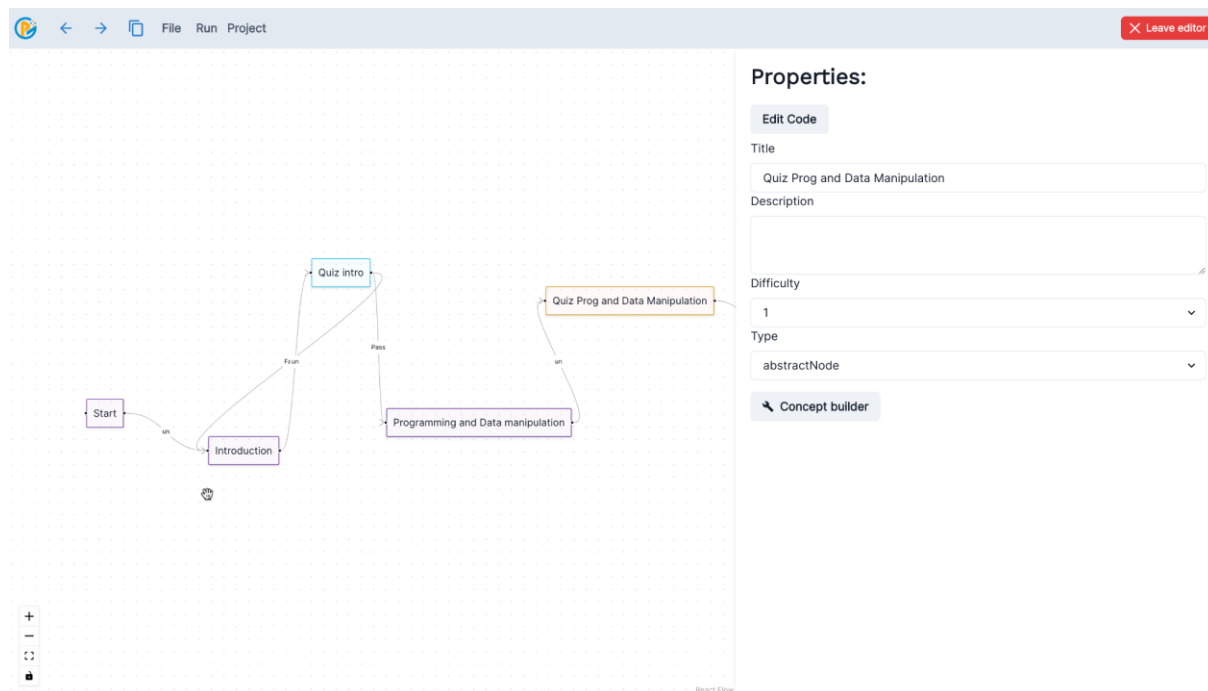


Figure 30. Property panel

Another facet of the Learning Path Editor is the distinctive **abstractNode**. This specialised node harnesses the power of the **Azure OpenAI** service, specifically utilising the **gpt-3.5-turbo model**. This dynamic node type serves as a remarkable tool for educators, enabling them to generate concept graphs and the related learning activities (i.e., multiple choice nodes) originating from topics of their choosing. For instance, in the illustrative example depicted in Figure 31, an educator can opt for the "Programming and Data processing in the context of machine learning" topic. By invoking an OpenAI endpoint, a comprehensive concept graph is generated (as depicted in Figure 32). This graph not only provides an overview but also empowers the educator to meticulously select precise concepts (Figure 33). These selected concepts are subsequently incorporated, alongside other preferences (see Figure 34), to craft a series of engaging multiple choice learning activities. This tailored set of activities, dynamically presented at runtime to learners following the designated learning path, ensures an immersive and personalised educational experience.

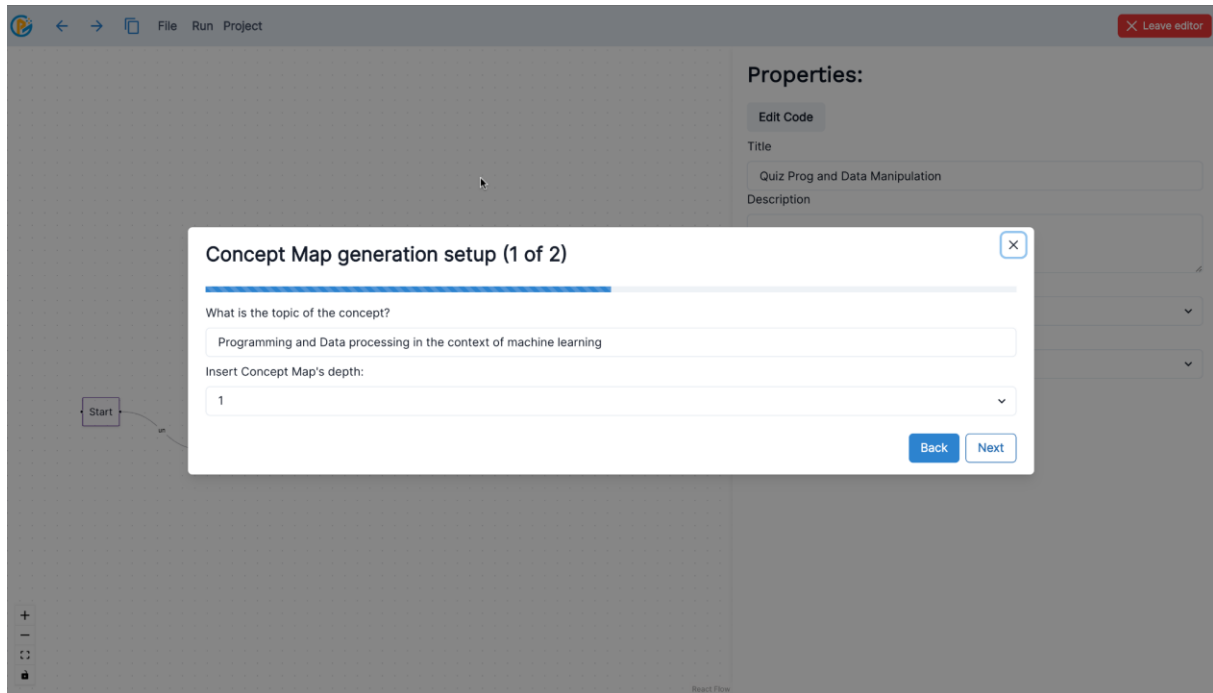


Figure 31. Concept map generation window

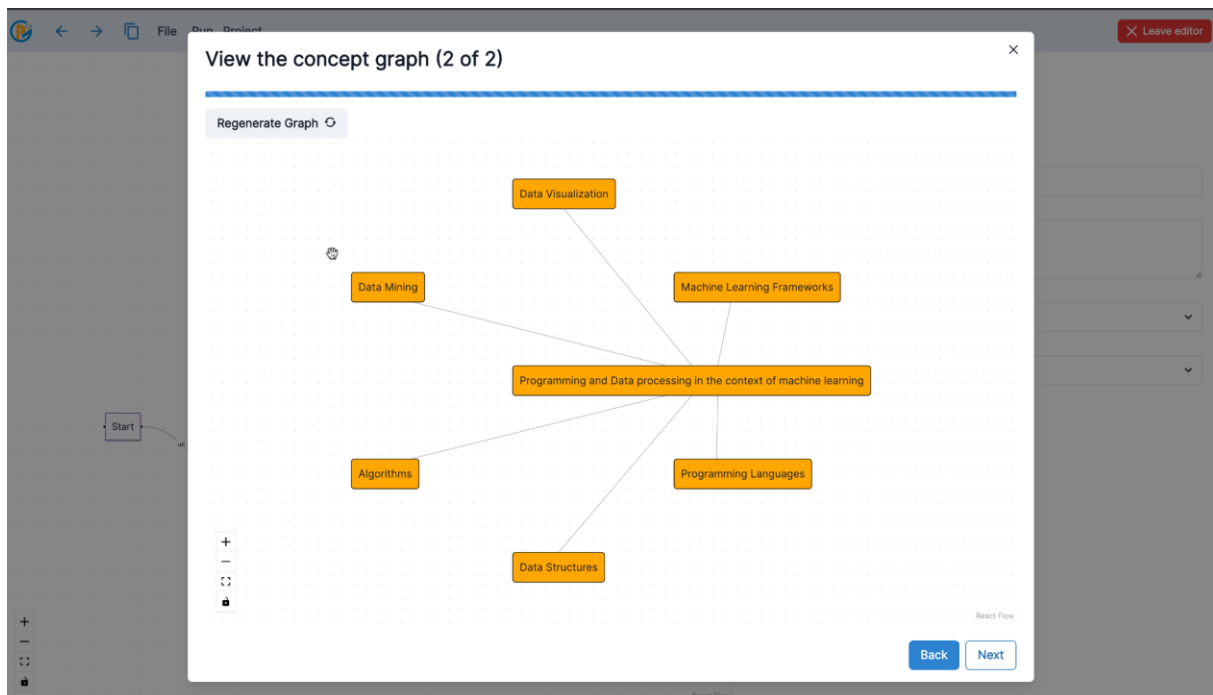


Figure 32. Resulting concept map

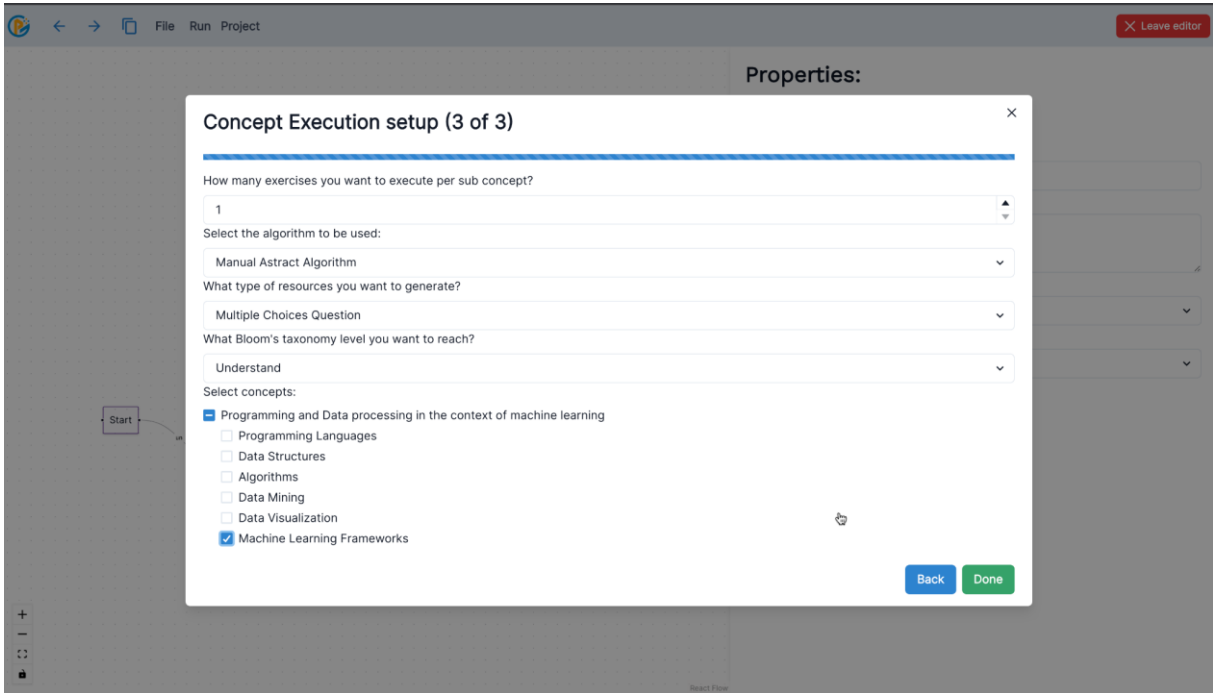


Figure 33. Concept map setup

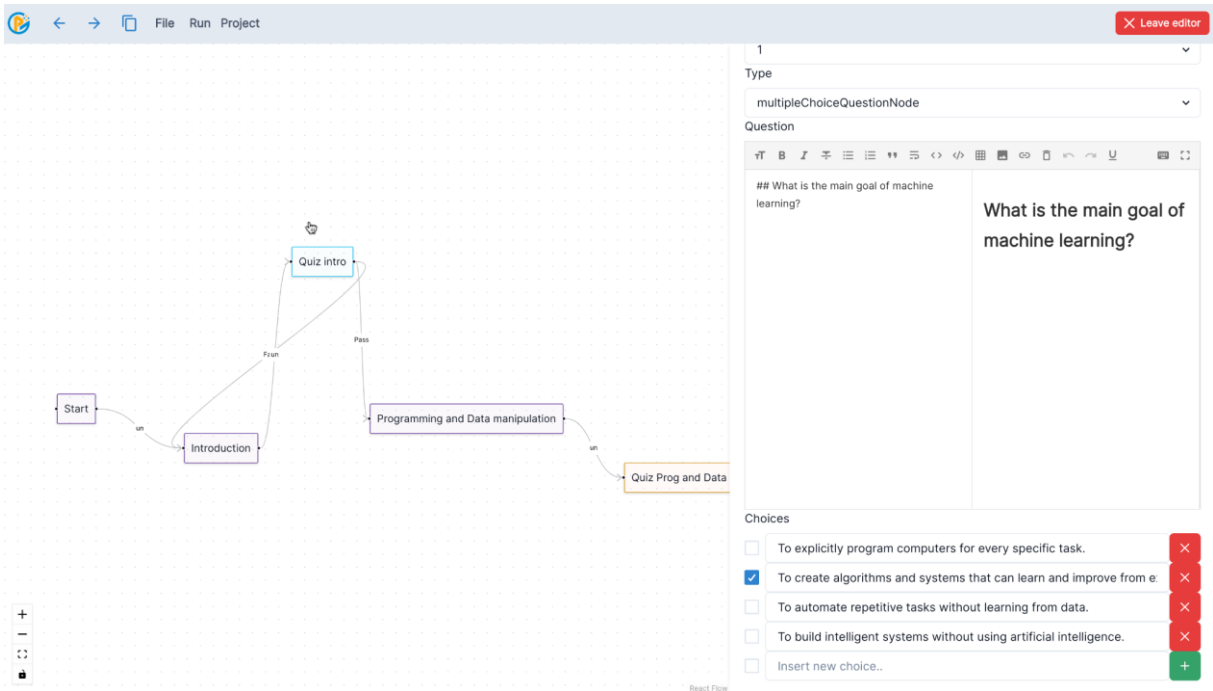


Figure 34. Multiple choice question node

In order to utilise the **abstractNode** functionality, it is essential to configure the `docker-compose.yml` file with the required information pertaining to the OpenAI endpoint and secret key, as illustrated in the Listings below. The **environment** section should include the following parameters:

```
environment:
  - MONGODB_URI=mongodb://prova:SECRET@mongodb:27017
  - CORS_ORIGINS=http://localhost:3000
  - COOKIE_KEY=any_long_and_random_string
  - TEST_MODE=true
  - OPENAI_SECRET_KEY=YOUR_OPENAI_SECRET_KEY
  - OPENAI_ENDPOINT=YOUR_OPENAI_ENDPOINT
```

To utilise the Azure OpenAI services effectively, the `YOUR_OPENAI_SECRET_KEY` and `YOUR_OPENAI_ENDPOINT` parameters must be changed with the specific values provided by OpenAI for a created project.

By configuring these environment variables, the editor will be able to effectively communicate with the Azure OpenAI service and seamlessly integrate the "abstractNode" feature into your learning paths. This integration makes the dynamic creation of concept graphs possible, fostering personalised and immersive learning experiences for both educators and learners.

OERs APIs

The OERs and data presented by the E4E are extracted from the ENCORE database implemented in WP3. This database has been implemented as an independent but interoperable component with the goal of allowing external tools to extract data related to the collected OERs.

The ENCORE database is integrated in a web platform (<https://encore-db.grial.eu/>) to ease the access and search of OERs through a graphical interface, but also through API endpoints. These endpoints are used by the E4E to retrieve relevant OERs based on a set of parameters. The ENCORE database platform includes the following API endpoints:

- `/api/oers/`
Accepted parameters: title, description, keyword, creator, publisher, language, subject, detailed_coverage, coverage, detailed_subject, format, type, entity, roer, oer_url, updated_at. **Description:** Lists all Open Educational Resources (OERs). It applies pagination and allows filtering based on the accepted parameters.
- `/api/skills/`
Accepted parameters: None. **Description:** Lists all skills.
- `/api/domains/`
Accepted parameters: None. **Description:** Lists all skills' domains.
- `/api/concepts/`
Accepted parameters: None. **Description:** Lists all concepts.
- `/api/subjects/`
Accepted parameters: None. **Description:** Lists all OER subjects.
- `/api/formats/`
Accepted parameters: None. **Description:** Lists all OER formats.
- `/api/types/`
Accepted parameters: None. **Description:** Lists all OER types.

- `/api/boolean/oers/`
Accepted parameters: `or_title`, `or_description`, `and_title`, `and_description`.
Description: Returns a list of OERs filtered by multiple parameters using Boolean logic (or, and).
- `/api/boolean/skills/keyword_search/`
Accepted parameters: `or_keyword`, `and_keyword`. **Description:** Returns a list of skills filtered by multiple keywords using Boolean logic.
- `/api/skills/keyword_search/`
Accepted parameters: `search`. **Description:** Returns a list of skills filtered by a keyword search.
- `/api/boolean/concepts/keyword_search/`
Accepted parameters: `or_keyword`, `and_keyword`. **Description:** Returns a list of skills filtered by multiple keywords using Boolean logic.
- `/api/concepts/keyword_search/`
Accepted parameters: `search`. **Description:** Returns a list of concepts filtered by a keyword search.
- `/api/oers/filter/domains/`
Accepted parameters: `green`, `digital`, `entrepreneurship`. **Description:** Returns a list of OERs filtered by skill domain (Green, Digital, Entrepreneurship).
- `/api/metrics/oers/`
Accepted parameters: None. **Description:** Provides statistics about OERs within the three skills' domains: Green, Digital, Entrepreneurship.

Enabler for Learners (E4L)

Adaptive learning and gamification

The rapid development of digital technology is transforming the way education is delivered and consumed. Not only are educators changing the way they design and create learning materials, but learners are also adapting their learning styles to take advantage of these new tools. As a result, traditional pedagogical strategies must be reevaluated and revised to effectively engage learners in the digital age.

Effective teaching from a student's perspective means having access to personalised, one-to-one tutoring. This approach allows educators to address specific misunderstandings and provide real-time feedback and explanations that are relevant to the student's experiences. However, this level of individual attention is not always practical or feasible for educators, especially when dealing with larger groups of learners.

On the other end of the spectrum, the most teacher-effective approach is the one-to-many lecture, where the teacher prepares the material upfront for a wide audience. While this method can be efficient, it often encourages passive learning and may not fully engage all learners in the classroom.

Digital technology can play a crucial role in bridging the gap between these two approaches. Adaptive learning, for instance, offers personalised learning experiences that cater to individual needs, rather than adopting a one-size-fits-all approach. By utilising techniques such as just-in-time feedback, personalised learning paths, and ad-hoc learning resource provision, learners can receive the customised support they require to succeed. Adaptive learning has been widely recognized as a promising approach to enhancing the overall learning experience (Martin et al., 2020; Xie et al., 2019).

Furthermore, the incorporation of gamification mechanisms in education can encourage motivation and engagement, improve student participation and cooperation, and stimulate learners to reach their learning objectives. Gamification leverages the inherent human desire for competition, recognition, and achievement, encouraging learners to take an active role in their own education. Combining gamification with adaptive learning can make the learning process more enjoyable and effective, leading to increased retention and improved outcomes

The use of Notebooks in Playful Education

Interactive notebooks have been widely used in face-to-face school classrooms as a metacognitive inquiry tool through which students engage in sensemaking and creatively represent their thinking (Chesbro, 2006; Galanti et al., 2020). Interactive notebooks also empower teachers with assessment flexibility ranging from formative check-ins to summative evaluations (Galanti et al., 2020).

Notebooks are increasingly being used in the field of education, offering various advantages such as facilitating self-learning and being more user-friendly for new students compared to

other programs. They also assist in explaining complex topics (Suárez-García et al., 2021). The primary field where notebooks excel is data analysis, manipulation, and visualisation (Shen, 2014; Yaniv et al., 2018; Zúñiga-López & Avilés-Cruz, 2020). In addition to data analysis, they also aid in learning programming languages such as Python, R, or Octave (Yaniv et al., 2018; Zúñiga-López & Avilés-Cruz, 2020).

Some good practices for using notebooks include the usage of literate programming aspects (e.g., markdown cells and visualisations), applying abstractions to handle complex control flows, and utilising descriptive filenames (Pimentel et al., 2019).

However, there are also critical aspects to consider. Notebooks require a basic understanding of programming, and they are not suitable for writing complex code that involves multiple files. They are not very effective for file management, and they are not suitable for programs that need to be executed as a single block.

Another critical aspect is that the output is not separated from the code (Johnson, 2020). Other issues include memory leaks, determining the correct order of execution for desired results, messy code (duplications, bugs), difficulties in reproducing the environment, poor file management, short lifespan of files, unsuitability for software development, challenges in applying good programming habits, lack of cloud functionality, absence of modularity (functions, classes, etc.), absence of module separation (tendency to put everything in a single file), difficulties in code testing (similar to modularity challenges), challenging version control, lack of default naming conventions leading to confusion, limitations in transforming a notebook into a flexible reusable script, and potential issues when trying to go beyond Jupyter's simplified operating system features (Johnson, 2020).

Furthermore, there are observed bad practices associated with notebook usage, such as a lack of code testing in most notebooks, as well as characteristics that hinder reasoning and reproducibility, including out-of-order cells, non-executed code cells, and the possibility of hidden states (Pimentel et al., 2019). Some of the most commonly raised issues are that developers using Jupyter notebooks do not follow style conventions, do not properly test their code, and do not provide versioning information, making it difficult or impossible to reproduce their results (Johnson, 2020).

Jupyter notebooks are used in education due to their interactive and flexible learning environment, which combines text, code, and computational output. Several studies have examined the positive perceptions of students towards Jupyter notebooks in various educational domains.

For instance, Ruiz-Sarmiento (2021) explored the use of Jupyter notebooks in mobile robotics education, while Nwulu (2021) investigated their effectiveness in power systems education. In addition to empirical evidence, this paper presents a case study that demonstrates the application of Jupyter notebooks in the Robotics subject during the 2019/2020 academic course. The study compares the learning performance of students using Jupyter notebooks with those from the 2017/2018 and 2018/2019 courses, where traditional problem posing approaches were employed.

The comparison of students' grades in the final exam reveals that the use of Jupyter notebooks significantly enhances learning in the Robotics subject. Moreover, the findings indicate an improvement over the traditional problem posing approaches, where students were given a list of issues to be solved independently.

One of the sharpest criticisms raised for the educational purpose about Jupyter notebooks in recent years is that notebooks encourage poor software development practices, like the issues listed above. However, as of this writing it has not been conclusively demonstrated that this is the fault of the Jupyter notebook rather than a failing of the users, who may choose to ignore established software development best practices when working in the notebook environment, as they may choose to do when using any other tool (Johnson, 2020).

Gamification refers to the incorporation of game design elements into non-game contexts (Deterding et al., 2011). The objective of gamification is to enhance user motivation, whether it's intrinsic or extrinsic, leading to improved learning outcomes (Marín et al., 2018). Gamification has found widespread application, particularly in the field of education and learning (Koivisto & Hamari, 2019). However, to achieve the desired effects, careful attention must be paid to the design and implementation of gamification elements in the course; otherwise, the intended objectives might not be met and could even result in negative consequences (Marín et al., 2018).

The use of gamification with notebooks has proven to be effective in motivating students, as demonstrated in various studies. For example, notebooks have been used for creating exercises in educational robotics, and including gamification elements to turn them into a robotic competition (Cañas et al., 2020). Similarly, gamification elements such as a simple answer app and a point counter app were added to the Graasp platform to enhance student engagement (De Santo et al., 2022).

Another study implemented an auto grading system within a gamified learning platform to foster competition, motivate students, and improve learning outcomes. The learning platform included various gamification elements, such as a missions page, a leaderboard, an embedded 2D action game, and an integrated Jupyter notebook server (Malone et al., 2023).

Other authors employed Jupyter notebooks as a web-based programming environment and gamification to motivate novices and simplify their introduction to programming (Brockner et al., 2022). The gamification was achieved by logging and analysing interactions and learning activities within JupyterLab and Jupyter Notebooks, and the data served as the foundation for integrated game elements and mechanics.

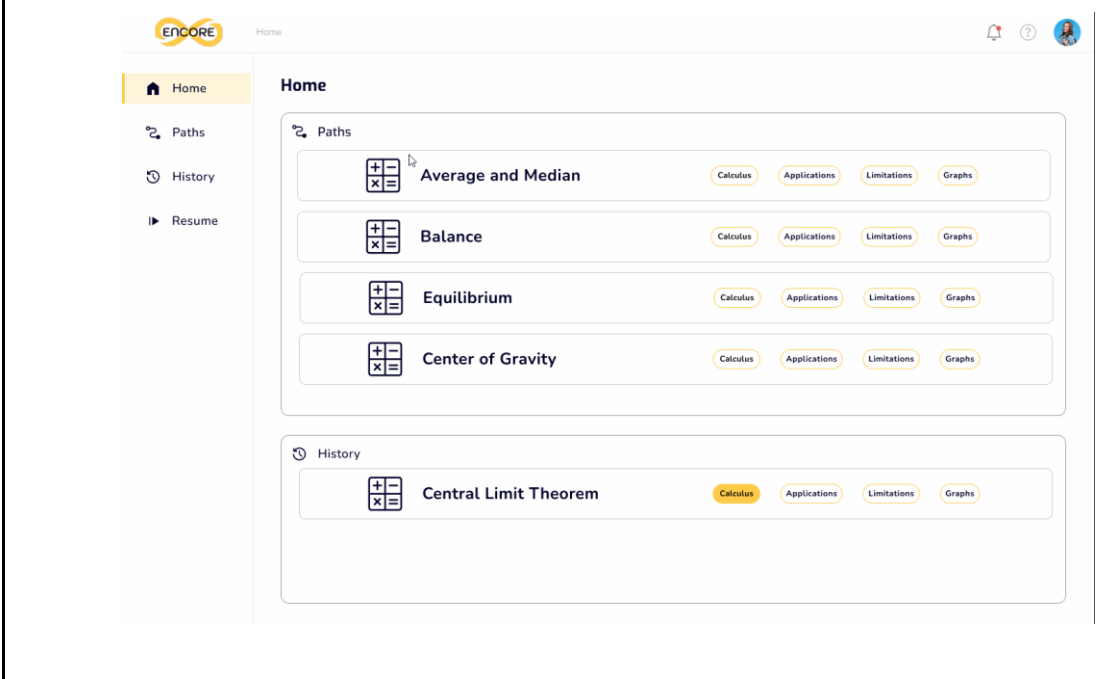
It is worth noting that implementing gamification directly within notebooks can be challenging due to their dynamic nature, consisting of cells where it might be difficult to maintain constant control over gamification elements. As a result, the gamification is often centred around the notebook context rather than directly implemented within it (Bräuer & Mazarakis, 2022). However, it is worth emphasising that despite these challenges, recent developments have shown promise in effectively leveraging gamification to enhance educational experiences (Bucchiarone et al., 2021; De Santo et al., 2022). To harness the full benefits of gamification, educators are encouraged to adopt a thoughtful and strategic approach. By carefully designing

and seamlessly integrating game elements into the notebook ecosystem, educators can cultivate an enriched and immersive learning environment. This deliberate integration not only augments the appeal of educational content but also fosters a more profound understanding of the subject matter, ultimately leading to more impactful learning outcomes.

Co-design process and prototype development

The design of the Enabler for Learners interface embraced a co-design methodology, primarily centred around the utilisation of prototypes, mirroring the approach taken with the Enabler for Educators.

In the following Table 2 we summarise the main screen used in the prototype dedicated to learners.

Enabler for Learners starting page	
	<p>The Enabler for Learners' home page provides learners with an initial overview of the available learning paths. These paths are derived from the outputs of the Plan phase, facilitated through the enabler for educators. Additionally, the interface displays the learners' history of completed and ongoing paths. Located at the top right corner, there are several icons: a profile icon for accessing the user's profile section, a help icon to access support documentation, and a bell icon for relevant notifications. On the left side, the menu offers options for selecting learning paths, viewing the learning history, and restarting any paths that were left incomplete.</p>
	
Path selection	
	<p>Upon selecting the "Paths" option from the left menu, a search bar at the top enables users to search for available learning paths using keywords and filter options for specific skills or concepts via the advanced search feature. The advanced search section, situated below the search bar, allows users to access various filtering options. These filters can help refine the search results according to skills or concepts. Immediately below the advanced search section, a list of paths appears, filtered based on the selected search criteria.</p>

Learning path navigation

After the user selects a learning path, they can choose specific learning fragments based on their personal preferences. Upon selecting a fragment, a comprehensive set of information is displayed, which includes the following details: the associated skills, concepts covered, the learning objectives, the structure of the assessment or test, and an estimated time duration for completing the fragment.

Resume a learning path

If a user initiates a learning path but lacks sufficient time to complete it, they have the option to pause and resume it at a later time. From the resume menu, the user can easily pick up where they left off, and all their progress, information, and completed activities will be saved and retained. This allows users to continue their learning journey seamlessly whenever they are ready to do so.

The screenshot shows the ENCORE Learning path interface. At the top, there is a navigation bar with the ENCORE logo, the text 'Learning path', and icons for a bell, a question mark, and a user profile. Below the navigation bar, the title 'Average and Median' is displayed next to a calculator icon. There are four tabs: 'Calculus' (highlighted in yellow), 'Applications', 'Limitations', and 'Graphs'. The main content area is titled 'Theory' and contains the following text:

In statistics, the average and median are two measures of central tendency used to describe the center or typical value of a set of data.

The average, also known as the mean, is calculated by summing up all the values in the data set and dividing the sum by the total number of values. It represents the arithmetic average of the data. The formula for calculating the average is:

$$\text{Average} = (\text{Sum of all values}) / (\text{Number of values})$$

For example, let's say we have a set of numbers: 4, 6, 8, 10. To calculate the average, we add up these values ($4 + 6 + 8 + 10 = 28$) and divide by the total number of values (4). The average in this case would be $28 / 4 = 7$.

The median, on the other hand, is the middle value in a sorted list of numbers. To find the median, we arrange the data in ascending or descending order and locate the middle value. If there is an odd number of values, the median is the value in the exact middle. If there is an even number of values, the median is the average of the two middle values.

At the bottom of the page, there are two buttons: 'Exit' and 'Next activity'.

Executing a learning path

Once we have started the path, we can change the fragment we choose at any time. After being presented with the established path, it may consist of a first theoretical part where the student learns the basics necessary for completing the exercises, which can be quizzes or other types of activities. When the student provides an answer, it will be corrected before moving on to the next activity. Once the path is completed, an overview of all the completed parts will be provided using a path tree. This overview will include the questions answered correctly, the time taken, the skills and concepts learned, and an option to review the entire path executed.

This screenshot is identical to the one above, showing the ENCORE Learning path interface for 'Average and Median'. The 'Calculus' tab is highlighted in yellow. The 'Theory' section contains the same text as in the previous screenshot, including the formula for the average and the example calculation.

Reviewing past activities

Selecting "History" on the home page will take the user to a page with a record of all the completed path fragments. Here, we can choose the one we want and see an overview similar to when we finished the path. We can review what we have done in the path fragment and retry it if desired.

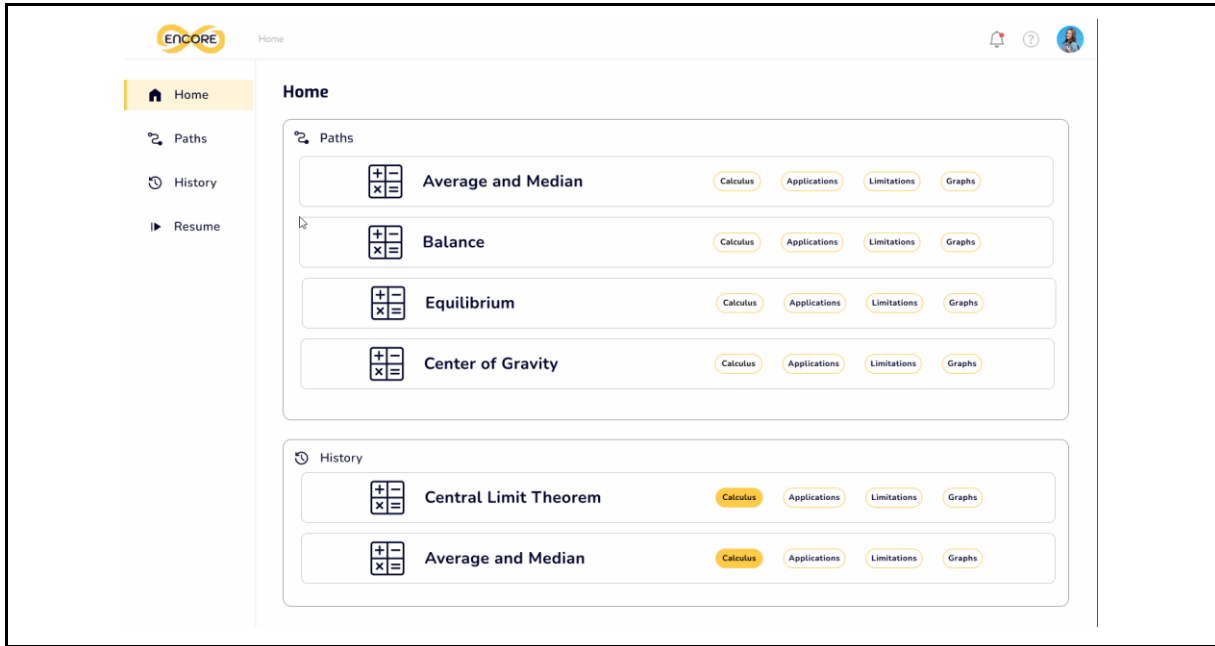


Table 2. Screens for the prototype interface for the Enabler for Learners (E4L)

Enabler 4 Learners (E4L) - Architecture and Development

In the following we present the overall architecture of the E4L (Figure 35) and its functionalities. Then, we describe how it has been implemented.

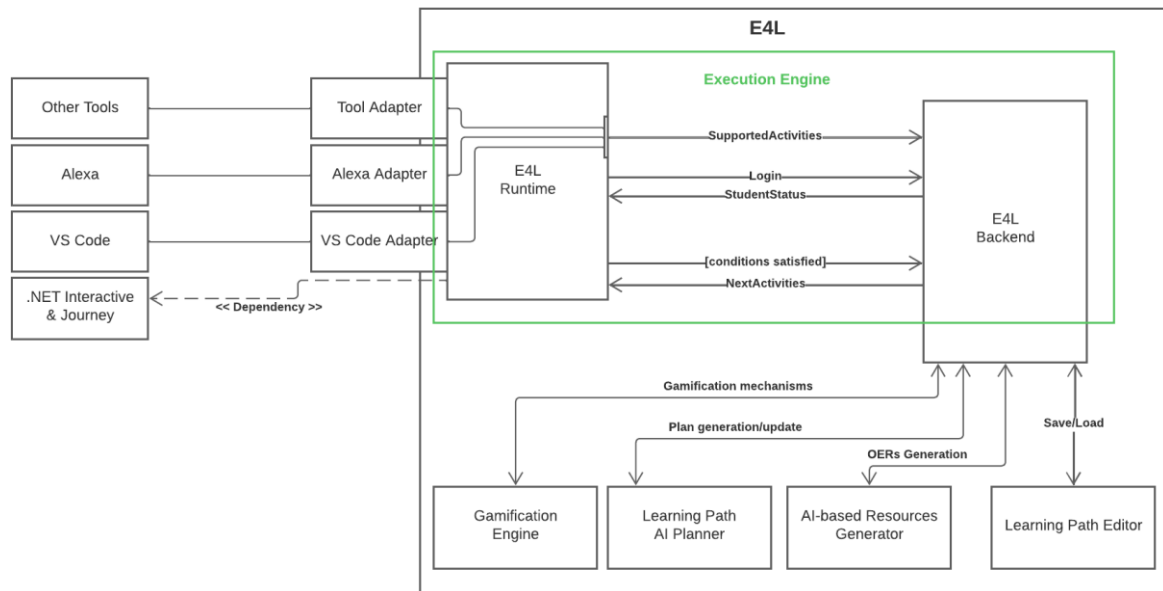


Figure 35. Architecture for the Enabler for Learners (E4L)

E4L aims to provide an open, content-agnostic and extensible framework for designing and consuming adaptive and gamified learning experiences. We imagine a student experience entirely tailored to their needs and choices. For example, we think students should be able to do some lessons and quizzes with voice assistants such as Alexa, switch to Integrated

Development Environments (IDE's) such as Visual Studio Code (VSCode) to do some coding activities, and then move to another frontend or Learning Management System (e.g., Moodle¹⁶) to do something else, all without friction. That is why we exploit the flexibility of **.NET Interactive**¹⁷ in the E4L execution engine (Figure 22). Students' interactions with external tools occur through *Adapters* that bind actions on the student frontend to .NET Interactive commands and bind .NET Interactive events to a supported rich output (e.g. audio for Alexa) with custom formatters.

The word "*adaptive*" in adaptive learning paths means being able to adjust the students' needs, like proposing exercises based on their previous responses or the capabilities of the platform they are on. This adaptation is allowed by the collaboration between the **E4L Runtime** and the **E4L Backend** components of the **Execution Engine**. The former handles the students' submissions and validates their responses, while the latter uses the results of the validation phase to propose the next possible activities in the learning path.

The **E4L Runtime** component constitutes the core of the student experience. It is responsible for handling user interactions and validating students' submissions. Its straightforward lifecycle is designed to exploit `Journey`'s strengths by using it in a semi-controlled fashion. When the assigned activity and its outgoing edges are retrieved from the E4L Backend, they undergo a transformation phase where the activity is converted into a Journey challenge and edges into Journey rules. Once converted, the challenge is ready to be launched. The activity is "shown" to the student in their frontend, thanks to .NET Interactive formatters. When the active frontend adapter produces an event, Journey intercepts it and runs the registered rules against the student submission. E4L then sends the result of this validation phase back to the backend which will use this additional knowledge to suggest the next suitable activity.

Learning Path Execution

The learning path execution starts with the E4L Runtime component querying the backend for an initial learning activity. A suitable initial activity in a learning path is a `PolyglotNode` that has no incoming edges. The **E4L Backend** then selects a suitable initial activity, gathers its set of outgoing validation edges, and sends everything to the runtime component. Once it has received the data, it converts the `PolyglotNode` into a **Journey Challenge** by creating the **.NET Interactive commands** that correspond to the `runtimeData` code submissions, sets the Challenge Rules using the validation edges, and configures the E4L progression handlers that manages the progression through the learning path. In order to set the validation rules, the E4L Runtime compiles edges's code field using Roslyn's C# scripting capabilities. The compiled validation function is then called with a **ValidationContext** argument that contains the Journey Challenge instance, a `Node` object containing all the node data, and an `Edge` object containing all the edge data. To enable the maximum customizability and interoperability between nodes and edges in the validation function, E4L leverages the capabilities of **.NET's Dynamic Language Runtime (DLR)**: the node and edge data (that are variable by nature and depend on the specific node and edge types) are deserialized into an **ExpandoObject** and then converted

¹⁶ <https://moodle.org/>

¹⁷ <https://github.com/dotnet/interactive>

into a dynamic type before being added to the ValidationContext instance. When the Journey Challenge is started, the **challengeSetup** commands are executed and the **challengeContent** content is shown. When the student submits its solution, Journey intercepts the code submission and runs the validation Rules. After that, the control is passed to the E4L progression handler that sends the validation results to the E4L Backend that will take those into account to propose the next suitable exercise for the student.

Once a learning path has been designed, it can be seamlessly shared with learners in the form of **VSCoDe notebooks**. This process begins within the editor, where the educator can download the notebook file (See Figure 36). Subsequently, the downloaded file can be opened locally in VSCode, as demonstrated in Figure 37, providing a familiar environment for learners.

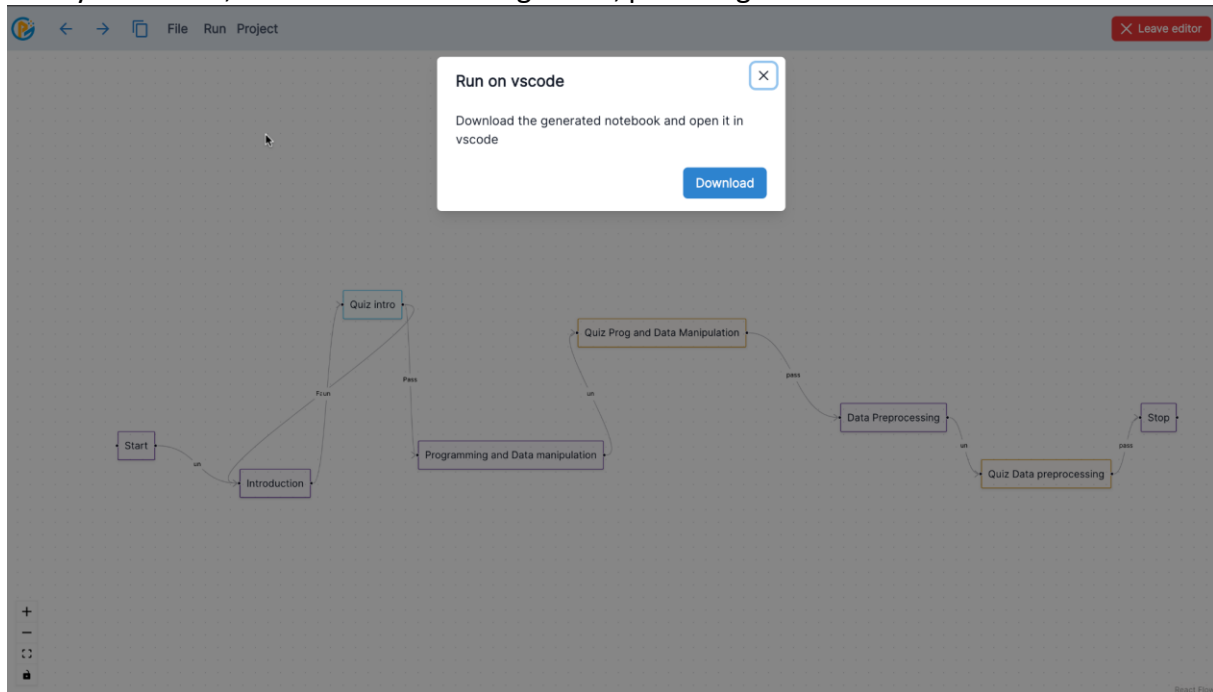


Figure 36. Run the learning path in VSCode

Upon opening the notebook, learners are immediately presented with a reflection of the educator-defined learning path. Each node within the path corresponds to a distinct cell within the notebook. This structure not only enhances organisation but also streamlines the learning process by seamlessly integrating textual content, code snippets, and interactive elements.

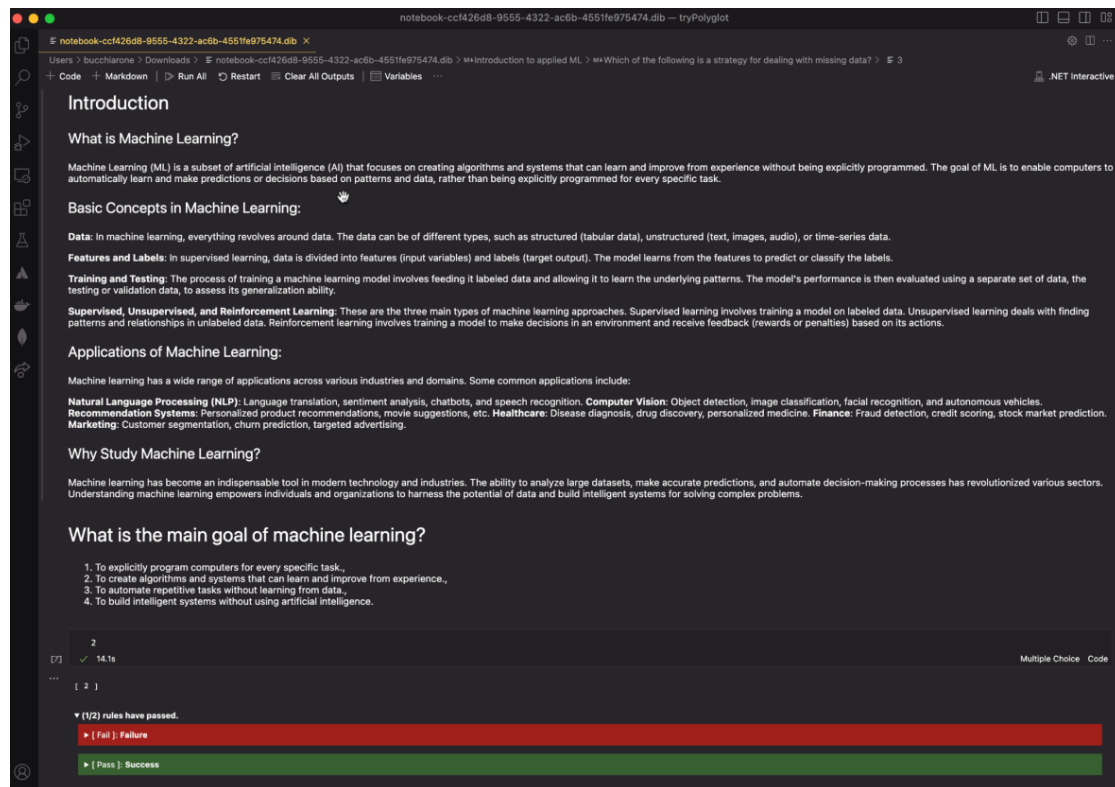


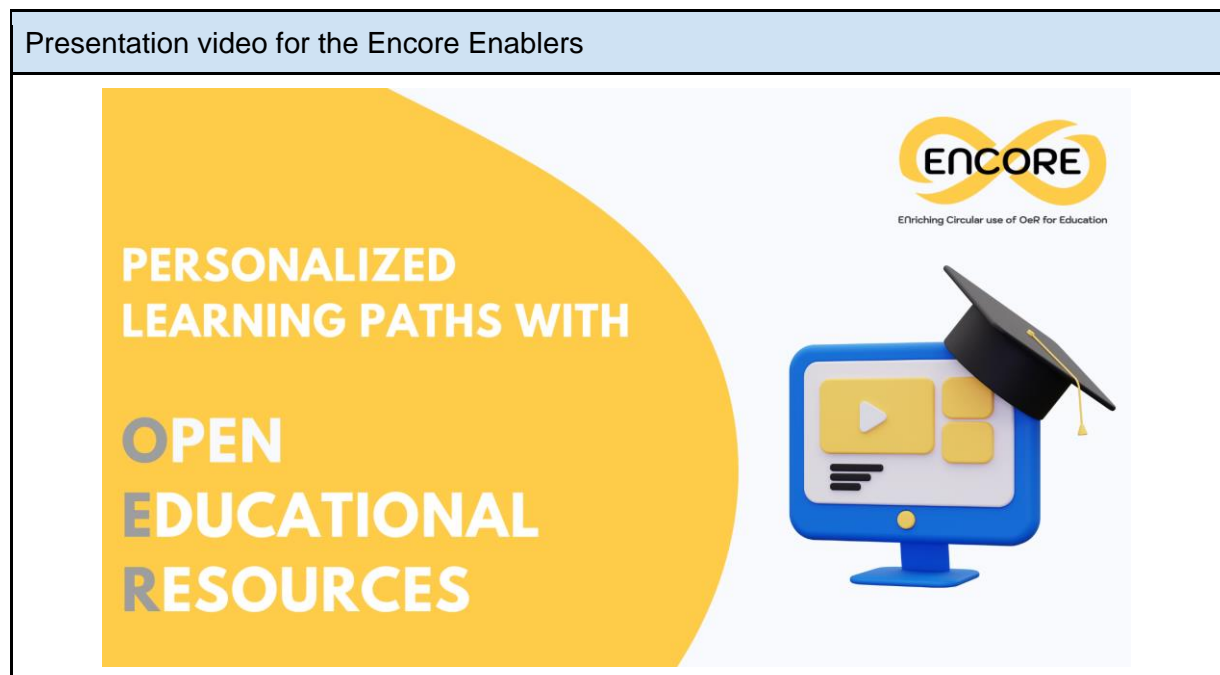
Figure 37. VSCode notebook interface

A defining aspect of this learning experience is the personalised execution of the notebook. Learners traverse the path dynamically, following success and failure edges as they encounter assessment nodes. Moreover, the integration of the abstractNode serves to generate multiple-choice questions that leverage both the concepts and parameters defined by educators. This dynamic approach ensures that learners are engaged with precisely the content that aligns with their progress and comprehension, fostering a uniquely tailored learning journey.

Enablers documentation

In order to facilitate the utilisation of the enablers, an informative video has been created¹⁸. This video will serve as supplementary material for WP5. It offers an encompassing overview of the ENCORE approach, delineating the functions of the enablers. Furthermore, the video provides a concise introduction to the various phases of the approach along with the corresponding digital tools.

The following table 3 presents the highlights from the video with additional information on the interface.



¹⁸ ENCORE user video:

<https://drive.google.com/file/d/1gjvegbLo3ZxqZf5X3EWDCdeSb4GfInl0/view?usp=sharing>



ENABLER FOR EDUCATORS

is a conceptual model for the creation of **personalized playful learning paths** that educators can create based on **skills** and **concepts** related to:

- **digital**
- **green**
- **and entrepreneurial skills.**

This process is currently being developed within the Erasmus+ Alliance for Innovation project **ENCORE (Enriching Circular Reuse of OERs - <https://project-encore.eu/>)**.

It provides an attempt to support educators in creating learning paths through data-driven approaches, allowing students to access them in a **personalized** and **playful** manner.

The project leverages the use of **Open Educational Resources (OERs)**, which are freely available educational materials that can be accessed, used, and modified by educators and learners. OERs play a significant role in ENCORE, as they form the basis for the development of the personalized learning paths. By utilizing OERs, educators have a wealth of content and resources at their disposal to tailor the learning experiences according to students' individual needs and interests.

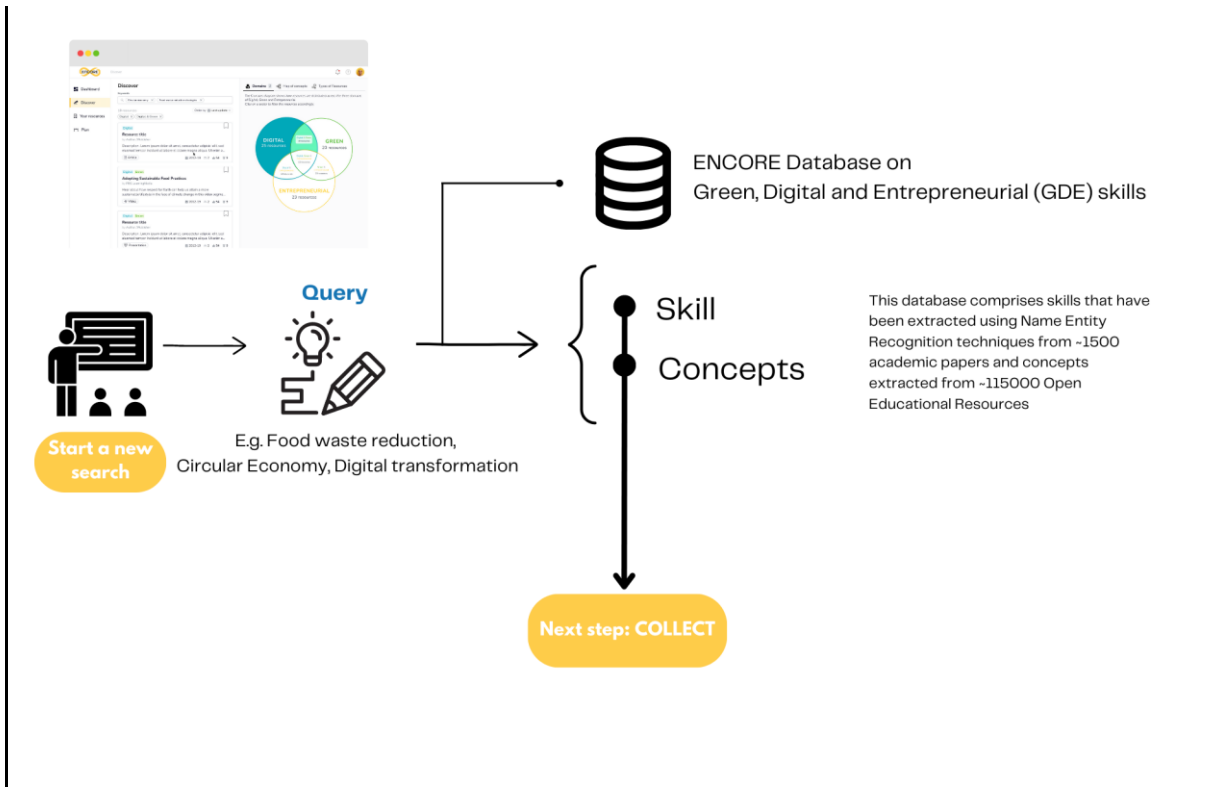
Step 1: Discover. This section outlines the procedure for traversing the OER database and assessing the outcomes.

DISCOVER

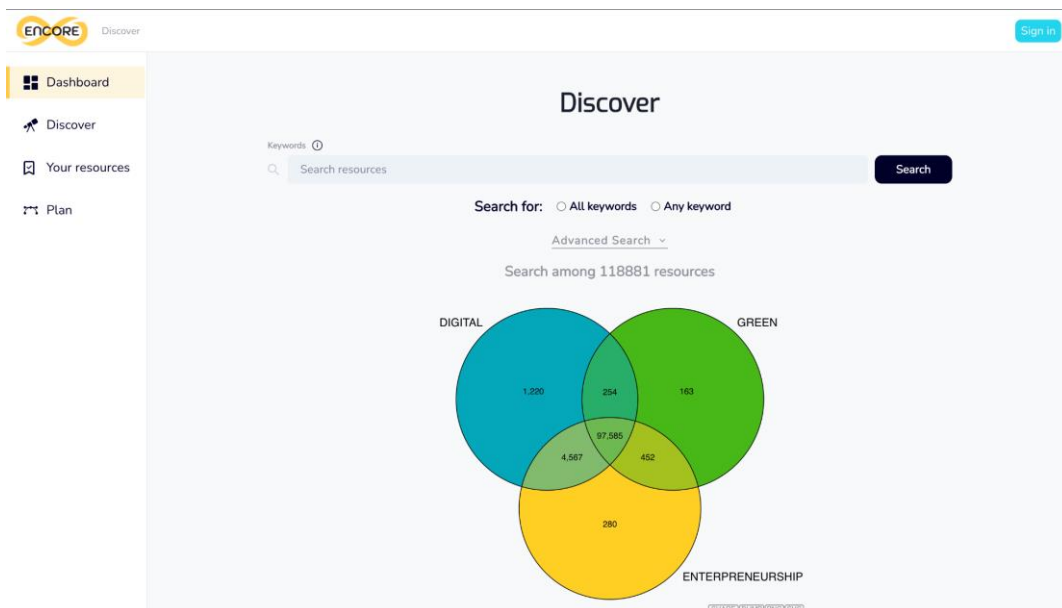


The **first step** of the process requires educators to explore relevant concepts and skills that will serve as a foundation for their learning activities.

These skills are identified within specific domains, namely **Green, Digital, and Entrepreneurial (GDE)**, and are selected from the ENCORE database. This database comprises skills extracted from academic literature and connected to the **ESCO** (European multilingual database of Skills, Competences, Qualifications, and Occupations). Educators will identify pertinent skills and knowledge concepts within the domain, such as "circular economy" or "food waste reduction" in order to identify relevant OERs.

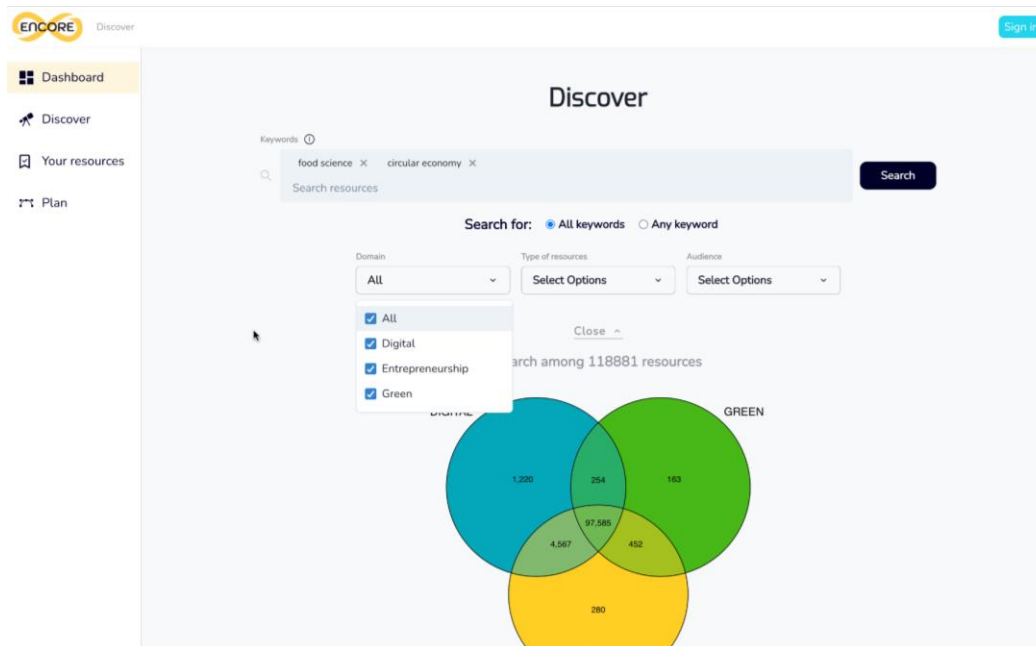


The search process begins by engaging with the search bar, where users can input keywords sourced from the GDE skill list or concepts derived from the OERs encompassed within the ENCORE database. This search can be executed by either incorporating all the keywords (AND search - all keywords) or including at least one keyword (OR search - any keyword). As exemplified in the prototype, the interface furnishes information through a Venn diagram, depicting the number of OERs categorised across the three GDE domains, accompanied by the number of accessible resources.

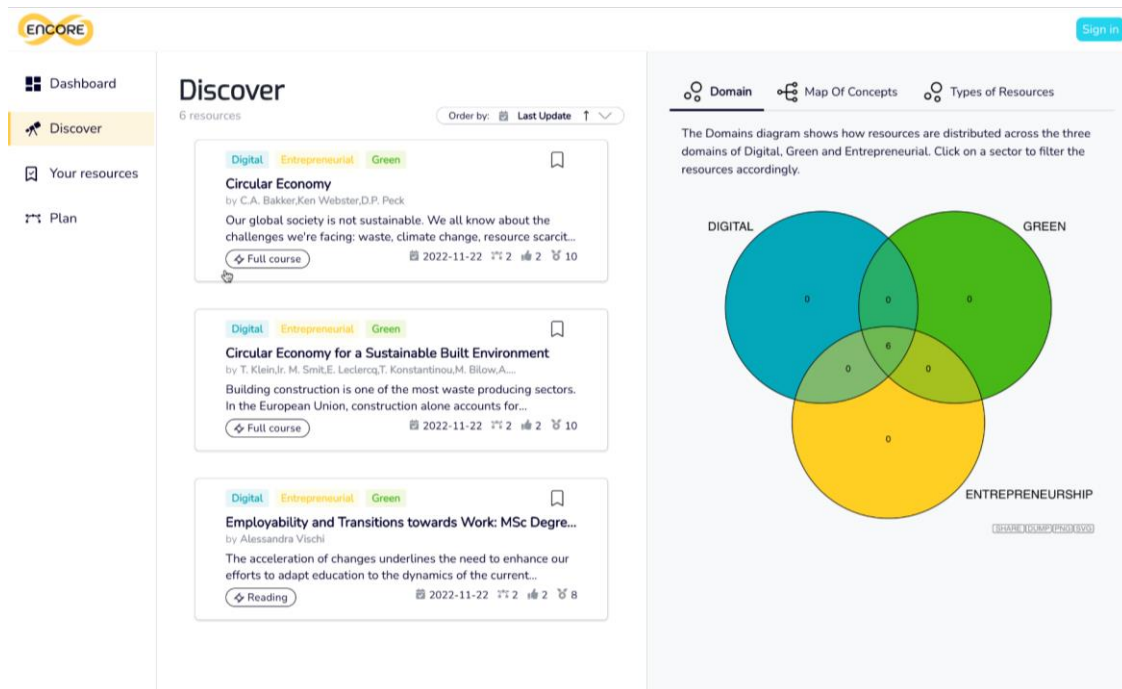


Additionally, users have the option to conduct a search using advanced search features. These include the ability to choose a preferred GDE domain, select specific resource types (such as videos,

PDFs, datasets, full courses, etc.), or narrow down the target audience (e.g. general public, vocational training, academics, etc.).



The results list offers a comprehensive display of the OERs matched with the search terms. Each item can be chosen, examined, and saved within customised collections. Additionally, the result list can be organised (for instance, by date, alphabetically, or by quality score). The outcomes can also be navigated based on their relevant GDE domain, via the concept map, or categorised by resource type.



The map of concepts is generated in the dedicated tab, showing the relevant concepts as they are extracted by the list of OERs.

The screenshot shows the ENCORE 'Discover' page. On the left is a navigation menu with 'Dashboard', 'Discover', 'Your resources', and 'Plan'. The main area displays a list of 6 resources, with the first three visible:

- Circular Economy** by C.A. Bakker, Ken Webster, D.P. Peck. Description: "Our global society is not sustainable. We all know about the challenges we're facing: waste, climate change, resource scarcit...". Tags: Digital, Entrepreneurial, Green. Full course.
- Circular Economy for a Sustainable Built Environment** by T. Klein, Jr. M. Smit, E. Leclercq, T. Konstantinou, M. Bilow, A... Description: "Building construction is one of the most waste producing sectors. In the European Union, construction alone accounts for...". Tags: Digital, Entrepreneurial, Green. Full course.
- Employability and Transitions towards Work: MSc Degre...** by Alessandra Vischi. Description: "The acceleration of changes underlines the need to enhance our efforts to adapt education to the dynamics of the current...". Tags: Digital, Entrepreneurial, Green. Reading.

On the right, the 'Map Of Concepts' tab is active. It shows a network diagram where concepts are connected by lines. The number of resources addressing each concept is indicated by the size of the node. Concepts include: sustainable packaging, ellen macarthur foundation, packaging, climate change, sustainability, greenhouse gas emissions, biodiversity, world popula, recycled, recycling, european union, circular economy, packaging waste, business models, const building construction.

Information for each OER can be accessed and reviewed. The OER can be viewed in a separate page and it can be saved in a dedicated collection.


This screenshot shows a detailed view of the 'Circular Economy' resource. The left sidebar remains visible. The main content area displays:

- Circular Economy** by C.A. Bakker, Ken Webster, D.P. Peck.
- Description: "Our global society is not sustainable. We all know about the challenges we're facing: waste, climate change, resource scarcity, loss of biodiversity. At the same time, we want to sustain our economies and offer opportunities for a growing world population. This course is about providing solutions we really believe in: a Circular Economy. In this course we explore the Circular Economy: how businesses can create value by reusing and recycling products, how designers can come up with amazingly clever solutions, and how you can contribute to make the Circular Economy happen".
- Full course button.
- Metadata: Last Update: 2022-11-22, Used: 2, Liked: 54, Quality Score: 10.
- Concepts covered: designers, recycling, businesses, circular economy, world population, economies, biodiversity, scarcity, climate change, facing, sustainable.
- Disciplinary field: High School.
- Context: Engineering.
- Publisher and Contributor fields.
- License: Creative Commons Attribution Non-Commercial Share Alike.

On the right, a Venn diagram shows the distribution of resources across three sectors: Digital (blue), Green (green), and Entrepreneurship (yellow). The diagram shows the overlap between these sectors.

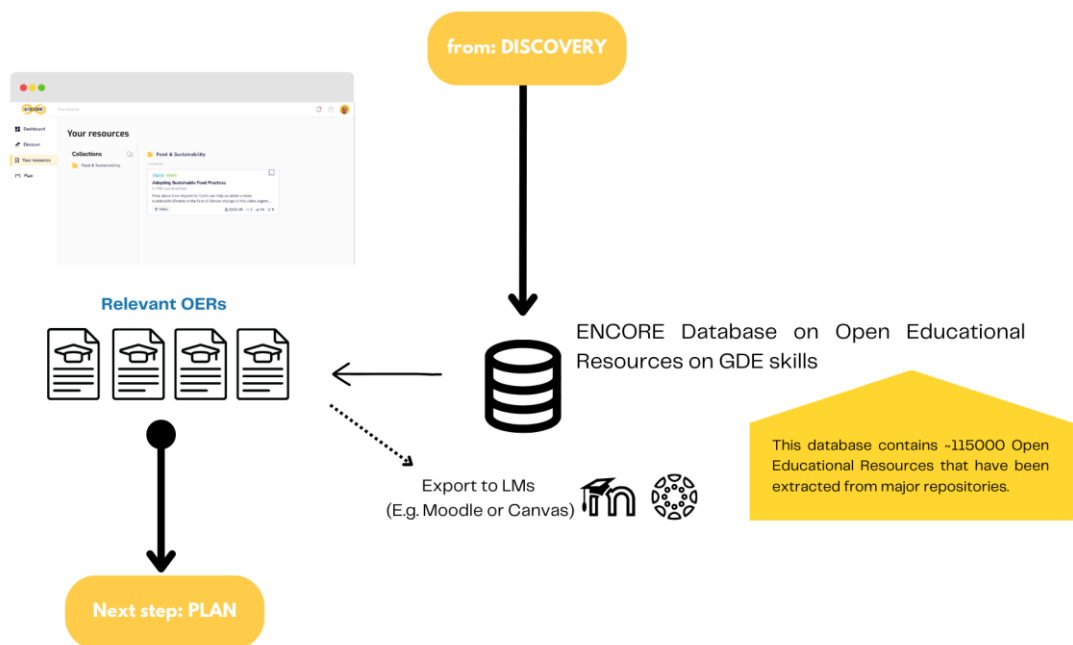
Step 2: Collect. This section demonstrates users how to curate their own personalised collections and to employ them for saving OERs

COLLECT

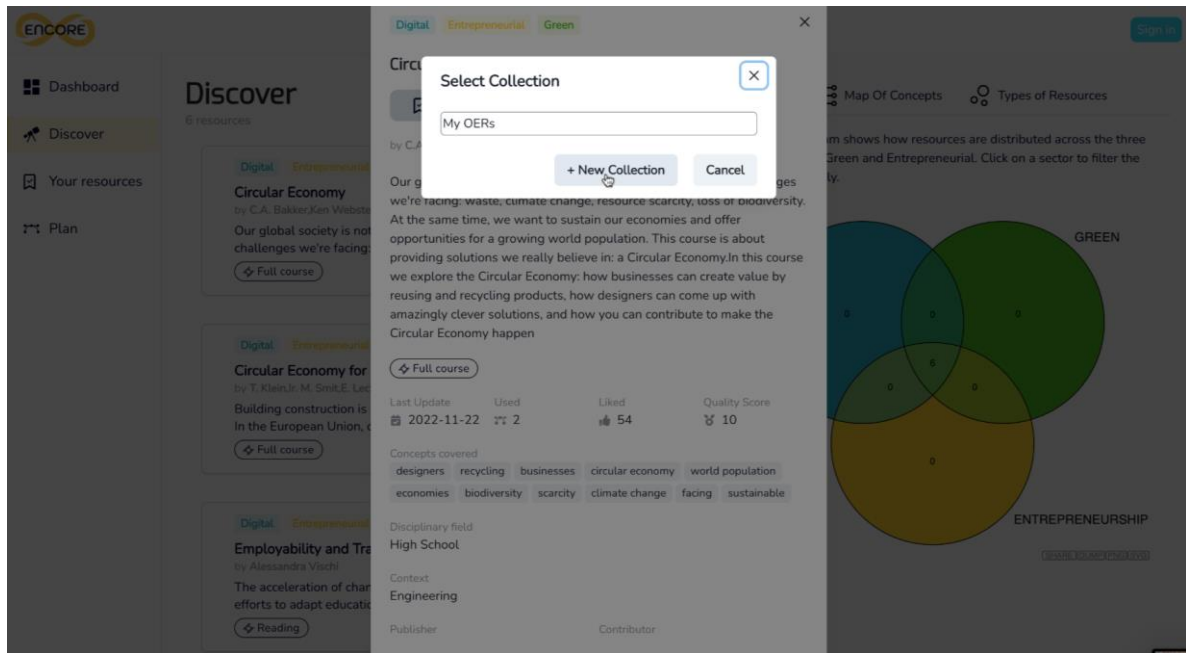


The educator can proceed to review the extracted educational materials within the OERs and carefully select the most relevant ones. They have the flexibility to export these materials to other **Learning Management Systems**, such as Moodle or Canvas, or utilize them to enhance and refine a learning path based on the concepts covered in the OERs.

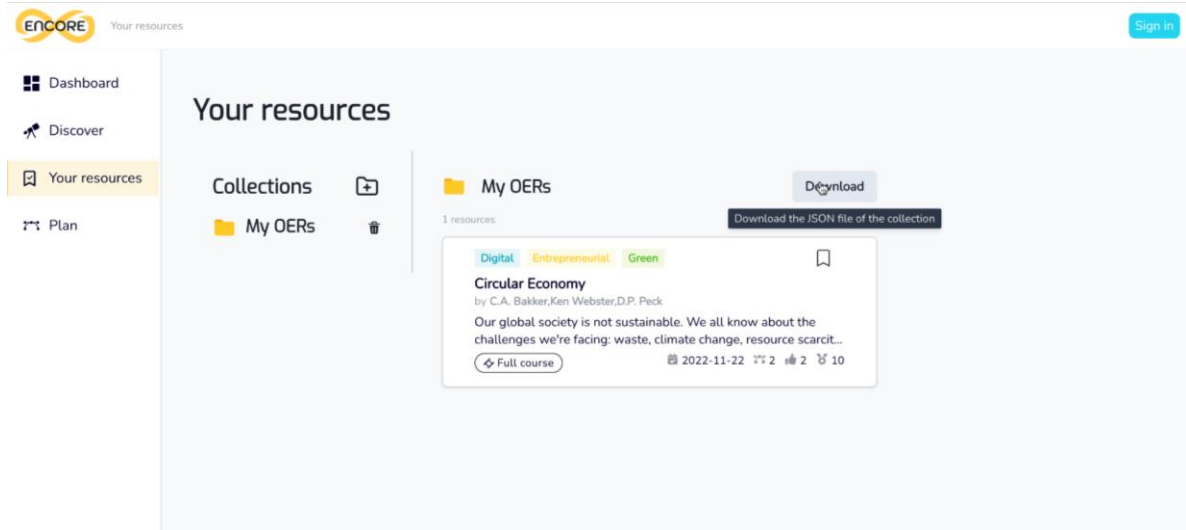
The second step comprises the collection of relevant OERs.



Every OER can be saved either directly from the result list or while viewing the resource. It can be added to an existing collection or a new one.



The collections created can be accessed in a dedicated section within the side menu. Users can find all their crafted collections along with the saved OERs.



Step 3: Plan. This section shows how to use the collection to generate a learning path by adding educational resources.

PLAN

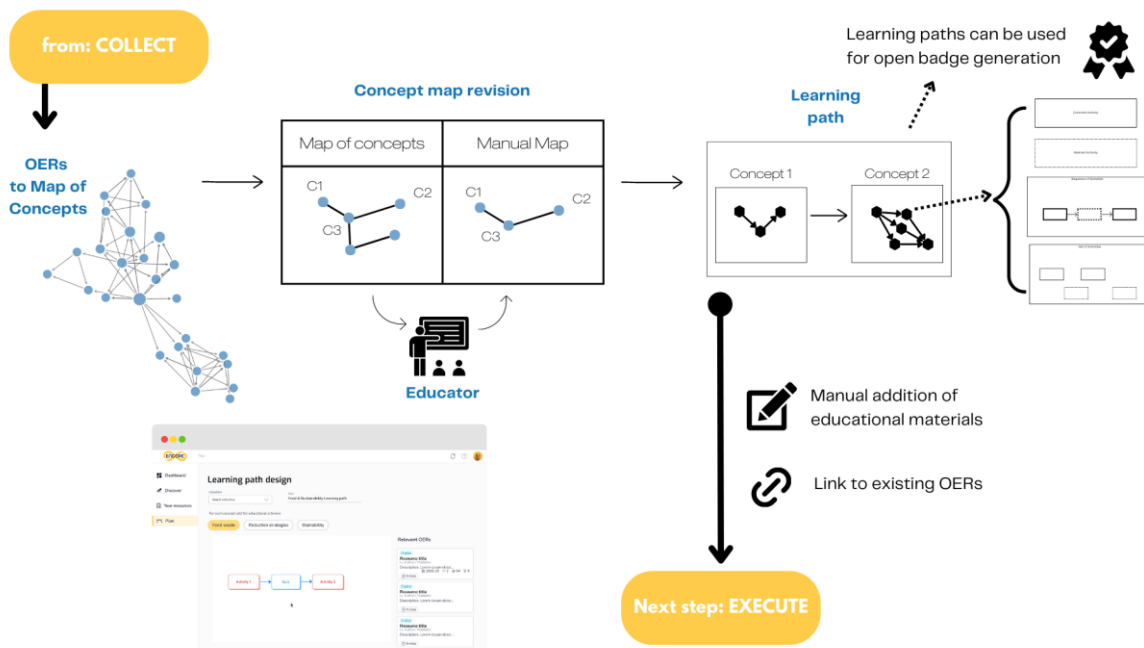


In the subsequent steps, educators have the ability to convert the primary concepts from the collected OERs into a **concept map** using semantic similarity algorithms. They can then personalize the generated map by adding new concepts, making edits to existing ones, and arranging them as needed.

The resulting concept map can be transferred into a **learning path**, where relevant **educational resources and activities** are associated with each node or concept.

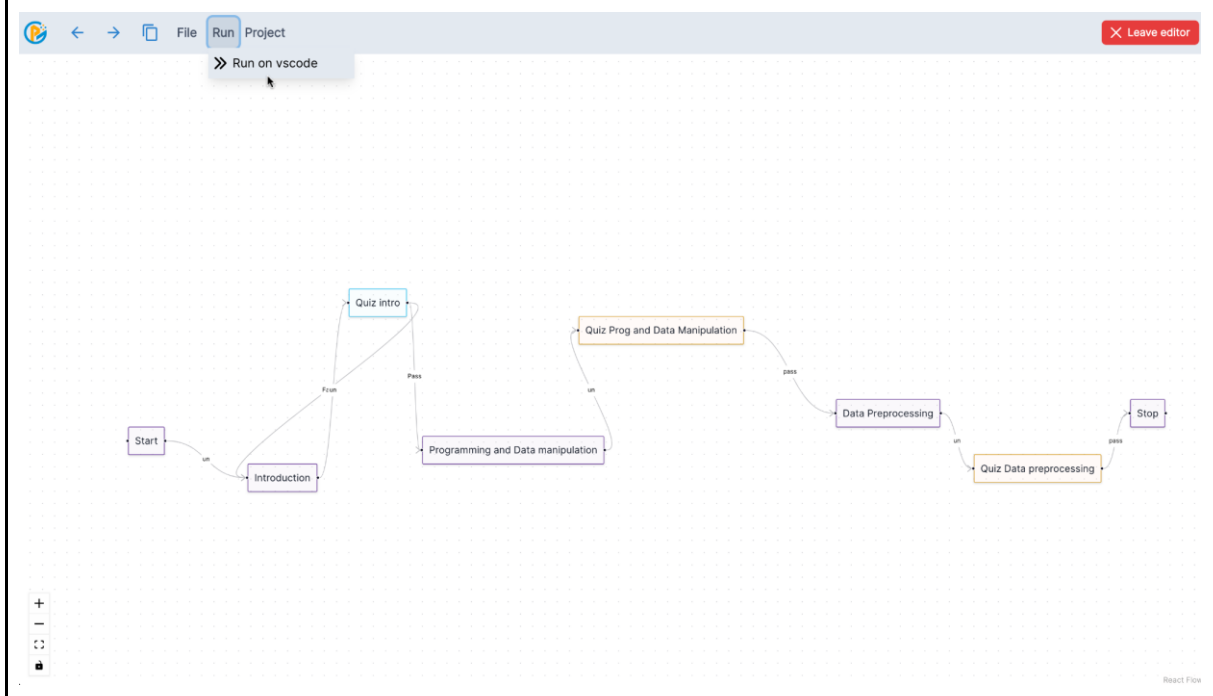
Educators can determine the order of these resources and include various types of educational materials. These materials can be manually added, linked to existing OERs, or generated using generative models. The resulting learning path can then be shared with students in the subsequent phase.

The learning paths can also be utilized to validate the **assignment of open badges**, depending on the successful coverage of concepts and resources throughout the path.



By accessing the plan tab the educator is able to create new learning paths by using the concepts and resources included in the collection of OERs

The learning path editor facilitates the customization of various nodes within the pathway. This can be achieved by incorporating exercises and resources from the collected Open Educational Resources (OER), or by selecting personalised materials for inclusion. Additionally, assessment activities can be integrated along the pathway.



Educators have the option to complete specific fields for each node, providing details about the resources, exercises, and materials featured in that node. Furthermore, they can set up various options for activating subsequent nodes once the learner successfully finishes the current one.

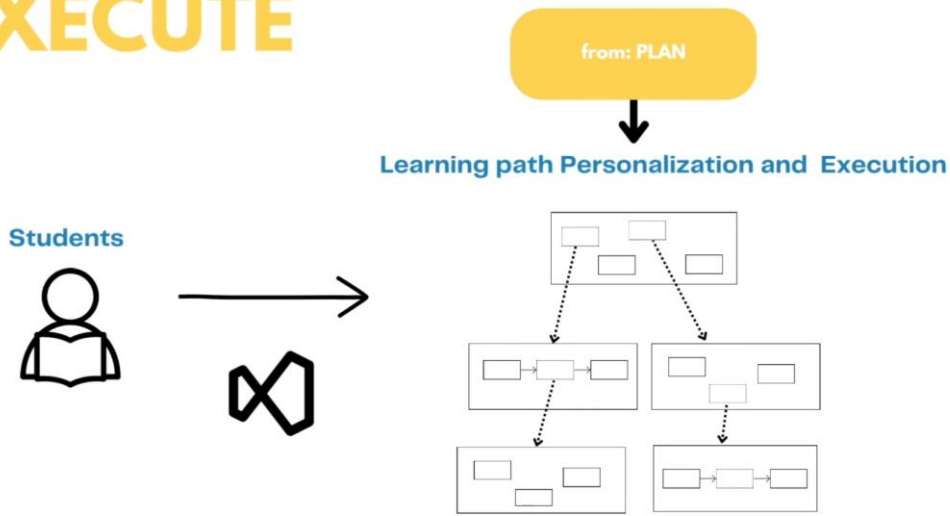
Step 4: Execute. The last section describes how learners can use the learning paths created by their educators.

EXECUTE

In the final steps, students gain access to the learning paths crafted by educators. They can utilize notebook interfaces to explore the **learning activities** presented within each node of the path, allowing them the freedom to personalize their learning experience by accessing different resources.

These notebook interfaces enable students to engage with the materials in a **flexible and personalized manner**.

EXECUTE

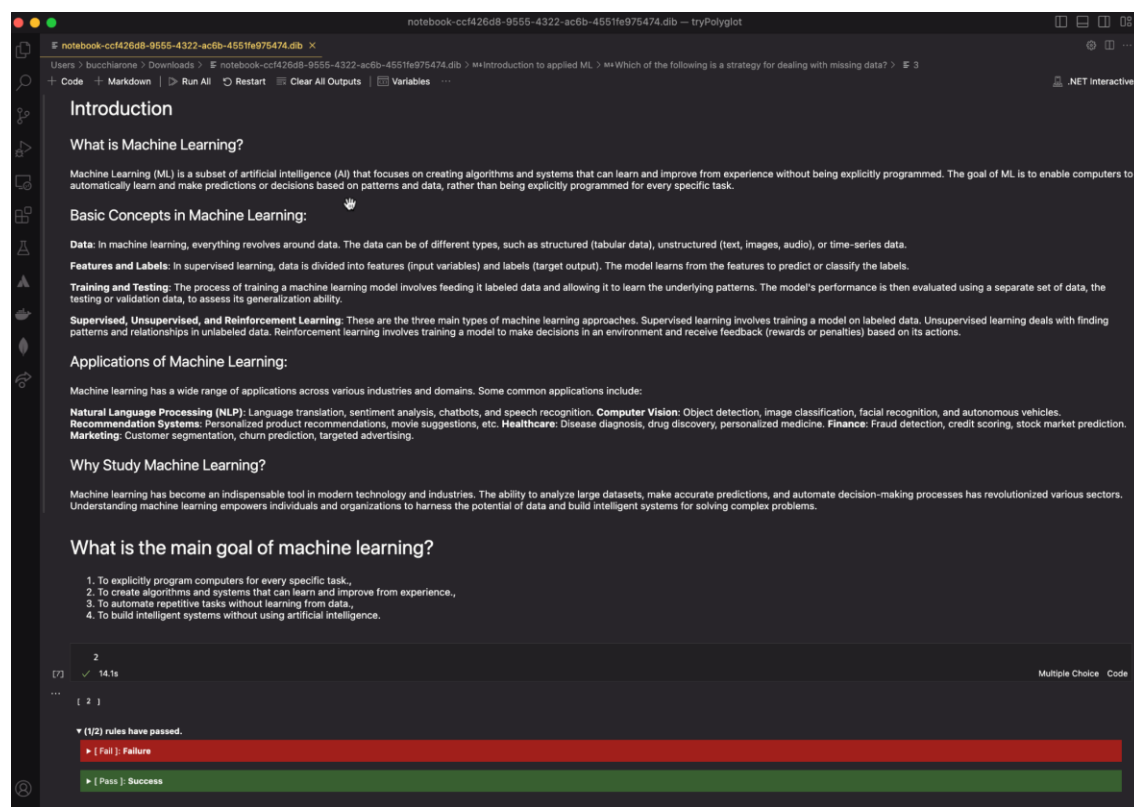


Learners have the capability to access the learning paths crafted by their educators. They can continue paths that have been previously started, and also revisit their progress along with the educational resources that were employed.

Learning Paths

The screenshot shows a user interface for managing learning paths. At the top, there is a search bar with the placeholder text "Search learning paths...". Below the search bar are two tabs: "My Learning Paths" (which is active) and "All". The main content area displays two learning path cards. The first card is titled "Epsilon Object Language" and includes tags "MDE" and "EOF". Below the title is the text "Intro Learning Path on EOL". The second card is titled "Food Science" and includes tags "FOOD SCIENCE" and "CIRCULAR ECONOMY". Below the title is the text "Food Science Intro Learning Path". Each card features a small thumbnail of a learning path diagram on the left and a red trash icon on the right. A blue circular button with a white plus sign is located in the bottom right corner of the interface.

The activities included in the learning path are accessible through various tools. For instance, on the screen below, the activities are accessed within Visual Studio, an integrated development environment (IDE) utilised for writing and editing programming code.



Conclusion

THE INNOVATIVE NATURE OF ENCORE

The ENCORE approach focuses on harnessing the full potential of AI in education, fostering interdisciplinary collaboration by combining expertise from various domains such as engineering, computer science, and pedagogy. By working together across disciplines, ENCORE seeks to improve how AI is used in education and create better learning experiences for students, by employing:

- **Techno-pedagogical approaches** to achieve the project outcomes: improving and refining educators' and trainers' usage of OERs,
- Combination of **Natural Language Processing** techniques and **pedagogical expertise** to support educational design,
- **Personalized and gamified learning paths** for learners to enhance engagement, motivation, and knowledge retention.



Table 3. Summary of the supporting video documenting the functionalities of the enablers



The integration of user documentation will be enhanced based on the feedback received during the piloting activities in WP5. Additionally, beginning with the content from the video materials, a user manual will be incorporated into the digital platform to provide comprehensive support.

LMS plug-in

Integration with Moodle

Overview

The ENCORE OER Plugin is an extension for Moodle designed to provide an easy way for users to incorporate Open Educational Resources (OERs) collected from the ENCORE database and through the Enablers into their courses. The plugin uses a JSON data structure to manage OER metadata and provide an interactive interface for users, specifically it provides a new type of resource: ENCORE OER.

Technological stack

- PHP (for server-side scripting)
- JSON (for data interchange)
- SQL (for database interactions)

Plugin Compatibility

The ENCORE OER Plugin for Moodle is designed to be compatible with all recent versions of Moodle at the time of development (up to Moodle 4.2.x). However, it is always recommended to test the plugin with your specific Moodle version in a safe environment before implementing it in a live scenario.

Technical Specifications

New Resource Type

The plugin adds a new resource type called "ENCORE OER". This can be found within the Moodle resource-adding interface.

Import and Display Components

When a user selects to add an ENCORE OER resource, they're presented with two components:

- An upload form to import a JSON file containing metadata about the OERs. This JSON file should follow the structure provided by the ENCORE Enablers presented in this document.
- A list/table of previously imported OERs for the current course. On the initial use of this resource in a course, this table will be empty.

Course-specific OER Import

Importing a new JSON file results in the contained OERs being uploaded to a course-specific database, meaning they will only be available within the current course, allowing the definition of different OER collections depending on the educators' and learners' necessities. The system parses the JSON file and stores the OER data in a structured format in the database.

Adding and Displaying OERs

If a user selects a previously imported OER from the OER table, the system will add this OER to the course space. It will be displayed as a URL that contains the OER's title, description, and associated skills. This ensures learners have immediate access to the pertinent details of the OER.

Workflow

Figure 38 depicts the workflow of the ENCORE OER Moodle plugin:

1. The plugin enables a new resource type at course-level: ENCORE OER
2. When the user clicks into this resource to add it, two components will be shown: (a) a form to upload a JSON file (in case there are no OERs available in the course yet, and (b) a list of previously imported OERs into the current course (which will be empty the first time you click into this resource within the current course)
3. If the user imports a new JSON file, the OERs will be uploaded into the database and will be only available within the current course space. If the user clicks into a previously selected OER from the available course-level OERs, the OER will be added and displayed in the course space as a URL containing the title, description, and skills.

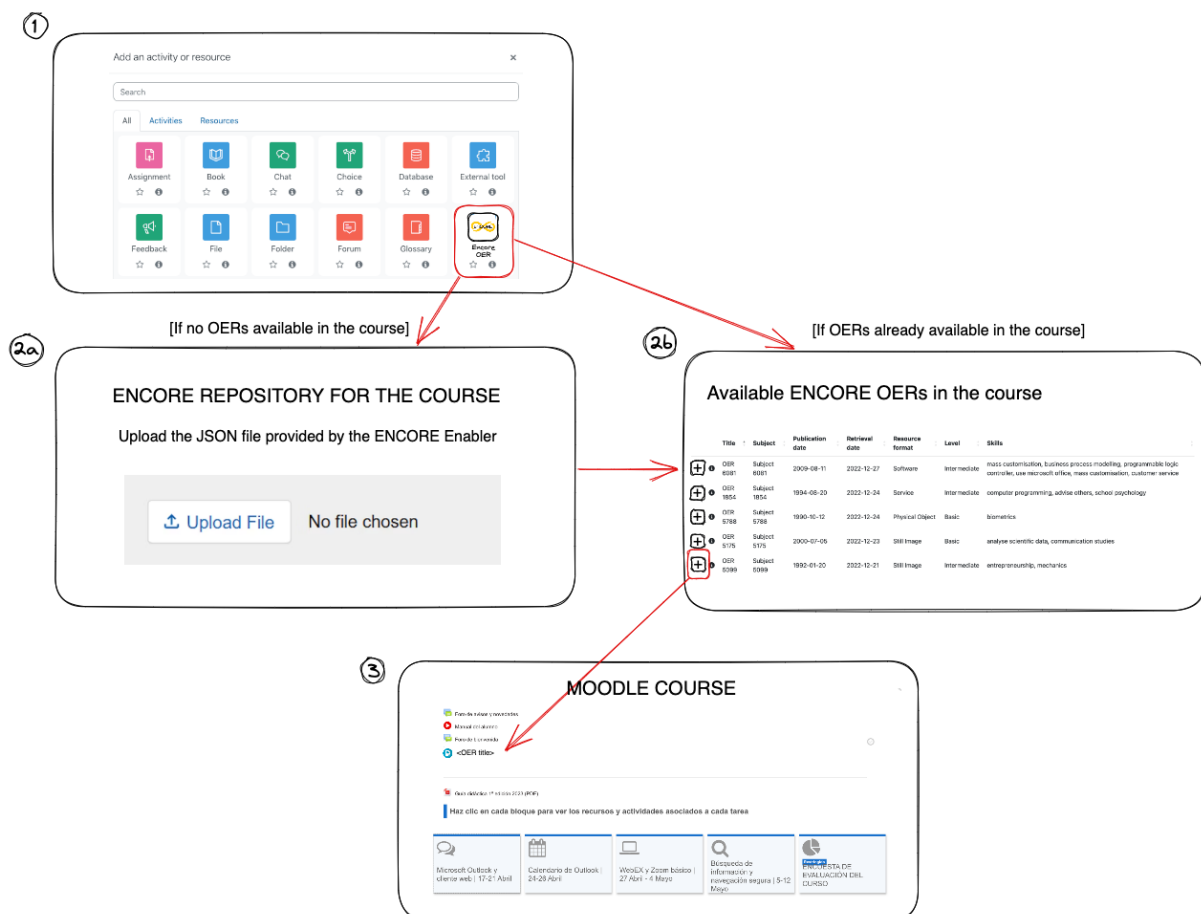


Figure 38. Workflow and functionality of the ENCORE OER Moodle plugin.

Conclusion

This deliverable presents the outcomes of Work Package 4 (WP4), detailing the Enabler for Educators (E4E) and the Enabler for Learners (E4L). These digital tools have been developed to facilitate user engagement with ENCORE technology, incorporating advancements from WP2 and WP3. The design of these enablers follows a co-design approach, drawing upon the diverse expertise within the ENCORE consortium.

As the last activity within WP4, the final task (T4.6) entails the development of prospective Business Model(s) suitable for universities, VET providers, and other training entities. These models will encompass the utilisation of the ENCORE tools to offer future training courses devised through the ENCORE approach. A dedicated deliverable (D4.2) will detail the various business model options that organisations can adopt to incorporate the ENCORE approach into their educational design processes.

The subsequent phase of the project involves implementing these digital tools within real-world scenarios, as outlined in the activities of Work Package 5 (WP5). To facilitate this stage and enhance wider adoption, the ENCORE enablers will be accessible via the project website. Furthermore, additional documentation will be supplied to assist users in effectively incorporating the project's digital tools.

Additionally, the enablers will play a role in supporting open badge recognition within the framework of Work Package 7 (WP7). This integration allows educators to create open badge systems as part of their learning path creation, enabling learners to earn such badges.

The achievements thus far have also been disseminated within the academic and scientific communities. Several publications have either been published or are currently in progress, including:

- Bucchiarone, A., Vázquez-Ingelmo, A., Schiavo, G., García-Holgado, A., García-Peñalvo F. J., and Zschaler, S. (2023). Designing Learning Paths with Open Educational Resources: An Investigation in Model-Driven Engineering, In *18th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1-7) doi: 10.23919/CISTI58278.2023.10211772.
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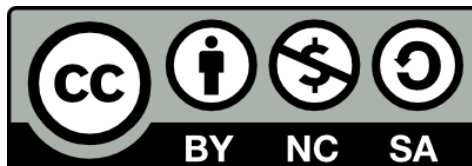
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