R.4.1. Dashboard for Interconnected Tools

for the Project Education 4.0: Living Labs for the Students of the Future (LLSF)

Contract number 2021-1-RO01-KA220-HED-000032176

This project has received funding from the European Union's ERASMUS+ research and innovation programme under Grant Agreement no. 2021-1-RO01-KA220-HED-000032176.

Project:	Education 4.0: Living Labs for the Students of the Future (LLSF)
Action Type:	KA220-HED - Cooperation partnerships in higher education
Contract number:	2021-1-RO01-KA220-HED-000032176
Responsible:	National University of Science and Technology POLITEHNICA Bucharest

Co-funded by the Erasmus+ Programme of the European Union

List of participants

Participant No *	Participant organisation name	Acronym	Country
1 (Coordinator)	National University of Science and Technology POLITEHNICA Bucharest	UNSTPB	RO
2	Universidade NOVA de Lisboa	NOVA	PT
3	Universita Politecnica delle Marche	UPM	IT
4	Universidad Nacional de Education a Distancia	UNED	ES
5	Tel Aviv University	TAU	IL

Revision history:

Rev	Date	Partner	Description	Name
1	10/Jan/2025	TAU	Final draft draft	Tal Soffer, Tetelbom Schuchmann Cintia, Soroka Zuta Anat

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For the students of the future.

Contents

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Education 4.0: Living Labs for the students of the future – The automatic catalog dashboard

Introduction

The Fourth Industrial revolution, or Industry 4.0, has revolutionized society with technological advancements, merging physical, digital, and biological spheres. This shift necessitates new digital skills like critical thinking and problem-solving. Universities are adapting by exploring new educational models. The labor market faces challenges from rapid tech advancements, widening the gap between industry and academia. The European Council's 2017 initiatives aim to boost university competitiveness through partnerships. The COVID-19 pandemic accelerated online learning, increasing interest in digital learning technologies. Education 4.0 responds by integrating human and tech advancements, promoting personalized, data-driven learning environments and innovative educational practices.

In light of these advancements, Education 4.0 includes a new perspective where the data is always available, and the role of schools and universities shifts from imparting knowledge to helping the students navigate this information filled world. Open science furthers the application of digital tools to allow reproducibility in research. One of the main challenges faced by academic researchers and their laboratories is the overwhelming volume of data available and the inability to assess the reliability or to harness its power. Digital, virtual and living labs emerge as a possibility for researchers to execute experiments from afar and collaborate with other laboratories in the development of research and products.

Our project proposes developing an international network of interconnected living labs to provide flexible digital options for master's and PhD students, from different parts of the world (Romania, Portugal, Italy, Israel, and Spain). The project focuses on data-centered learning, to support Digital Education and Innovation programs in IoT and Data Engineering and provides a unified

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resource for researchers to access from across the planet, at their convenience. One of the aims is to create more opportunities for accessible higher education and improve digital readiness and resilience in educational services. In this sense, the project supports the integration of universities around Europe, providing accessibility through a platform where European Credit Transfer and Accumulation System (ECTS) points can be awarded to participating students.

The aim of this report is to outline the development of an automatic catalog/dashboard for a distributed eLearning training platform focused on IoT and Data Engineering. The objective of this catalog is to serve as a central hub, providing information on various labs, enhancing collaboration among teachers, students, and researchers, and offering flexibility for labs to manage and update their courses.

Literature Review

The Fourth Industrial revolution, or Industry 4.0, has brought significant changes to all aspects of society with advancement of technologies and the blur between the physical, digital, and biological spheres(Schwab, 2016). These changes drive industry and society to reorganize, and educational institutions to reassess the digital skills necessary to enter the workforce, including critical thinking, problem-solving and digital literacy. In response, universities are searching for new models of education.

According to the International Labor Organization, the labor market is being tested by accelerating technological advancements(World Employment and Social Outlook, 2024,). Even though there is a wave of digital innovation, quality of life and production rates have not grown accordingly. The gap between industry and academia thus increases, and aligning education with workforce needs becomes a bigger need.

In December 2017, the European Council published several initiatives aimed at fostering international competitiveness in universities. Among them are instigating partnerships between European universities and suggesting the creation of networks that enable students to combine studies across EU countries.

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In parallel, the COVID-19 pandemic accelerated the shift from traditional to online learning, indicating the need for interactive environments and virtual solutions for higher education. Consequently, interest in and investment in digital learning technologies that support remote and hybrid learning models have increased. There is a growing need for comprehensive platforms that showcase various digital learning solutions and technologies available to educational institutions and instructors. Recent technological advancements have enabled global collaboration while fostering innovative learning experiences.

In this context, Industry 4.0 and the related challenges concerning the effects of science and technology on society raise the need for a framework to ensure that technological advancements are conducted responsibly, ethically, and sustainably, considering societal needs and ethical values. Responsible Research and Innovation (RRI), developed in the early 2000s, focuses on societal needs and values in the context of technological advancements brought about by the Fourth Industrial Revolution (von Schomberg, 2013)**. RRI emphasizes the participation and collaboration of relevant stakeholders, prioritizes ethical and governance values, and aims to offer open access to scientific knowledge.**

RRI focuses on five key areas: gender, open access, science communication, ethics, and public engagement .RRI has been a key component of the EU's research and innovation framework programs, particularly Horizon 2020 and Horizon Europe[1]. These programs have integrated RRI principles to ensure that research and innovation activities are conducted responsibly and ethically

In this context we should refer to other central concept to EU methodologies which is the Co-Cration theme which about collaborative innovation, where diverse stakeholders work together to create value and develop solutions in real-life contexts. This approach enhances the innovation process by incorporating multiple perspectives and ensuring that the developed solutions are practical and effective(Lucchesi & Rutkowski, 2021).

Education 4.0, also brought as a response to Industry 4.0, creates innovative educational practices that play a critical role in preparing the workforce for this new reality. It integrates human and technological

[1] https://www.era-learn.eu/support-for-partnerships/governance-administration-legal-base/responsible-research-innovation

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advancements to create personalized, data-driven learning environments where teachers act as facilitators and peers play a crucial role in collaborative learning. It emphasizes aspects such as learning anytime and anywhere with e-learning tools, personalized learning, data interpretation, and new assessment methods(Aziz Hussin, 2018). They allow researchers and educators to share knowledge and students to access more information, including active learning and hands-on practice, which are essential for mastering these skills. Online and blended learning developed in recent years also improves the educational process, as students and educators can connect regardless of their location and adjust the experience to their rhythm and needs.

Digital and Virtual Labs:

The above developments are expressed in the living lab concept, which embodies co-creation and collaborative innovation. Living labs bring together diverse stakeholders to develop and test solutions in real-life contexts, ensuring practical and effective outcomes. This approach aligns with the goals of Industry 4.0, Education 4.0, and RRI by fostering innovation, enhancing education, and addressing societal challenges responsibly.

The Living Lab is a real-life test and experimentation environment. It serves as a practical testing and experimentation space where open innovation processes are conducted, bringing together various stakeholders to collaboratively create within real-world settings.

In Education, Living Labs, as a dynamic approach to learning and research, offer a unique and immersive way to engage students in STEM and engineering fields. Combining real-world scenarios, collaboration, and practical problem-solving, Living Labs bridge the gap between theoretical knowledge and its practical application, and provide both students and teachers with many advantages that foster innovation, critical thinking, and skill development(Tercanli & Jongbloed, 2022).

Digital labs are interactive tools, usually offered through online platforms, that allow students to simulate experiments. Students can collect, process and analyse the data from the experiments, and extract results through the digital technology available in the laboratory. Virtual labs provide remote access to experiments, and students can learn according to their needs.

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Methodology

The automatic catalog/dashboard is a crucial tool that integrates and supports the living labs, enhancing their functionality and fostering a collaborative, data-driven educational environment.

The methodology adopted for the development of the Living Labs catalog is based on the Research and Development (R&D) Method by Borg and Gall (Borg & Gall, 1983) andsummarized in ten steps by (Gustiani, 2019) :

1. Research and Information Collection
2. Planning
3. Developing Preliminary Form of Product
4. Preliminary Field Testing
5. Revising Main Product
6. Main Field Testing
7. Revising Operational Product
8. Operational Field Testing
9. Revising Final Product
10. Disseminating and Implementing

The ten steps listed above were adapted to our project as the development of the product is part of a research project and not with the goal of implementing it. Additionally, the scope of testing is smaller and requires less iterations.

Therefore, in our research these were the steps that were carried out:

1. Research and Information Collection
2. Planning
3. Developing Preliminary Form of Product
4. Preliminary Field Testing
5. Revising Main Product

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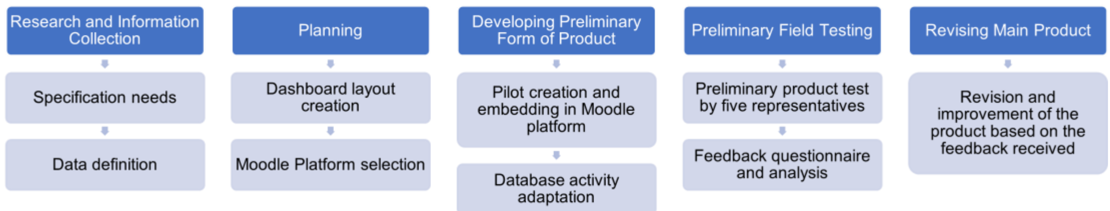
6. Main Field Testing
7. Revising Final Product

The chart below summarizes the process until now:

Figure 1 - Research and Development process



The first step, **Research and Information Collection**, included literature review, needs analysis and analysis of similar products in academia. The literature review (reviewed in the introduction) explored the difference between Massive open online courses (MOOCs), digital labs and virtual labs and analyzed existing digital products and services. In this stage the needs analyzed and the framework for the dashboard was defined and the potential benefits:

1. **Centralized Resource Management**: It provides a centralized repository for all resources, including research papers, case studies, and best practices, making it easier for students and educators to access relevant materials.
2. **Enhanced Collaboration**: The dashboard facilitates communication and collaboration among students, educators, and industry partners, enabling them to share ideas, discuss challenges, and work together on projects.
3. **Real-Time Data Analysis**: It allows for real-time data collection and analysis, helping students to understand and interpret experimental results more effectively.
4. **Progress Tracking**: Educators can monitor student progress and engagement through analytics, allowing for timely interventions and personalized support.
5. **User Feedback**: The platform can incorporate feedback mechanisms to continuously improve the learning experience based on user input.

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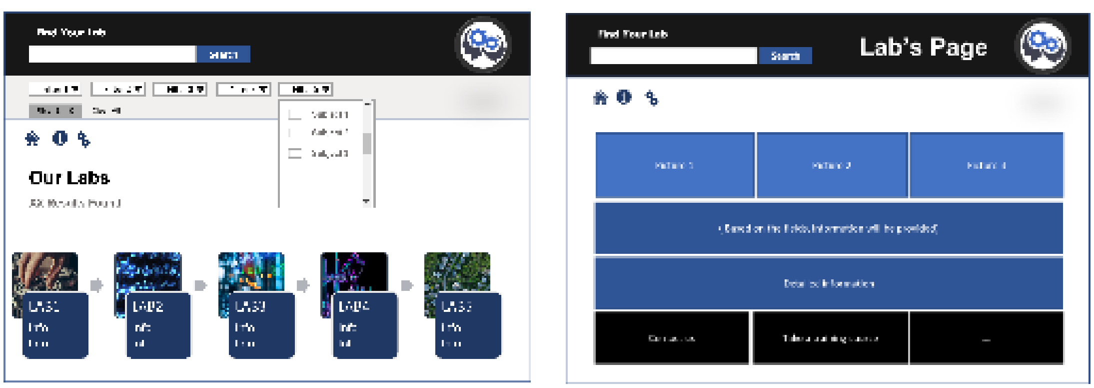
6. **Integration with Industry**: By connecting with industry partners, the dashboard can provide students with access to real-world datasets and insights, enhancing the practical relevance of their learning.

In the second step, **Planning**, research objectives and steps for development and implementation were set. A wireframe for the dashboard was created, following the previous findings. The wireframe included two screens, one showing the catalog and one as a lab page (Figure 1). In the first screen, the different labs available are presented, with an image and basic information. To improve the process of finding a specific lab, the interface includes a general search bar and filters according to the fields in the laboratories' description. The second screen shows a lab page, with multiple images, more detailed information and options that redirect to the lab's person of contact and courses.

Figure 2 - Wireframe interfaces



Additionally, the Moodle platform was selected to support the dashboard. After a comparison with Content Management System (CMS) systems like WordPress and interactive form systems like Type form, the researchers found that a Learning Management System (LMS) like Moodle offers more options of including learning material distribution, higher scalability, integration with other systems, and suitability for higher education. Out of the LMSes, Moodle was chosen as it is already implemented in most universities that are partners in this research, and therefore the target population is familiar with it.

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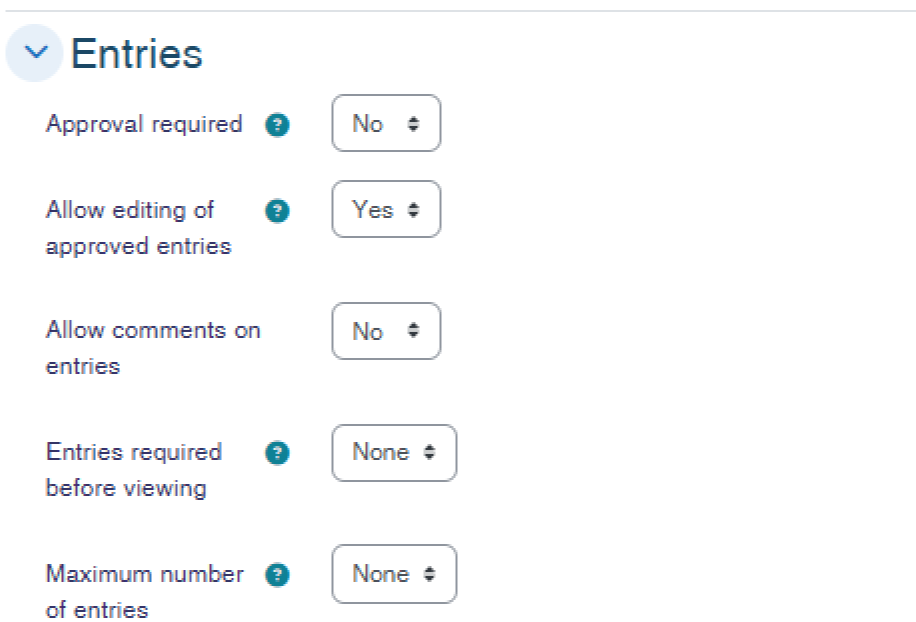
During the third step, **Developing Preliminary Form of Product**, a preliminary product was created, using the Moodle platform and actual data from the participant labs. The lab catalog was developed based on the wireframe designed and the existing activity in Moodle, called “Database”.

The Database activity in Moodle allows lecturers and students to create, share, and search for a collection of entries about any subject. The format and structure of these entries can be adjusted to include images, files, URLs, numbers, text and more. Moodle also allows the customization of permissions, as default researchers and lecturers can add entries, students can only access them, and all users can comment on the entries. The Database activity's versatility, combined with its well-established standardization, makes it ideal for our Dashboard.

Entries options in the Database activity:



Mount Orange, Moodle 2024.

When creating and preparing the activity, the teaching staff can either add fields or use a preset. A preset offers different layouts, however, does not allow the customization of the fields, so for the Living Labs dashboard the fields were entered manually and the layout designed using the “template” options.

The catalog was prepared based on the field discussed previously, and later a video manual on its use was created and shared with the testers (link to video). The fields were added to the activity according to the

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mapped needs: Lab name, Description, Field of study, University, Location, Learning process (Fully online; Hybrid; Face to face), Overview, Syllabus, Lab website, Contact information, Publications, and Courses taught in the lab (ECTS). In the Overview field all other basic information on the lab was added, namely: Aim of the Lab, Technical Infrastructure & Data Collection, Pedagogy/Learning Process, Student Assessment, Students Main Output, and Possible Collaborations.

Manage fields

Create a field

Create fields to collect different types of data. Fields define the structure of the entries in your database.

Field name	Field type	Required	Field description
Lab name	Short text	Yes	
Description	Short text	Yes	
Field of Study	Short text	Yes	
University	Short text	Yes	
Lab image	Image	Yes	appears in the list view
Location	URL	No	link to google maps
Learning process	Checkboxes	No	
Overview	Text area	No	
Start date	Date	No	
End date	Date	No	
Syllabus	File	No	
Lab website	URL	No	
Contact information	Short text	No	
Publications	File	No	
Courses taught in the lab (ECTS)	Text area	No	

Fields added to the activity.

After setting the fields, the interface can be adapted by using the “template” options. Through these options, available only in this activity, the teaching staff can manipulate the layout by text, using tags, CSS and JavaScript. The changes were made to the activity to adapt it to the

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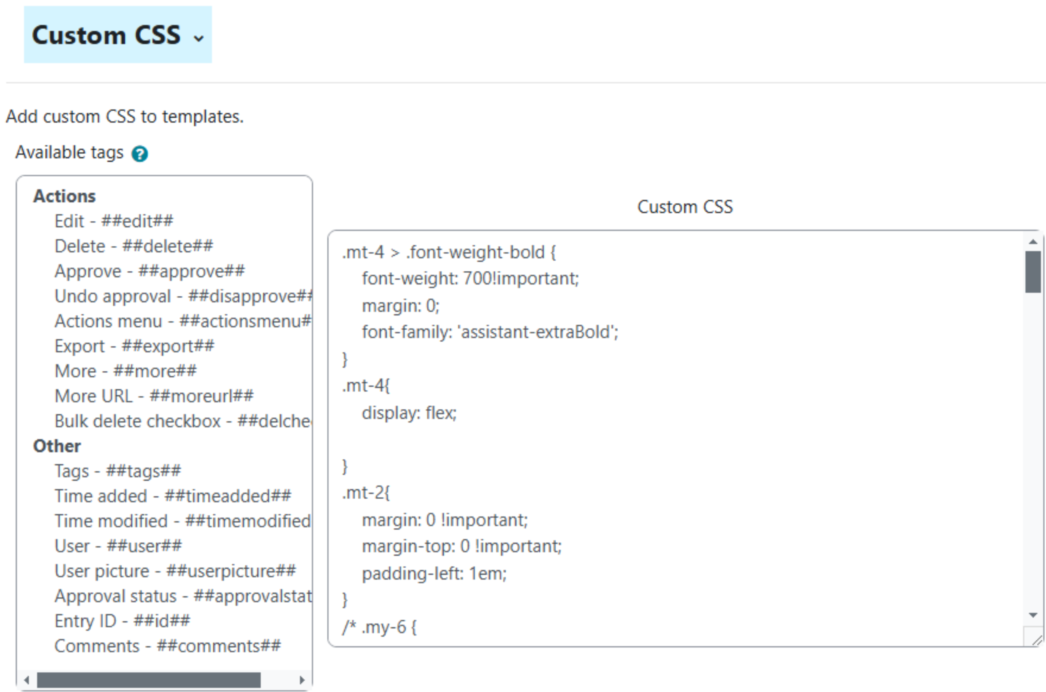
Dashboard's needs. New CSS; Bold field names; Include a description field (text only, no question); Fix minor bugs; Add an option so that the database won't be available to students; Allow student rating; Allow reordering of questions; Specify which fields appear in Single and List Views.



CSS field used to make changes in the database activity.

In the fourth stage, **Preliminary Field Testing**, a first product test was performed by nine representatives from partner universities. A promotional video was developed to introduce the catalog (link to video).

Feedback was given through Google Form and analyzed. The questionnaire on the demo dashboard provided insights into the usability and functionality of the Living Labs catalog. Nine representatives from the partner universities were asked to rate the relevance and accuracy of Laboratory data, user experience, and potential user engagement. Most participants found the information accurate and required minor modifications. The dashboard interface was considered very user-friendly, especially due to the use of the familiar Moodle platform. Users suggested improvements such as allowing changing roles and improving accessibility. The field of "contact information", already present in the demo, was highlighted as essential. Regarding user engagement, the participants were asked how likely it is that students, researchers, and professors will use the catalog. Students were considered "somewhat likely" to use it, especially when guided by instructors, while researchers' engagement was uncertain due to the catalog's focus on

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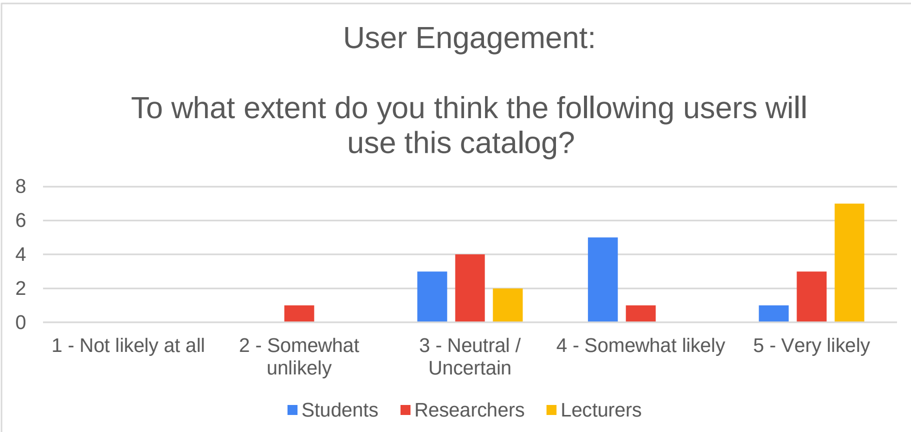
teaching. Lecturers were perceived as the most likely to use the tool, as a tool for configuring labs and improving teaching outcomes. Figure 1 summarizes the answers.

Figure 3 - User engagement insights from the preliminary field testing



Feedback given also includes suggestions for improving content management and enhancing the user experience, such as adding an image carousel, additional filtering options and improved interface design.

The fifth step of the research was **Revising Main Product** based on the feedback received. The suggestions and recommendations were implemented, including improvements to the interface and the possibility of adding more than one file.

After that, the catalog was presented to more testers in a training workshop in Lisbon, according to the step of **Main Field Testing**. A wilder scale of participants (12) revised the product and experimented with the features. The data and feedback were collected by a revised Google Form and discussed face-to-face.

Summary of Feedback

User Experience

- ***General Feedback****: Most users found the catalog user-friendly and convenient for different user groups (students, researchers, lecturers).*
- ***Suggestions for Improvement****:*
  - *Make the "create new entry" button more visible.*
  - *Improve keyword search functionality.*

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   - *Use larger or bold letters for main features.*
   - *Add a "methodology" field and "qualifications" field.*
   - *Include a level category (introductory, basic, advanced).*
   - *Offer suggestions related to previous searches.*
   - *Enhance customization of content (e.g., support for markdown, mathematical formulas, and workflow presentations).*

User Engagement

- ***Students**: Generally positive engagement, with most users rating it as "somewhat likely" or "very likely" that students will use the catalog.*
- ***Researchers**: Mixed feedback, with some users feeling researchers are not the main target.*
- ***Lecturers**: Positive engagement, with many users rating it as "somewhat likely" or "very likely" that lecturers will use the catalog.*

Motivation

- ***Main Motivations**:*
   - *Organized and centralized information.*
   - *Lecturers can improve their courses.*
   - *Students can find courses and teaching activities.*
   - *Researchers can find collaboration opportunities.*

Content Management for Lab Managers

- ***Ease of Use**: Generally found to be easy and intuitive.*
- ***Suggestions for Improvement**:*
   - *Clarify the "edit" option under the "About" label.*
   - *Improve text editing capabilities.*

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- *Add filters and sorting options.*
- *Include categories and sub-categories with drop-down lists.*

The final stage of Revising Final Product was performed after the third iteration of tests with the catalog, in January 2025, in Bucharest. In that, the product was presented for real-time testing at the LTTA C3 conference. Participants were given an overview of the product and the project, and then asked to access the dashboard, navigate through the existing labs, and enter information about their own lab. All participants successfully completed the task within a few minutes (up to 10 minutes), accessing the component from various platforms, including mobile devices.

Conclusion

The successful development and testing of the Living Labs catalog/dashboard provide a strong foundation for future research and development in digital education. The project demonstrates the feasibility and benefits of creating interconnected, data-driven learning environments. Future research can build on these findings to explore new features, expand the platform's capabilities, and further enhance its impact on education.

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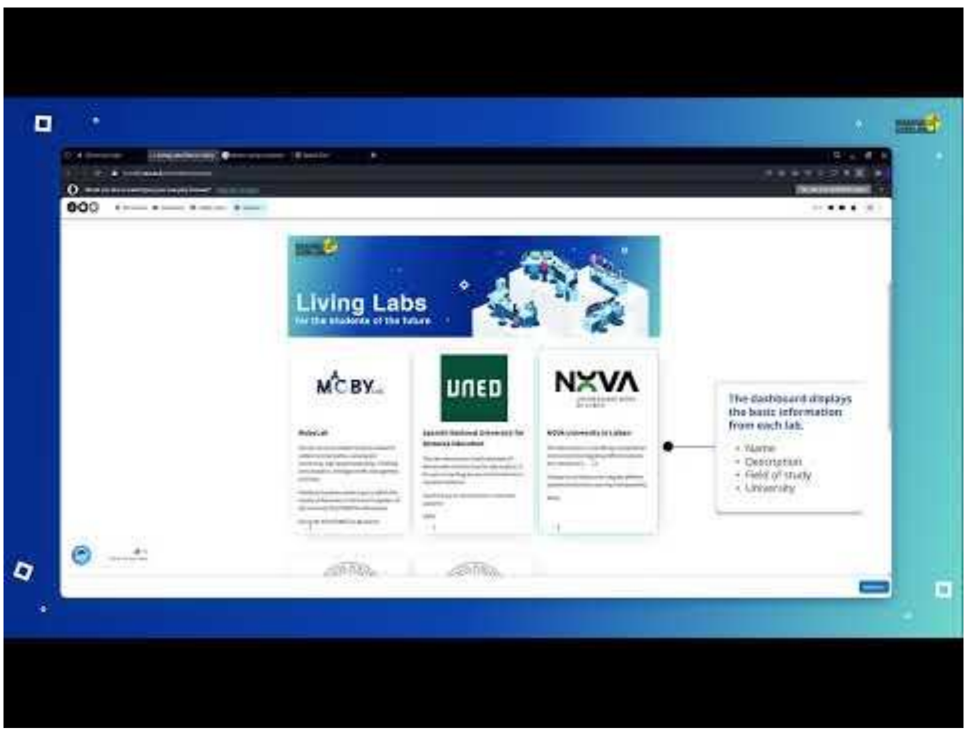

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EDUCATION 4.0 LIVING LABS

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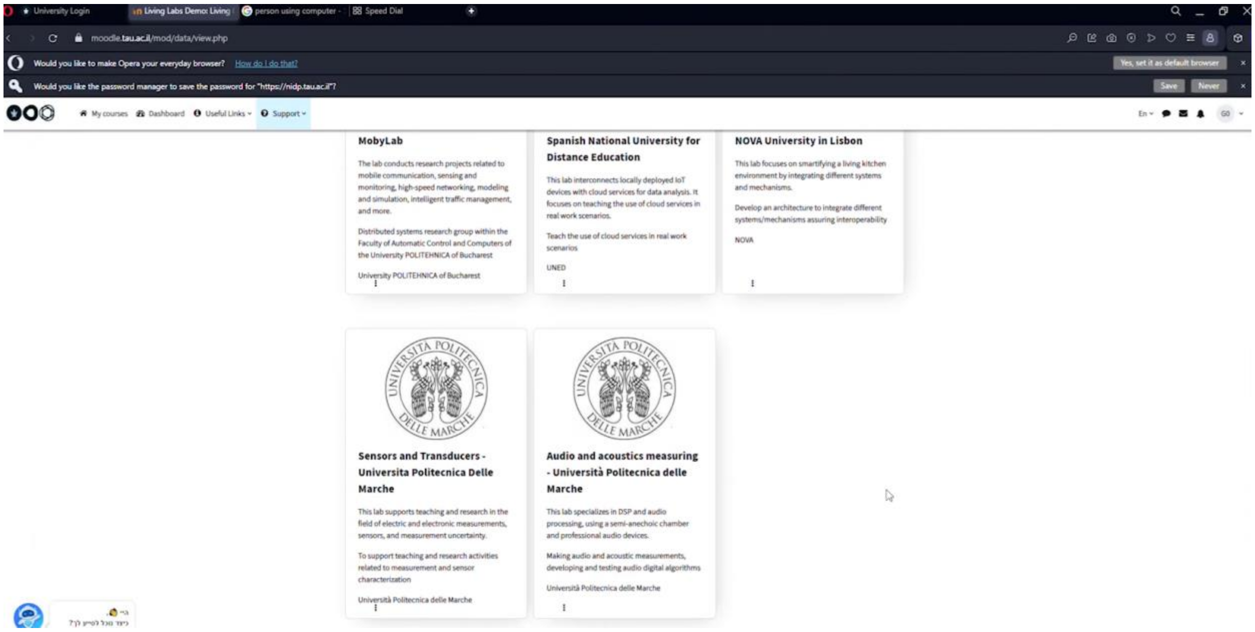

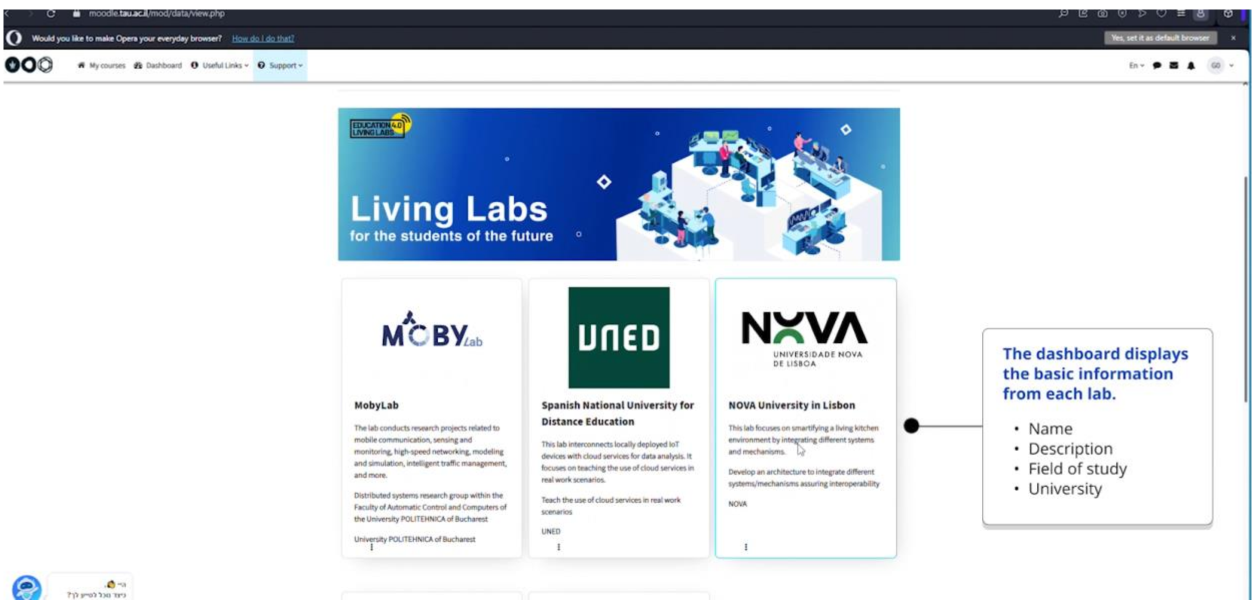

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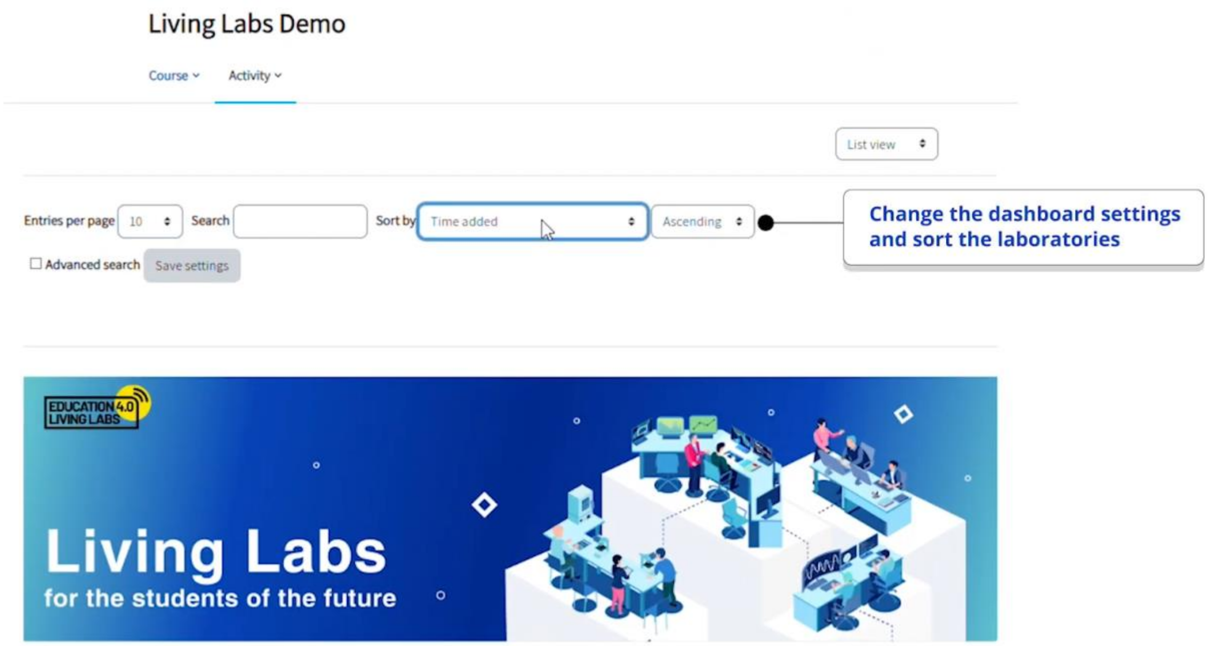

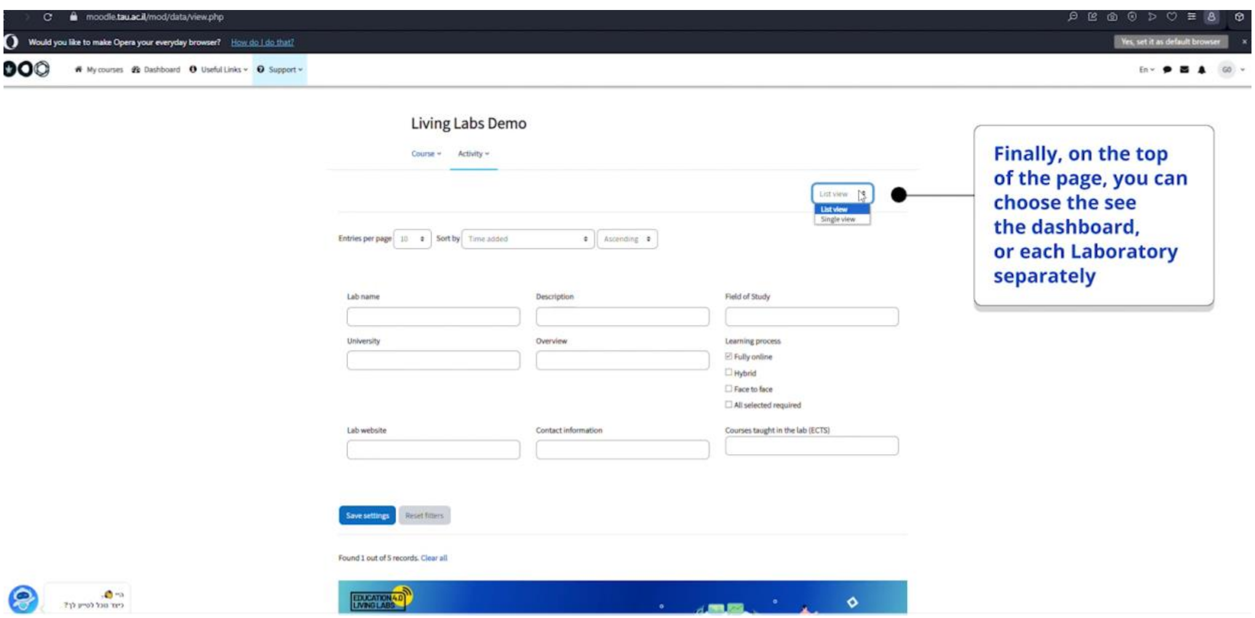

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