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Guidelines for Digital Problem-based Teaching-Learning

D-PBL: advancing project-based learning into the Digital Era

Nr. 2021-1-PT01-KA220-HED-000032011

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GUIDELINES FOR PBL DIGITAL TEACHING-LEARNING PLANNING

In this publication, we are presenting the main findings related to the project activities and the intellectual products of the project. The publication will include the main findings from R1 (Digital Competencies Survey), reflection on the usage of R2 (EAD Training Toolkit/Course for Teachers) and R3 (Architecture of Digital D-PBL cells) and will concise partners' experiences gained within their context during the Piloting Phase. Guidelines, consisting of the findings from all project phases, both good practices and problems, presented in a systematic and structured way, will help academia to adopt the innovative approach in developing transformational competencies, will help institutions to develop blended mobility. All partners were actively and equally involved by gathering feedback from the participants and reflective entrances on the lessons learned, by preparing the content for the publication.

1. FRAMEWORK OF THE GUIDELINES

The teaching professions face rapidly changing demands, which require a new, broader and more sophisticated set of competences than before. The ubiquity of digital devices and applications requires educators to develop their digital competence. The European Framework for the Digital Competence of Educators (DigCompEdu)¹ (UNESCO, 2018) is a scientifically sound framework describing what it means for educators to be digitally competent. It provides a general reference frame to support the development of educator-specific digital competences in Europe. DigCompEdu is directed towards educators at all levels of education, from early childhood to higher and adult education, including general and vocational education and training, special needs education, and non-formal learning contexts. Figure 1 shows the six areas, which include 22 different competences. The focus is not on technical skills. Rather, the framework aims to detail how digital technologies can be used to enhance and innovate education and training.

¹ European Framework for the Digital Competence of Educators: DigCompEdu
https://joint-research-centre.ec.europa.eu/digcompedu_en

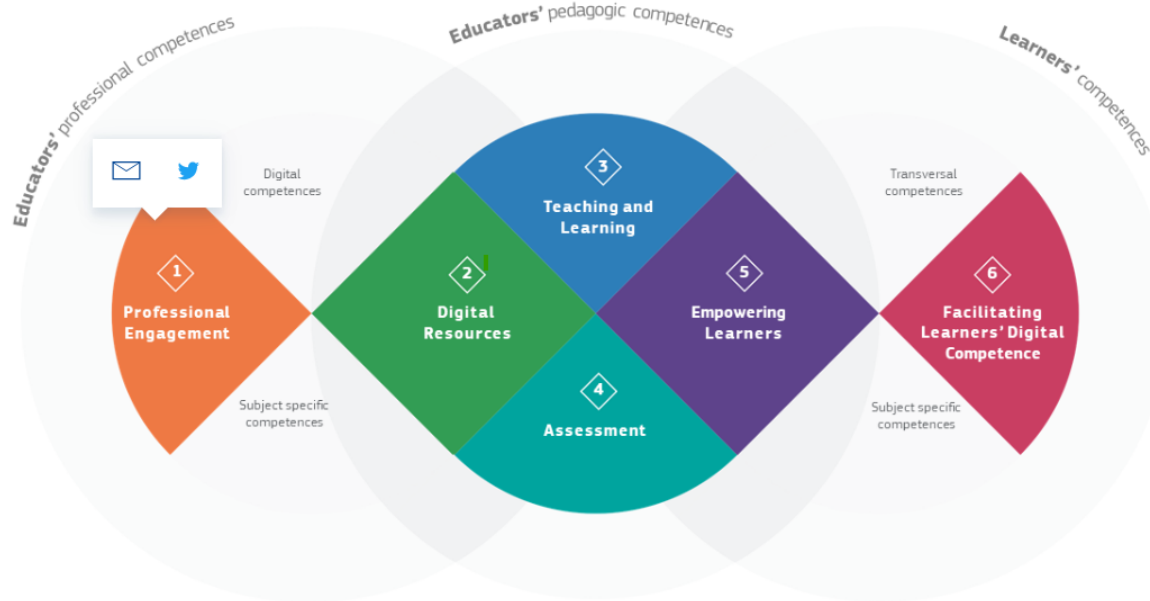


Fig.1. DigCompEdu six areas for digital competences

(Internet source: https://joint-research-centre.ec.europa.eu/digcompedu_en)

DigCompEdu framework is good theoretical guideline for educators on any level of digital competency. For Newcomers and Explorers, it can be a tool of progression, where for Experts and Leaders it can serve as encouragement to further excel and share their knowledge and participate in collaborative actions in teaching processes.

DigCompEdu aims to provide a common ground for educators' digital competencies development. It could be employed as both a comprehensive framework and a tool for assessment and fostering educators in the digital world. DigCompEdu strongly relies on the progression model, initially inspired by Bloom taxonomy, to support and encourage educators to understand their personal strengths and weaknesses, by describing different stages or levels of digital competence development ranging from A1 to C2 (Filatovaitė & Stakėla, 2021). As a comprehensive framework, we used it throughout all of plan stages assessing digital competency level of lecturers (R1) and used it to train them and educate them further (R2). Accordingly, it brings a plethora of benefits to the different stakeholders, particularly educators:

- common environment for further discussion and knowledge exchange
- solid foundation for policies in field of education
- based on well-established and empirically proved progression model
- integrates many previously defined frameworks, researches, and best practices into a single model

- makes a strong impact on digital society
- good starting point for e-learning ecosystem development
- it illustrates learning and teaching lifecycle in a proper way

Furthermore, the idea of student's self-regulated learning should be enforced further and actual methods and guidelines could be developed as it can help in their future work outside of educational facilities. One of our project questions is – Do student know how to apply their gained technical skills and do they know how to work in teams and do collaborative work. Using self-regulated method students can be more confident in their gained knowledge and can acquire certain organizational skills as well. Self-regulated learning path/method/process would contribute to the quality of their knowledge.

Assessment tools should be developed as well. This framework can help and be useful in creating assessment methods that would generate valuable and meaningful feedback to the lecturer and students themselves (Punie & Redecker, 2017).

Teachers' digital competence is defined as teachers' skills to access, identify, and organize digital resources relevant to professional content (Knutsson et al., 2012), to share, interact, engage, and collaborate with students, and to use digital technologies and resources to implement the teaching and learning. Teachers must critically and creatively exploit digital technologies or resources to enhance and innovate teaching and promote students' digital competence (Ghomi & Redecker, 2019).

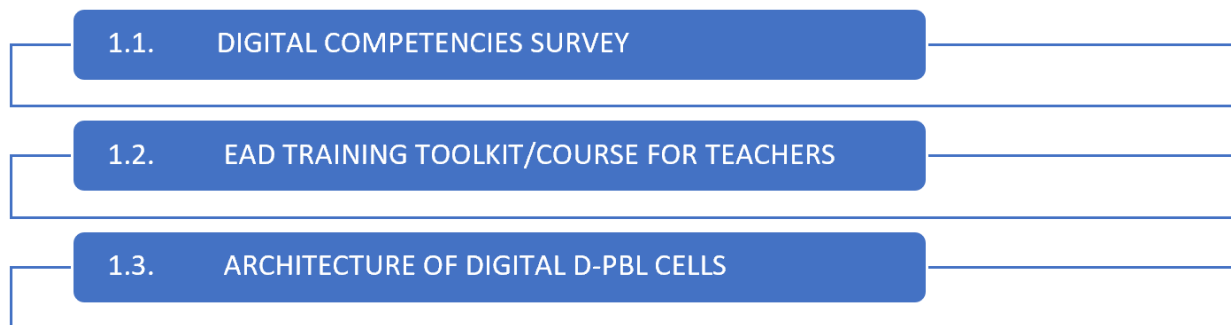
Thus, DigCompEdu is a good technical guideline, but lacks practical application, so improvement of the framework can be reflected through creation of tools and methods for different areas of the framework.

Certain segments that could be further enhanced and extended:

- There are no practical guidelines that could be used in day-to-day activities of the educators
- It doesn't include pedagogical approaches and innovative learning models, such as project-based learning, problem solving and others
- Certain parts must be updated as the research was taken 5-6 years ago, particularly considering advancing of technologies
- The impact of Covid-19 and the fact that e-learning has boomed in the last two years has to be considered as well
- Innovative technologies and their practical usage in education should be extended in a big extent
- It doesn't investigate possibilities of the modern learning environments

- Multidisciplinary and multinational work has not been addressed as crucial factor

In order to consistently gather information and analyse the resulting experience from the perspective of students, lecturers, and institutions, a participatory-made framework is developed. The framework of guidelines is created according to the DigCompEdu competences, each part of project strengths and weaknesses, problems and issues. Also we have collected the feedback, comments and other useful information from teachers who were involved in the questionnaire.



This study is carried out in the framework of the D-PBL project – Advancing project-based learning in the Digital Era. The aim of the D-PBL project is to combine digital teaching-learning with project based-learning, applied in an international context. The objectives of the D-PBL project are grounded on three dimensions:

- give sense to the technical skills by providing a real context to the learning path;
- give effective business-useful digital competencies;
- integrate students in real multi-national teams.

The project's sequence of activities towards the main results starts with the assessment of the lecturers/teachers' digital literacy levels, and for that the project was deliver the EAD Digital Competencies Survey. Each partner were participated in survey creation. The questionnaire was orientated to survey teachers about the digital skills/competences. It is the responsibility of lecturers to provide students with up-to-date

digital knowledge and competences. The better prepared a lecturer is, the better he or she can convey that information to students.

In order to achieve the expected results of this phase of the D-PBL, it was decided to use the Delphi method, i.e. to bring together a group of experts and repeatedly ask them questions about how to make a particular decision or solve a problem.

The D-PBL Delphi group was organized to decide on the structure of a questionnaire aimed at grasping the level of proficiency related to the skills and competencies required to use D-PBL in the classroom as well as identifying blocking factors and preferred ways of training of an individual teacher.

The questionnaire evolved following the Delphi method over an iterative process in three phases. Each iteration incorporated the outcomes of the previous one refining experts' perceptions about the fields studied: assessment, skills and competences, blocking factors, training settings. The Delphi groups were organized by each partner. The results from each iteration were aggregated to identify common trends that were used to refine the questionnaire.

In total, 67 experts participated in the Delphi study.

At the first round the panellists were asked to answer the following questions:

1. Which skills and competencies shall a teacher master to design and implement academic activities supported by a D-PBL digital cell?
2. What type of training activities can be effective for the teachers to develop the skills and competencies you have identified in the previous question? Which of these will be more appropriate for individual learners according to their level of digital literacy (use a scale from 1 to 4 where 1 refers to a newcomer and 4 to an expert)? To answer this question, please fill in the table below. The example provided in the table is just for your guidance; please remove it from your answer.

Training activity	Level of digital literacy of the learner (1 to 4; 1 is the lowest level)
Online video tutorials	1

3. Why are not teachers taking advantage of youngsters' innate digital proficiency in using new technologies, aiming to develop and promote innovative learning environments in the classroom? Why are not all teachers exploring these obvious opportunities to promote professional digital competencies in our students? What is

preventing teachers from exploring these opportunities? Which blocking factors can you identify?

The input from the panellists of all the Delphi groups was merged to identify the most prominent aspects mentioned by the pool of the 67 experts. The result of this analysis was used to draft the questions for the second round:

1. How relevant are the following skills and competencies for teachers willing to promote D-PBL academic activities in their classes (use the following scale: 1 – irrelevant, 2 – low relevance, 3 – relevant, 4 – high relevance, 5 – indispensable):

- Empathy
- Leadership
- Teamwork related: communication, negotiation, include and motivate all
- Positive attitude towards ICT
- Engage and inspire students, facilitate independent thinking
- Motivate, empower students
- Communication and Interpersonal skills
- Organization and planning.
- Flexibility, adaptability
- Creativity
- Working in multicultural, multidisciplinary teams
- Group formation and functioning
- Designing projects for PBL/D-PBL
- Digital design
- Assessment practices, evaluation at different stages of the development process
- Agile methodologies
- Digital classroom management
- Audio and video editing software tools
- Active listening
- Open-minded to new learning approaches

2. Indicate your level of agreement with the following statement for each one of the activities below. (use the following scale: 1 – strongly agree, 2 – agree, 3 – uncertain, 4 – disagree, 5 – strongly disagree). I agree that the activities below are adequate

ways for a teacher to learn the skills and competencies required to promote D-PBL academic activities in their classes.

- A lecture or a talk
- Infographics development
- Multimedia content development and online publication (e.g. website)
- Podcast production and publication
- Online video tutorials
- Conferences/Congresses
- Online conflict management
- Online team building
- Use of monitoring/interaction tools
- Online Workshops/Courses
- Creating a mind map, students can recall information more easily, explore and organize ideas and concepts
- Demonstration
- Exchange/visits with others using the same teaching method
- Experimental learning
- Interactive quizzes and games
- Student role playing activities
- Team working for the design of courses using common sw tools
- Podcasts production and publication
- Work on projects in hybrid environments
- Workshops in different areas like graphical design, team management, didactic content structure and design
- Creating a video project: cloud-based video creation platform, upload students work on YouTube
- Creating online content engagement focused
- Developing adaptable evaluation rubrics
- Create lesson blog
- Create lesson wiki
- Conferences/Congresses
- Online Workshops/Courses

- Reflection-upon-Practice Seminars
- Practice and experience cases in specific domains
- Face to face training
- Specific preparation meetings
- Online pdf tutorials

3. Indicate your level of agreement with the following statement in relation to each one of the reasons stated below. (use the following scale: 1 – strongly agree, 2 – agree, 3 – uncertain, 4 – disagree, 5 – strongly disagree). I agree that the reasons stated below are blocking factors that prevent teachers from exploiting youngsters' innate digital proficiency in using new technologies for the benefit of the teaching/learning processes.

- Lack of competencies with new technologies
- Lack of technological means and resources
- Lack of time to learn new tools and technologies
- Attitude, aversion to change
- High costs of learning environments
- Lack of incentives from HEI to use technology in classes
- More work, increased workload
- HEI politics and rules to rigid are barriers to technology adoption in classes
- Assessment problems related to technology use
- Lack of time and support for the use of ICT as well as for class materials preparation
- Lack of students proficiency using technology
- Technologies can affect the time of the classes
- Lifelong Learning
- Technology state (not mature)
- Difficulty of the evaluation process
- Difficulty to define PBL projects
- Huge variety of digital tools
- The actual consensual approach is still very conservative
- The fact that digital learning is not mandatory
- Attitude, fear of exposure and making mistakes

The results of this second round provided the necessary information to design the first version of the questionnaire. This first version of the questionnaire was validated by the pool of experts at the third round of the Delphi study. The comments from the experts were then used to fine tune the questionnaire and get to its definite version.

The final version of the questionnaire (**Error! Reference source not found.**) has 18 questions, 15 of which derived from DigCompEdu. The remaining questions are meant to assess individual blocking factors and preferred ways of learning; these are critical to be able to propose a personalized training path.

Table 1

D-PBL questionnaire

Source	Area	Question	Recommendation for low performance	Scale
Descoped	1 - Professional Engagement, collaboration	I use digital channels and technologies to work together with students and colleagues inside and outside my educational organisation	participate in online training opportunities, e.g. online courses, MOOCs, webinars...	1 to 5
DigCompEdu	2 - Digital Resources, search strategies	I use different internet sites and search strategies to find and select a range of different digital resources	start using internet to solve simple tasks requiring one single app; evolve to harder tasks requiring the use of several apps/sites and integration of features/data	1 to 5
DigCompEdu	2 - Digital Resources, editing resources	I create my own digital resources and modify existing ones to adapt them to my needs	suggest specific training opportunities (video tutorials, MOOC, ...) adequate for several levels of proficiency	1 to 5
DigCompEdu	3 - Teaching and Learning, value creation	I carefully consider how, when and why to use digital technologies in class, to ensure that they are used with added value	analyse best practices, case studies	1 to 5
DigCompEdu	3 - Teaching and Learning, monitoring interaction	I follow-up my students' activities and interactions in the online environments we use	suggest specific training opportunities (video tutorials, MOOC, ...) adequate for several levels of proficiency	1 to 5
DigCompEdu	4 - Assessment, tracking progress	I use digital assessment formats to evaluate student progress	analyse best practices, case studies; list of possibilities/tools to do it	1 to 5
DigCompEdu	4 - Assessment	(feedback) I use digital technologies to provide effective feedback	analyse best practices, case studies; list of	1 to 5

			possibilities/tools to do it	
DigCompEdu	5 - Empowering Learners	(personalised learning opportunities) I use digital technologies to offer students personalised learning opportunities and promote their active participation in the class	analyse best practices, case studies	1 to 5
DigCompEdu	6 - Facilitating Learners' Digital Competence	(communication and collaboration) I set up assignments which require students to use digital means to communicate and collaborate with each other or with an outside audience	suggest specific training opportunities (video tutorials, MOOC, ...) adequate for several levels of proficiency	1 to 5
DigCompEdu	6 - Facilitating Learners' Digital Competence	(safe and responsible behavior) I teach students how to behave safely and responsibly online	suggest specific training opportunities (video tutorials, MOOC, ...) adequate for several levels of proficiency	1 to 5
DigCompEdu	Questions about you	Age (under 25, 25-29, 30-39, 40-49, 50-59, 60+, prefer not to say)		select one
DigCompEdu	Questions about you	Study field, more than one is possible (mother tongue, foreign languages, mathematics, physics, chemistry, biology, geography/geology, computer science, history, social science, political science, economics, visual arts/design, music, drama, physical education, religious studies, philosophy/ethics, I do not teach, prefer not to say, other-specify)		select many
DigCompEdu	Questions about you	Which digital tools have you already used for teaching and learning? (presentations, watching videos/listening to audios, creating videos/audios, digital quizzes or polls, interactive apps or games, digital posters/mindmaps/planning tools, blogs or wikis, I have not yet used, prefer not to say)	develop your skills and competences in the tools not used	select many
DigCompEdu	Questions about you	I find it easy to work with computers and other technical equipment (1-5)	start using computers to solve simple tasks using simple/user-friendly/fun tools; progress to other tasks and other tools	1 to 5
DigCompEdu	Questions about you	I use the Internet extensively and competently (1-5)	start using internet to solve simple tasks requiring one single app; evolve to harder tasks requiring the use of several apps/sites and integration of features/data	1 to 5

D-PBL	3 - Teaching and Learning	My proficiency level in the following skills and competences is:	list of competences [round2 skills] (round2, question 1 alternatives) [other (specify); suggest ways to overcome each one of them	1 to 5 for each one
D-PBL	3 - Teaching and Learning	I prefer the following activities to learn the skills and competences required to promote D-PBL academic activities in my classes.	list of activities [round2 activities] (round2, question 2 alternatives) [other (specify); suggest ways to overcome each one of them	select many
D-PBL	3 - Teaching and Learning	I find the following to be blocking factors preventing me from exploiting youngsters innate digital proficiency during my classes	list of blockers [round2 blockers] (round2, question 3 alternatives) [other (specify); suggest ways to overcome each one of them	select many

1.2. EAD TRAINING TOOLKIT/COURSE FOR TEACHERS

The Erasmus+ project *D-PBL* (Digital Project-Based Learning) has introduced an innovative approach to teaching and learning by equipping educators with the tools they need to foster a collaborative, student-centered learning environment. A core component of the project is the *EAD Training Toolkit/Course for Teachers*, designed to enhance educators' abilities to integrate digital tools into their teaching practice and implement project-based learning (PBL) strategies in the classroom. This toolkit serves as a practical guide for teachers who want to empower their students through dynamic, real-world learning experiences.

What is the EAD Training Toolkit/Course?

The *EAD Training Toolkit/Course* is an online educational resource designed specifically for teachers to help them understand and apply the principles of Project-Based Learning (PBL) in combination with digital technologies. Developed as part of the *D-PBL* Erasmus+ project, the course provides teachers with a comprehensive set of resources, instructional strategies, and hands-on activities that can be used to integrate PBL methodologies into the classroom. The toolkit not only focuses on pedagogical best practices but also emphasizes how to use digital tools to enhance the learning experience.

Key Objectives of the EAD Training Toolkit

The primary goal of the *EAD Training Toolkit* is to provide teachers with the knowledge, skills, and confidence they need to:

- **Understand and implement PBL:** Teachers are introduced to the principles of Project-Based Learning, a student-centered pedagogy that encourages critical thinking, collaboration, and real-world problem-solving.
- **Integrate digital tools into teaching:** The toolkit explores how digital technologies can enhance PBL by providing platforms for collaboration, communication, and research. This includes the use of multimedia tools, online platforms, and digital resources that align with modern teaching and learning practices.
- **Enhance collaborative learning environments:** The course offers strategies for fostering a collaborative and inclusive classroom environment where students can work together on long-term projects, research tasks, and creative assignments.
- **Promote active learning:** By focusing on hands-on, problem-solving approaches, the toolkit helps educators move away from traditional teaching methods and engage students in active, experiential learning.
- **Support students' digital literacy:** In line with the goals of the Erasmus+ project, the toolkit helps teachers develop their students' digital competencies, preparing them for success in an increasingly digital world.

Structure and Content of the Course

The *EAD Training Toolkit/Course for Teachers* is designed to be flexible and user-friendly, allowing teachers to navigate it at their own pace. The course is divided into several modules, each focused on a specific aspect of Project-Based Learning and the use of digital tools:

1. **Introduction to Project-Based Learning (PBL):** This module covers the fundamental concepts of PBL, including how to design and implement PBL projects in the classroom, and how to assess students' learning through projects.
2. **Digital Tools for PBL:** Teachers learn about various digital tools that can support PBL, such as online collaboration platforms, multimedia creation tools, and virtual environments. The module includes hands-on tutorials to help teachers familiarize themselves with these resources.
3. **Designing a PBL Project:** In this section, teachers are guided step-by-step through the process of designing a PBL project, from identifying learning objectives to creating project tasks and assessment criteria.

4. **Facilitating Collaboration and Communication:** This module provides strategies for fostering effective communication and collaboration among students, both in face-to-face and online settings, using digital tools like Google Classroom, Padlet, and Slack.
5. **Assessing PBL Outcomes:** Teachers are taught how to assess students' progress and learning outcomes in a PBL setting, with a focus on both formative and summative assessments. This includes peer assessments, self-assessments, and teacher evaluations based on project milestones.
6. **Incorporating 21st Century Skills:** This section emphasizes the importance of teaching skills such as critical thinking, problem-solving, communication, and collaboration, which are central to both PBL and the digital world.
7. **Reflection and Continuous Improvement:** Teachers are encouraged to reflect on their own teaching practice and how they can continuously improve their approach to using PBL and digital tools.

Training is a vital skill for personal and professional development, but how do you create a training toolkit that suits your needs and goals? A training toolkit is a collection of resources, methods, and tools that help you plan, design, deliver, and evaluate training activities. In this part of the project, participants learned how to build a training toolkit that works for teachers and students, whether you're a trainer, a learner, or both.

The guide “How to create the training toolkit”:

1. Assess your needs and goals.

The first step to building a training toolkit is to assess your needs and goals.

2. Choose your methods and tools.

The next step is to choose the methods and tools that best fit your needs and goals. There are many types of training methods, such as lectures, demonstrations, simulations, case studies, games, and quizzes. Each method has its advantages and disadvantages, depending on the topic, the audience, and the learning outcomes. Similarly, there are many tools that can support your training, such as books, videos, podcasts, slides, worksheets, surveys, and apps. You'll need to consider the availability, accessibility, and affordability of these tools, as well as how they enhance or complement your methods.

3. Organize your resources.

The third step is to organize your resources in a way that makes them easy to find, use, and update. You can use different formats and platforms to store and share your resources, such as folders, files, cloud services, websites, or learning management systems. You'll also need to label, categorize, and index your resources, so that you can quickly locate

and retrieve them when you need them. Additionally, you'll need to review and update your resources regularly, to ensure they are relevant, accurate, and current.

4. Apply your toolkit.

The fourth step is to apply your toolkit in your training activities. This means using your methods and tools to plan, design, deliver, and evaluate your training. You'll need to align your toolkit with your needs and goals, and adapt it to different contexts and situations. You'll also need to test and refine your toolkit, to see what works and what doesn't. Furthermore, you'll need to seek feedback and input from your audience or learners, to improve your toolkit and your training.

5. Learn from others.

The fifth step is to learn from others who have built or used training toolkits. You can find inspiration, ideas, and tips from other trainers, learners, experts, or peers. You can also join communities, networks, or groups that share your interests or goals. You can access online or offline sources of information, such as blogs, podcasts, webinars, books, or courses. You can also participate in events, workshops, or conferences that showcase or discuss training toolkits.

6. Keep learning and growing.

The final step is to keep learning and growing as a trainer or a learner. Building a training toolkit is not a one-time project, but a continuous process of exploration and improvement. You'll need to update your toolkit as your needs and goals change, as well as the training methods and tools evolve. You'll also need to challenge yourself to try new things, experiment with different approaches, and learn from your successes and failures. By doing so, you'll create a training toolkit that works for you and helps you achieve your desired outcomes.

This toolkit includes user manuals (in video and e-book format) covering all technical, pedagogical, and behavioural features concerning distance learning. This output allows the targets of the training actions – teachers/lecturers – to later use the digital cells and apply the PBL in class context. The first stage is necessary to select the materials to be included in the toolkit and to design the learning contents format. Meanwhile the participants have selected based on the previous stage check-up. The teaching materials are developed and made available through an e-platform with easy access to the learners. The EAD toolkit is the main support tool for the piloting phase and available in English and in all the partners' languages, facilitating its appropriation by a wider number of HEIs in the partner's countries and at European level.

Based on the deliverables of R1, researchers (all partners) discussed the topics and materials to be included in the toolkit. Each partner pre-selected candidates. Final decisions were taken by the researchers (1 tutor selected per partner country), based on their expertise and according to the results of the survey of R1. Additional experts were invited to contribute to the creation of specific modules of the course material. The selected tutors draft the teaching materials will be included in the program. The learning contents of modules of the program translated in the partners' languages. E-learning experts and instructional designers will design the platform and multimedia content. The Moodle-based platform will allow the students to study and download the contents (ePub and PDF), ask questions and make comments to the teachers and researchers. The teachers will monitor the activity of the students and evaluate them in the virtual classroom.

Benefits for Teachers

The *EAD Training Toolkit* offers several key benefits for educators:

- **Professional Development:** By completing the course, teachers enhance their digital competencies and gain valuable pedagogical skills in PBL, which can have a direct impact on their classroom practice.
- **Student Engagement:** The toolkit helps teachers create more engaging and interactive learning experiences, which can increase student motivation and involvement in their learning process.
- **Collaboration with Peers:** Teachers are encouraged to collaborate and share ideas with other educators, creating a professional learning community that supports ongoing development.
- **Increased Digital Literacy:** Teachers themselves become more digitally literate, better equipped to integrate technology into their teaching practice and help their students develop the necessary digital skills for the future.

Impact on Students

By equipping teachers with the tools and knowledge to effectively implement PBL with digital technologies, the *EAD Training Toolkit* has a direct and positive impact on students:

- **Real-World Problem Solving:** Through PBL, students engage with real-world issues and challenges, which fosters critical thinking and problem-solving skills.
- **Increased Collaboration:** Students learn to collaborate with peers, both in-person and online, which helps build teamwork and communication skills.

- **Enhanced Digital Competence:** As teachers incorporate digital tools into PBL projects, students are exposed to new technologies and learn how to use them effectively, boosting their digital literacy.
- **Personalized Learning:** PBL allows students to take ownership of their learning, pursuing projects that interest them while developing key skills that are relevant to their future careers.

Conclusion

The *EAD Training Toolkit/Course for Teachers* from the Erasmus+ *D-PBL* project represents an important step in modernizing education and empowering teachers to use innovative approaches like Project-Based Learning and digital tools. By offering a comprehensive training experience, the course not only enhances educators' skills but also benefits students by creating more engaging, interactive, and meaningful learning experiences. As education continues to evolve, resources like the *EAD Training Toolkit* are crucial in preparing both teachers and students for the demands of the digital age and the future workforce.



1.3. ARCHITECTURE OF DIGITAL D-PBL CELLS

In the ever-evolving landscape of education, the integration of digital tools with Project-Based Learning (PBL) is a promising avenue to create dynamic, student-centered learning environments. One innovative approach to implementing this integration is through the architecture of Digital D-PBL Cells. These cells serve as the backbone of a transformative pedagogical model that combines digital technology, collaborative learning, and real-world problem-solving. The concept of Digital D-PBL Cells is gaining traction, especially within educational projects like those supported by Erasmus+, as they aim to revolutionize how students engage with content, collaborate, and develop essential 21st-century skills.

What Are Digital D-PBL Cells?

The term Digital D-PBL Cells refers to a modular framework used in the Digital Project-Based Learning (D-PBL) model. These “cells” are digital learning environments or platforms where students can collaborate on real-world projects,

share resources, access digital tools, and engage in meaningful learning experiences. These cells are interconnected within a larger digital ecosystem, enabling dynamic interactions not only within a classroom but also across geographic and disciplinary boundaries.

Each D-PBL Cell is designed to encourage critical thinking, creativity, and collaborative problem-solving, drawing on the strengths of digital tools and technologies. The architecture of these cells allows for the seamless integration of educational content, digital collaboration platforms, and tools for assessment, creating an immersive and flexible learning environment.

Key Components of the Digital D-PBL Cell Architecture

The architecture of Digital D-PBL Cells is built around several key components that ensure an effective, cohesive learning experience:

Digital Collaboration Platforms

The core of any Digital D-PBL Cell is its collaboration platform. These platforms allow students to work together, regardless of location, fostering teamwork and communication. Tools like Google Classroom, Microsoft Teams, or more specialized platforms like Padlet, Miro, and Slack can be integrated within the cell structure to enable file sharing, real-time discussions, group work, and document co-editing. These tools also help in managing timelines and organizing tasks, ensuring that every team member contributes to the project.

Virtual Learning Spaces

Virtual learning spaces within the D-PBL Cell are designed to be flexible and adaptable to the needs of different types of projects. These spaces include shared digital whiteboards, cloud storage for documents and resources, video conferencing for meetings, and collaborative coding or prototyping environments. These spaces facilitate continuous communication, knowledge sharing, and collective decision-making. They can be further customized with project templates or task boards that streamline project management and task delegation.

Digital Tools for Research and Creation

A critical feature of the D-PBL Cell is access to a variety of digital tools that support the research, creation, and presentation aspects of project-based learning. These tools include digital databases, simulation software, graphic design tools, programming environments, and data analysis tools. For instance, in a science-based project, students may use digital lab simulators or data analysis software, while in an

art and design project, they may use graphic design platforms like Adobe Suite or Canva. This access allows students to conduct research, analyze data, and present their findings in innovative and engaging ways.

Learning Analytics and Assessment Tools

Assessment is an integral part of the D-PBL Cell architecture. In addition to traditional assessment methods, learning analytics platforms are embedded to track student progress, monitor collaboration efforts, and assess the quality of individual contributions. These platforms provide real-time feedback, allowing teachers to offer targeted support where needed. Tools like Google Forms, quizzes, rubrics for peer assessments, and automatic grading systems can be part of the assessment architecture, ensuring transparency and fairness.

Digital Resource Repositories

Within each D-PBL Cell, students have access to a digital repository of resources, such as e-books, research articles, instructional videos, case studies, and project-specific guides. These resources are curated by teachers and available to students at any time, ensuring they can access the information they need to advance their projects. These repositories are typically integrated with content management systems (CMS) or digital libraries, offering organized and searchable collections that support learning.

Teacher Facilitation and Monitoring Dashboards

The D-PBL Cell also includes tools for teachers to facilitate and monitor student progress. Teacher dashboards provide real-time access to project timelines, team activities, and student participation. These dashboards allow educators to track individual contributions, provide personalized feedback, and adjust their teaching strategies accordingly. The teacher's role is not to deliver content directly but to act as a guide, supporting students in the project process and ensuring the learning goals are met.

Interdisciplinary Connectivity

One of the most significant advantages of Digital D-PBL Cells is their capacity to facilitate interdisciplinary learning. Projects often span multiple subjects and require students to draw on a broad range of skills and knowledge. The architecture of the D-PBL Cells supports this by allowing students to connect with peers, mentors, and experts from different disciplines. Virtual collaboration with external experts,

organizations, or institutions is encouraged, fostering a more holistic, global perspective on problem-solving.

Advantages of Digital D-PBL Cells in Education

The integration of digital tools within the D-PBL Cells framework offers several distinct advantages:

1. Increased Collaboration and Communication

By breaking down geographical barriers, Digital D-PBL Cells enable students to collaborate with peers from around the world, fostering a global learning community. Digital platforms enable seamless communication, enabling students to work together more effectively, exchange ideas, and provide peer feedback.

2. Enhanced Problem-Solving Skills

The project-based learning approach nurtures students' problem-solving skills by challenging them to address real-world issues. The digital aspect of D-PBL Cells further enhances this by providing access to vast amounts of information and advanced tools to test hypotheses and prototypes.

3. Real-World Connections

The architecture of the D-PBL Cells fosters an authentic learning environment by incorporating real-world challenges and connecting students with external experts. These connections make learning more relevant and meaningful, helping students understand how their academic work connects to the broader world.

4. Personalized Learning

Digital D-PBL Cells offer the flexibility to cater to individual learning preferences and paces. Through adaptive tools and continuous feedback, students can pursue projects that match their interests and strengths, promoting a more personalized learning experience.

5. Scalability and Flexibility

The modular nature of Digital D-PBL Cells means that they can be scaled up or down depending on the class size, project complexity, and learning objectives. The architecture can easily accommodate large, interdisciplinary projects or smaller, more focused assignments, ensuring flexibility in teaching and learning.

Students communicated with other group mates that are distant and with the hosts in the company, always supervised by the academic advisor. The purpose of R3 is to achieve the optimal D-PBL room, i.e. the respective furniture, layout, decking, circulation, and hardware, software and computing accessories. Needs analysis

something that we already are certain is that traditional classrooms are not suitable for PBL, and common desktop-based ICT labs, neither. Traditional classrooms' furniture, layout and circulation were designed and arranged for the student working independently and to support the one-sense flow of the information from the lecturer towards the student. Similarly, traditional desktop-based ICT labs were designed for the individual student work. However, the D - PBL concept is the opposite: students should work in small groups, some of the group mates are physically close, but most of them are working distantly, in other countries, even in the other side of Europe. And the hosts in the companies too. Also, the center of the learning process is the student, which means that the flow of information reverses the traditional. The previous experience at ISMAI while applying EAD in pilot courses swiftly taught us that lecturer's positioning matters. There are students in the room, there are students outbound, the whiteboard is useless and it is quite easy to lose direction (Silva, M. V. d., Gonçalves-Seco, L., & Marques dos Santos, J. P. (2019, December, 18-19). The DTL/EAD project: synchronous classes with outbound students extensively participating through digital technologies. Paper presented at the IV Virtual International Conference on Education, Innovation and ICT, Virtual). These classes are "directionless" and require a 360° approach from the lecturer. It points to be the 2PI-classroom. Therefore, the D-PBL concept needs suitable rooms that meet its functioning and particularities, and such rooms have to be created. Such rooms will accommodate several individual groups and the necessary paraphernalia, which we call the cell, the D-PBL cell. A set of cells compose the D-PBL room. Target groups The target groups are students and lecturers, as they will work together in the cells and rooms. Elements of innovation It would be difficult to accept that innovative active pedagogies would be independent of the places where they come to action. Indeed, the places and their arrangement must suit and support the innovative approach and should be designed purposefully. At this time the D-PBL cells and rooms do not exist, and are to be created in this Result. Expected impact much like the "thing" that is built in a Project-Based. Learning course, we expect that the conception of the cell and the arrangements of cells in the room are the "thing" of the D-PBL project. "Things" are important, as they translate into a visible and tangible collection of objects and place the underlying concepts of the project. Also, the D-PBL cells and room may be visited, either physically or online, improving the impact of the idea. Transferability potential The drawings, contents, and description of the usability of the D-PBL cells and room will be fully transferable and replicable in

other places, mainly HEIs. The preference for inclusion of common, affordable and environmentally friendly materials and equipment will be present all the time in order to maximize the transferability of the outcomes.

Project-based learning (PBL) and group discussion rooms demand flexible spaces. In such cases all furniture must be equipped with wheels, so changing to a different layout is easy. Figure 1 portrays one possibility, keeping a table for the lecturer, video projector, whiteboard and abundant flipcharts. Remark the tables and seats further apart from the lecturer's table are taller. Although this room is not directionless, it adapts easily to other configurations, as in the example of Figure and Figure . These examples represent a possible simulcast lecture or even a traditional one.



Figure 1. Steelcase's layout for a PBL room



Figure 2. Adaptation of the PBL room for a simulcast lecture (bird view)



Figure 3. Adaptation of the PBL room for a simulcast lecture (floor view)

Conclusion

The architecture of Digital D-PBL Cells represents the future of education, where digital technology, project-based learning, and collaboration converge to create a rich and engaging learning experience. By providing students with the tools they need to collaborate on real-world projects and develop critical skills, these cells prepare them for success in the digital age. As the educational landscape continues to evolve, the use of D-PBL Cells will play a key role in shaping a generation of innovative, adaptable, and globally minded learners. Through the seamless integration of digital tools and collaborative learning structures, the architecture of Digital D-PBL Cells offers a new paradigm for educational excellence.

2. REFLECTIONS ON LESSONS LEARNED

This task is implemented following the framework developed in framework of the guidelines. In accordance with agreed methods, procedures and deadlines defined in the framework, partners collected information on good practices, problems, and challenges, using the developed project outcomes. Each phase of the project had its own challenges for each project partner. Table 2 shows the strengths and weaknesses of some of the partners' phases of the project and comments on them.

Table 2

Partner	Strengths	Weaknesses	Comments
Question	What problems or challenges did you encounter during the research (questionnaire survey)?		
UFV (Spain)	Ease of adapting content to levels of complexity. Part of the target audience is sympathetic to obtaining digital skills. The opening of a space for reflection for teachers to examine where they were and where they wanted to go. Teachers' involvement. The methodology used. Mixed methodology: qualitative and quantitative	Diversity of proficiency levels. Difficulty classifying content by levels of complexity Difficulty in integrating the different competencies and skills identified by the partners in the Delphi prior to the survey.	<i>"We found profiles opposed to the development of these competencies".</i>
VTDK (Lithuania)	For the implementation phase of this project, we have carefully considered which researchers will work on this project. We have selected highly experienced researchers who have worked on similar projects before and have the skills to carry out high-quality research and data analysis.	For this phase of the project, we did not have any problem sites.	<i>Insufficient number of respondents</i>
UPatras (Greece)	<u>Thorough Preliminary Research:</u> Prior to the project's initiation, we conducted an extensive review of related works. This provided us with a solid foundation and	Limited Scope: Despite our thorough preliminary research, our project may not have covered all aspects of the topic. This could limit the	<i><u>Survey Distribution:</u> Reaching out to the desired demographic and ensuring they complete the survey can be a significant challenge.</i>

	informed our approach, enabling us to conduct high-quality work.	comprehensiveness of our findings.	<i>Data Quality: Some respondents may rush through the survey or not take it seriously, affecting the quality of the data.</i>
Question	What issues or challenges did you face in gathering information for the training toolkit/storyboard materials?		
<i>UFV (Spain)</i>	The collection of information was integrated with a UFV project that was beginning to create training courses and digital skills, which facilitated the creation of content. In addition, the topics in area 5 were within the expertise of the people in charge of developing them and helped them to capture that knowledge.	The transfer of the project from one person to another at this stage brought some delays and modifications in the contents.	<i>Being able to provide comprehensive training in a digital competence area and cover all levels of the digcomedu framework was a challenge.</i>
<i>VTDK (Lithuania)</i>	We have worked quite hard on the development of this product, improving our competences in many areas. We have shared some of the knowledge and competences we have acquired with members of our institutional community through various events: conferences, workshops, meetings.	The platform itself is quite difficult to navigate. A lot of material, difficult to navigate to find the topic you want.	<i>We had no experience in storyboarding, so at the beginning it was very difficult to understand why so much work had to be put in and what the point of it would be. Once we had selected the necessary material and condensed it, we realised that it was a very useful tool for teachers.</i>
<i>UPatras (Greece)</i>	<u>Comprehensive Content:</u> The EAD Training Toolkit/Course for Teachers was developed after thorough research and understanding of the educational needs of teachers. <u>User-Friendly Design:</u> The storyboard materials were designed to be intuitive and easy to understand,	<u>Limited Customization:</u> The toolkit/course may not cater to the specific needs or preferences of all teachers due to its standardized format.	<u>Frequent Template Changes:</u> During the phase of collecting and creating the educational materials, the template of the format of the educational material changed several times. This could have caused

	facilitating effective learning for teachers. <u>Relevance:</u> The content of the toolkit/course was relevant and up-to-date, reflecting the current trends and requirements in education.		<i>confusion and inefficiencies in the development process.</i> <u>Engagement:</u> Ensuring the course content is engaging and holds the attention of the teachers could have been a challenge.
Question	Describe good practices, problems and challenges, using the developed outcome of this project.		
<i>UFV (Spain)</i>	The spaces already designed within the UFV for the development of learning experiences were essential to comply with this point.	We didn't detect any weaknesses in this section.	<i>At present, training is being carried out with teachers on the use of these spaces and actions are being carried out to promote them and design posters and resources for them.</i>
<i>VTDK (Lithuania)</i>	A very relevant project for today. New teaching methods are being introduced to students, and there are many more opportunities for students to study in a more convenient and innovative way. The methodological material provided in the Moodle environment for each module produced is very useful and innovative to improve the competences of both students and lecturers.	Progress in digitisation has gained momentum, but not all subjects can benefit from this kind of teaching - for example, analysing laboratory work in physics, mechatronics, or other engineering disciplines cannot be done in a purely visual way, and requires physical contact.	<i>There is a need to develop an appropriate and objective student evaluation system that assesses all competences related to D-PBL training.</i>
<i>UPatras (Greece)</i>	<u>Innovative Approach:</u> The architecture of Digital D-PBL cells represents a novel approach to problem-based learning, potentially offering more engaging and effective educational experiences. <u>Flexibility:</u> The digital nature of the D-PBL cells allows for adaptability and	<u>Limited Interaction:</u> Despite promoting collaborative learning, digital project-based learning may lack the interpersonal interactions and social dynamics present in traditional classroom settings. Physical separation and reliance	<u>Assessment and Evaluation:</u> Designing meaningful assessments and evaluating learning outcomes within the digital context can pose challenges. It's important to develop assessment

	customization, catering to diverse learning needs and styles. <u>Collaborative Learning:</u> The project promotes collaborative learning, fostering critical thinking and problem-solving skills among learners.	on digital communication tools can hinder the development of interpersonal skills, teamwork, and emotional intelligence among students. Incorporating opportunities for face-to-face interaction or synchronous communication can help mitigate this limitation and foster a sense of community within the digital learning environment. <u>Learning Curve:</u> Transitioning to a digital project-based learning environment may entail a steep learning curve for both educators and students. Familiarizing oneself with new technologies, software applications, and digital workflows can be time-consuming and overwhelming, potentially impacting the efficiency and effectiveness of the learning process.	<i>strategies that align with the objectives of D-PBL cells and accurately measure students' knowledge acquisition, problem-solving skills, and collaborative abilities.</i>
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