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Specification:

Virtual Project Campus

Within the Erasmus+ KA2 Capacity Building Project (CBHE)

CompIIT – Competences for International Innovation Projects

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CompIIT

Summary

The Virtual Project Campus (VPC) is a digital infrastructure with IT tools for project management and collaboration, including eLearning courses on project management, tutorials, case studies and other supporting tools and documents. It is complemented by servers for the Armenian Higher Education Institutions (HEIs), a digital classroom for virtual collaboration and the integration into Digital Education Ecosystem (DEE) of the European Partnership in Project and Innovation Management (EuroPIM). This modern, cloud-based digital infrastructure supports cross-border development, teaching and learning in virtual communities, specifically in project-based, problem-based and challenge-based education. The VPC provides a modern, realistic and future work-place related study environment which usage will prepare students for and international, digitalized and projectized working environment by developing their project competence, their international communication competence and their entrepreneurial mindset. The VPC puts the focus on working in agile and interdisciplinary cross-border innovation projects, including the required digital literacy for using such virtual project environments. The Virtual Project Campus contains:

- IT (cloud software for project management)
- Digital Project Lab (classroom for interactive team work)
- Integration into Digital Education Ecosystem (DEE)
- eLearning Module “Project Management Tool Box”

The Virtual Project Campus will use an IT infrastructure which is similar to a professional working environment in multinational companies. It is based on the same IT infrastructure as the Digital Education Ecosystem (DEE) of the EuroPIM consortium. Most of the DEE is Open Source Software which will be transferred to the servers of the Armenian HEIs. The setup of the servers (KVM virtualization) will be the same as for other EuroPIM partners which allows joint administration and maintenance. This common configuration and setup allows an easy integration of Armenian HEIs into the cross-border DEE. Apart from project IT, the DEE also contains cross-border identity management (based on eduGAIN), an interconnected, seamless Learning Management System (LMS) infrastructure (based on Moodle, but including other LMS, too) which allows seamless access to all course from any university with the home account. The DEE is developed in a number of Erasmus and DAAD projects and hosted at IDiAL/FH Dortmund:

The DEE and the IT infrastructure of the Virtual Project Campus will be used for various purposes in education, research and management:

- for teaching how to work with it
- for students to organize their learning and group work
- for doing the cross-border innovation projects

- for the teachers, for developing the new courses in the OpenCoPs
- for any kind of cooperation between the HEIs and their partners (e.g. companies)

The IT infrastructure will be based on MS365/ Teams (own EuroPIM tentant) and Atlassian Confluence + Jira (free cloud licenses for small teams). Servers (with KVM/docker virtualization) will be set up and integrated with Nextcloud, Moodle and the DEE. All Armenian partners will be integrated into the DEE identity management and the eLearning Community Server (ECS). The HEIs will be equipped with special classrooms called “Digital Project Labs” which are equipped with computers and IT as it is used in a typical project office.

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1. Introduction

Project-based learning in higher education becomes more relevant and job-field-related if it is done in real, or at least realistic, project settings, e.g. including specific team situations or case studies from companies. Such projects are specifically valuable if they are conducted by internationally mixed student teams, best case in interdisciplinary teams. Online participation can be both more realistic and helpful in case physical mobility is not possible. Therefore, we are conducting virtual projects with cross-border student teams. Selecting the right projects and matching the right students with the relevant company cases is very important for an effective and efficient competence delivery. The project selection based on the desired competence gain, the development of a meaningful sequence of projects in order to implement an individual competence development path, the estimation of the contribution of the projects to the desired competence profile of the student, and the implementation of the projects need to be supported by digital tools and a virtual environment. This allows access to projects and company cases from different countries and an international, cross-border learning experience – best case in realistic interdisciplinary teams. This specification describes the concepts and tools for this approach and their integration within the Virtual Project Campus.

2. Concept of Virtual Project Campus

2.1. Project-oriented work in virtual settings

Conducting projects is an important element in higher education curricula – summarized as project-based learning (PjBL, also called PBL which we do not use in order to avoid mixing it up with problem-based learning). E.g. in engineering or IT education, projects are expected to deliver in addition to the technical competences also professional and global competences which are particularly relevant in today's working environments [1]. Projects train such competences in a holistic, implicit way, delivering soft skills integrated into typical engineering work. Project competence is important for graduates in IT, engineering and management. Instead of teaching it in theoretical courses, such competences are delivered by doing projects and creating relevant project situations [2]. Project situations and the selected project cases for PjBL should be as close as possible to real world situations which can be achieved either by doing the projects in real situations (work-integrated learning [3]) or by using real company cases in student's projects [4].

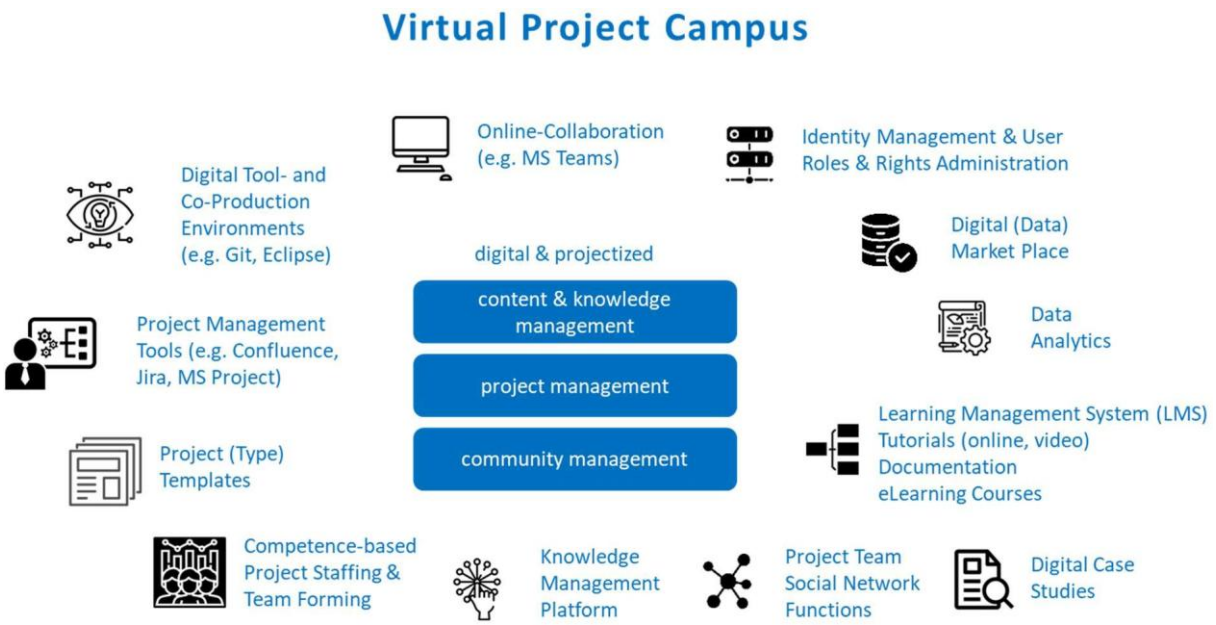


Figure 1: Overview of the components of the Virtual Project Campus (VPC)

The focus of the Virtual Project Campus (VPC) is a specific area of PjBL: cross-border projects which are conducted by internationally mixed student teams in a fully virtual online setting, using agile frameworks like Scrum (see module specification "Scrum & Kanban") which is widely used in software industry for self-managed small teams of software developers. The resulting learning settings are offering an interesting variety of project situations, especially with respect to communication and collaboration [5]. These projects are very relevant for the international educational programmes in project management, IT and engineering, e.g. as conducted within the "European Partnership for Project and Innovation Management

(EuroPIM)" [6]. While doing such projects [7] we found that there is a lack of methodology for selecting project cases and forming the student teams with respect to the intended learning outcomes, especially regarding the soft skills which are trained by doing the projects. Therefore, the underlying concepts for the forming of soft skills in projects based are part of the didactic concept. Furthermore, the selection of projects and team roles (supported by personality tests) based on intended competence gains is a relevant approach.

The Virtual Project Campus contains (but isn't limited to) these components (see. Fig. 1):

1. Identity Management and User Rights & Roles Administration: this component is based on the user service (identity management) of the DEE. It allows the registration of students, teachers and administrators from different HEIs and the assignment of roles in the VPC.
2. Online Collaboration, meaning tools for online collaboration (e.g. MS Teams, zoom, big blue button (BBB)) which is the core of the virtual cross-border collaboration.
3. Digital Tool- and Co-Production Environments: these are the tools which are used for doing the project task, not the project management tools. Within the projects, tasks based on the case study have to be performed, e.g. the development of a software, or the design of a machine component, or the development of an online course by the teachers. Such tasks require tools which can be cloud-based and available online, e.g. Git or Eclipse for software development. In addition, file repositories (e.g. Nextcloud) are provided.
4. Project Management Tools, especially cloud-based tools, for the project management tasks, e.g. Atlassian Confluence for documentation (user stories) and Atlassian Jira for ticket management (on Kanban or Scrum boards) in the case of agile project management, or MS Project in the case of traditional project management.
5. Project (Type) Templates which serve as a starting point for the different project types (see section 3.4: innovation projects, cross-border projects, startup projects). These templates contain typical project forms, e.g. a project charter, project plan templates, milestone checklists, forms for project meeting, a generic project phase model.
6. Competence-based Project Staffing and Team Forming: as described in section 3.1 the projects can be staffed with taking the existing competence and the competence-based learning outcomes of the students into account, e.g. by conducting personality tests or other assessments at the project start and assigning project roles accordingly.
7. Knowledge Management Platform: sharing knowledge in projects and between projects and making implicit knowledge in project explicit and usable is a core tasks and specifically tricky in virtual cross-border projects. The VPC can employ different types of digital knowledge management tools for this purpose.
8. Project Team Social Network Functions: organizing virtual communities can be supported by functionality known from social networks, e.g. for scheduling, chat, information exchange, forming groups, and commenting (using tools like Discord etc.).
9. Digital Case Studies can be used for providing the tasks of a virtual cross-border project. This type of information is described in detail in section 3.3.

10. Learning Management Systems (LMS) like moodle are a core component for educational activities, providing learning materials and organising teaching and learning, including competence assessment. The Virtual Project Campus uses the LMS of the Digital Education Ecosystem (DEE) to make educational resources available cross-border.
11. Digital (Data) Market Place and Data Analytics are a set of databases and data analytics tools (cloud-based) which make data-driven project execution and management possible. Typical open source data base and data analytics technology stacks (e.g. ELK, TICK) can be used for this and can be installed on the virtual servers of the DEE.

2.2. Competences & Learning Outcomes

Students in IT, engineering and management require in addition to the technical competences also professional and global competences which are particularly relevant in today's working environments [1]. Project-based learning in typical, domain-specific projects (e.g. engineering projects, innovation projects, software development projects, IT projects, etc.) develop domain-specific technical and scientific competences and inherently – as a positive side-effect – also professional and global competences, e.g. interdisciplinary, international and intercultural skills (3 x "i"), communication and language skills, and other so-called "soft skills". This inherent competence acquisition can be amplified and controlled by creating and facilitating learning situation which are tailored to such competence development, specifically by setting up projects and projects teams in which students can experience and learn such competences.

Considering the acquisition of soft skills through teamwork and learning experiences connected with team collaboration and communication links the PjBL concept to the professional world and future work situations of graduates which inherently leads to the development of more complex competences [8]; by competence authors mean "knowledge, know-how and knowledge to be", which enables people to acquire and develop skills at individual and professional level. In their conceptualization, [9] distinguish between soft skills and competencies, where skills branching to soft and hard skills belong to a higher construct as competencies. The authors highlight that development of competencies and soft skills depends on interaction between individual traits like personality and abilities as well as contextual factors.

Although various studies have defined soft skills in different ways, there appears to be consensus that individual personality play a major role in influencing soft skills. [10] defined soft skills as a combination of the abilities, attitudes, habits, and personality traits that allow people to better perform in their workplace, complementing the technical skills required to do their jobs and influencing the way they behave and interact with others. Several factors can influence a person's personality like individual attitudes, behavioral habits, personality traits and their individual competences (abilities). The Big Five factor model represents a broad set of traits that are a collection of many facets; these are (i) neuroticism, (ii) extraversion, (iii) agreeableness, (iv) openness to experience and (v) consciousness [11].

3. Project-based Education on the Virtual Project Campus

3.1. Didactic Concept

In order to support the implementation of realistic projects with industry, e.g. in a virtual cross-border Master School, according to our research and experience [23], several core methods and tools are required:

1. It is desirable that a student project with a company from one country can be done by a virtual cross-border team with students and teachers from several countries by using online collaboration and digital project tools and platforms. Such a learning setting is very similar to many international projects in industry, using agile and digital processes and tools. It trains inherently not only the technical competence but also the professional and global competence of students. It requires an elaborated cross-border IT infrastructure which was implemented and tested by EuroPIM in the past. We call this cross-border digital learning and teaching infrastructure a "Digital Education Ecosystems (DEE)" [20]. Apart from cross- coupled learning management (Moodle, ILIAS) and collaboration (MS Teams, Big Blue Button) systems with a cross-border identity and user management systems, the DEE includes management apps (for students and teachers), file sharing and collaboration tools, especially for conducting projects.
2. To ensure the desired learning outcomes, it is important to define the competence profile of the students before and after the project and their desired competence profile at the end of the educational programmes. Based on the type of the projects and company cases and based on the learning setting and the composition of the student team, a competence gain can be assumed which we try to determine.
3. In order to support students and teachers in selecting the right projects and in order to map students to projects and company cases which are relevant for them, it is important to provide a tool for planning the individual student journey based on a sequence of projects with the desired competence delivery. For this purpose, the student journey configurator (SJC) tool of EuroPIM [21] can be adapted and used. It is used to build the right sequence of projects for the desired overall competence gain.

For our didactic model for competence development by doing selected projects (see Fig. 2) we assume, that we have a pool of projects (A, B, C) which are linked to company cases (A, B). They are forming a "Virtual Project Campus" where teachers and students can select projects which they want to do. During their studies, we assume that students are conducting a sequence of student projects (see Fig. 2, project A, B, C) and that the projects are categorized by project type (see Fig. 2, type 1, 5, 7), e.g. as agile innovation projects, digital transformation projects, international team projects, customer-centric projects. Based on this, typical sets of competences are defined which are trained while doing such projects (and by conducting related educational activities, e.g. team trainings, intercultural trainings). The project types are connected with a certain set of technical challenges and requirements, same

as soft factors which are typical for such projects. These soft factors define the soft skills which are needed and which are trained by the projects. The soft factors are derived from anticipated project situations (e.g. communication settings, potential conflicts) which are connected with the team roles and team situations which occur in such types of projects. In connection with the relevant technical competences, this forms the competence delivery (ΔCP) achieved by using the projects in PjBL settings. The accumulation of competences (see right part of Fig. 2) leads to the desired competence profile CP(t_n) of the graduates of the participating educational programmes.

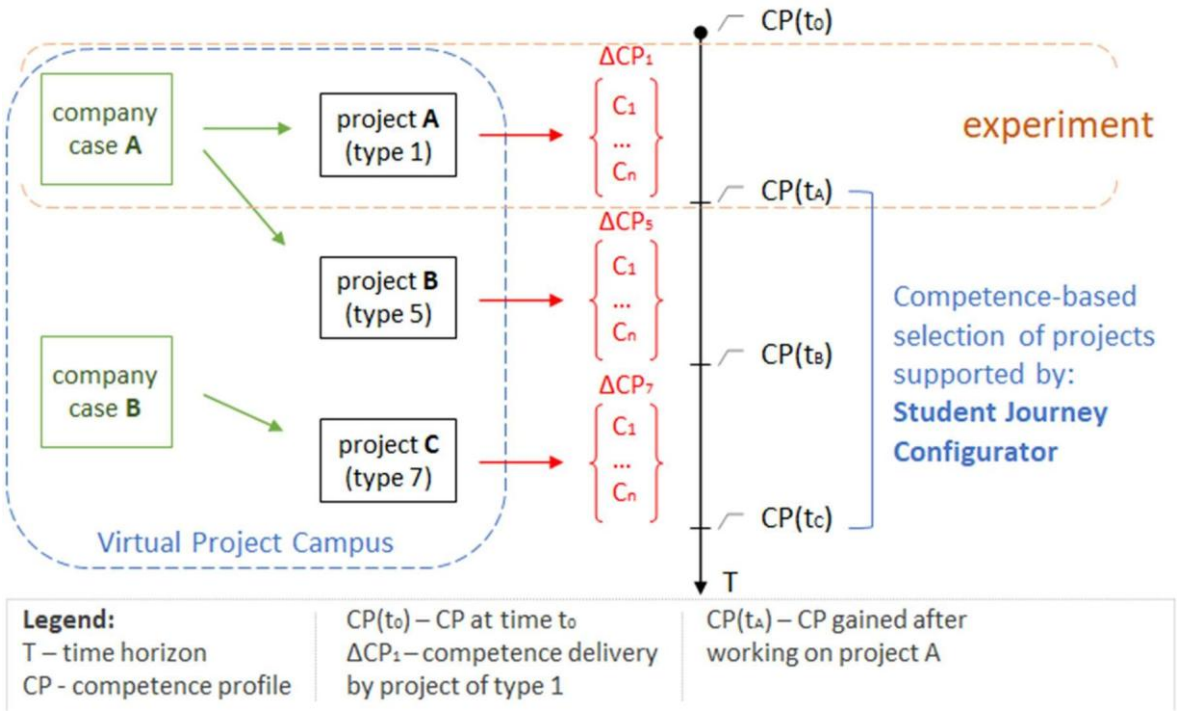


Figure 2: Model of the competence-based selection of projects and team roles for PjBL [23]

Example of applying the didactic concept:

In this setting, we are developing a guideline on how to construct (or select) project cases and how to form student teams based on the intended learning outcome, specifically looking at the soft skills. As an example, we refer to the development of a mobile app in teams of 4-5 students (mixed from two different countries) which was conducted in agile sprints, using the scrum method, in a 100% online setup [24]. This format was conducted and evaluated several times within the EuroPIM partnership.

The scrum project foresees individual work of the students and collaboration is happening only in specific team situations, the so-called scrum ceremonies. The scrum ceremonies are the relevant learning situations with respect to soft skills. In addition, this type of project foresees only 3 team roles: the scrum master who is a process-focussed facilitator and coach, the product owner who is a result-focussed driver and shaper, and the team members who are considered to be a group of equals. Therefore, the scrum ceremonies can be considered as

tasks (see Fig. 3) which contain specific team situations (see description of the 5 ceremonies in Fig. 3) which are connected to specific soft skills (see [24]).

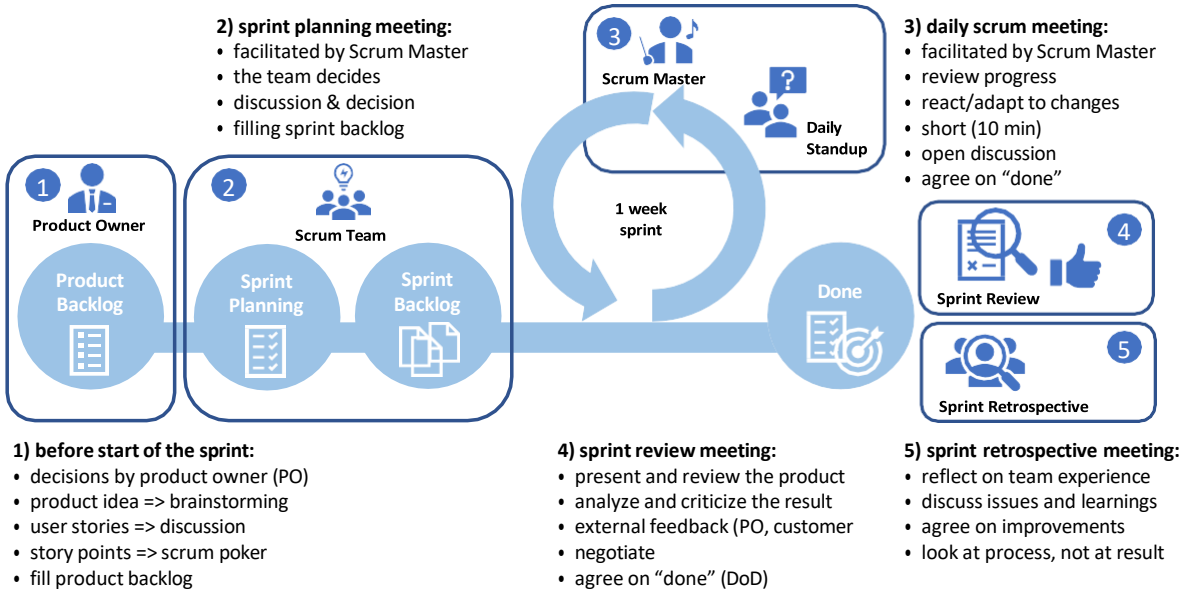


Figure 3: Analysis of the 5 scrum ceremonies regarding team situations and team roles [24]

Based on the experience, we propose a 5-step approach [22] for designing international and interdisciplinary cross-border projects where students from different back-grounds and cultures can train technical, professional and global competences.

1) Before the course:

- Based on the planned learning of the course, define a possible case study to stimulate a relevant project scenario (preferably with industry involvement, e.g. the development of a mobile app as in [24])
- Define the list of project tasks to be performed by the team within the course => Tasks will determine the roles of the team members => in case of the scrum project (Fig. 3) these are the 5 scrum ceremonies and the 3 scrum roles which are part of the project.
- Design a self-evaluation questionnaire for the students to assess their soft skills before doing the course (e.g., as a catalogue of soft skills, the list provided by Matturro et al. [10] can be used; questions may be adapted from [19]) => initial profiles of students
- Based on the required team roles, define which students will be assigned to a specific team and which role each student may perform in order to fulfil the project tasks □ this is an initial assignment which will be refined at the beginning of the course
- Plan the intended learning outcomes based on the initial profiles of the students and the anticipated project (learning) situation during the project

2) At the beginning of the course:

- Perform a team building exercise with each student team in order to define the set roles for the project => build a balanced team (based on personality traits assessment [11] or Belbin's role theory [15])
- Invite company representative to provide the case => create a realistic project kick-off situation (e.g. in the discussion of user stories, see (1) in Fig. 3)
- Reflect with students on the experience during team building and project kick-off and ask them to refine their self-assessment

3) During the course

- Provide students with project management methodology => training of technical competence (e.g. a scrum training and test)
- Provide students with tailored soft skills trainings and knowledge
- Project work in cross-border (cross-cultural) teams => training of global and professional competences
- If required, conduct team exercises, e.g. for conflict resolution

4) At the end of the course:

- Organise reviews (e.g. pitches, feedback sessions) with company representative □ training of professional competence
- Assess the quality of the project results => evaluation of technical competence (e.g. in the sprint review in Fig. 3)
- Conduct the self-evaluation survey on acquired soft skills => evaluation of the soft skills gap closed during the course

3.2. Educational Resources

Educational Resources provided in the LMS in connection with the VPC are:

- eLearning Module "Scrum & Kanban" (5 ECTS)
- eLearning Module "Agile Management in Virtual Project Environments" (5 ECTS)
- eLearning Module "Project Management Tool Box"
- eLearning Module "Communication for international project management" (10 ECTS)

The description of the content of the educational resources can be found in the respective module specifications. The content of the modules can be found in the LMS.

3.3. Digital Case Studies

Case-based learning is widely used for teaching in a single scientific domain but not very much elaborated and mature for interdisciplinary student teams. The main challenge is to design case studies which contain both domain specific, intradisciplinary research problems and elements which require interdisciplinary teamwork. Both aspects need to have a sufficient depth to be relevant in higher education and digital case elements integrated where possible to simulate a real-world context behind the case problems. For a realistic and complex learning

set-ting, the case should be derived from real industrial problems which allows company cooperation and challenge-based learning approaches. As an interesting add-on, the cases should support the work in virtual cross-border projects which involves approaches used in Collaborative Online International Learning (COIL) settings. Designing, validating, using, and evaluating such case studies requires an elaborated approach going beyond traditional case writing. In [23] we present (1) the methodology of deriving the real, in-depth case studies supported by digital elements and (2) the guideline on writing-up such case studies, both validated by interviews with industry partner(s), academic experts, and students in (international) Master's programmes in industrial engineering, informatics and business studies.

Based on real industry cases, the complexity of such case studies goes beyond the typical one-dimensional, simplified, and well-structured cases studies typically used in business education. Instead of leading students to an already known solution, the more complex real- world cases offer unsolved and only partly pre-defined case problems which need explorative work and real research. With this contribution we develop the case method further towards cases which require interdisciplinary teams for problem-solving and which create realistic work-place-relevant learning settings, including transdisciplinary work with the business environment outside academia. Key requirements for such case studies are:

1) The case needs to be derived from a recent, mainly unsolved problem in a company which offers the required complexity while allowing to derive one or several case problems from it which are usable in research and education. This requires an elaborated approach for case research and development.
2) The case needs to contain at the same time intradisciplinary and interdisciplinary case problems and research questions. The intradisciplinary research questions allow the required depth for training domain experts on Master's level. The inter-disciplinary research questions require a collaboration of the domain experts and create the relevant learning settings for realistic and authentic project-based education. Both aspects can be used in one learning setting or individually.
3) The case needs to contain all the data and material required to research on it, going beyond the typical textual description in classical business cases which are an abstraction and simplification.

Digital Case Studies in our understanding are case studies:

- which can be used for problem-, project- and challenge-based learning,
- which can be used for research and for learning,
- which can be used in disciplinary activities, but specifically also in interdisciplinary activities, e.g. interdisciplinary student projects,
- which can involve companies for transdisciplinary research and learning,

- which are represented by digital means (e.g. eLearning material, online descriptions, videos, data, tools) which enable the use in Online Collaborative Learning (or synonymously used terms), specifically in cross-border, international settings (Collaborative Online International Learning – COIL),
- which have different levels of complexity, specifically for usage in Master's education, with a focus on less structured cases with unknown results and open, un-solved research questions,
- which are developed in a modular way, enabling a tailoring to a specific need.

Based on the requirements and the process of case writing and teaching, the following elements should be part of a digital case study (specification):

1) Case description: this is a (textual) introduction and summary of the case, employing storytelling techniques.
2) Context and environment of the case, used for scoping and setting boundaries of the relevant content of the case (not the teaching environment)
3) Purpose of use of the case study: this aspect describes how and for whom the case may be used in research and teaching.
4) Research problems & learning tasks, an outline of potential research problems and learning tasks contained in the case, using different complexity levels
5) Research plan(s): outlines of potential research plans and scenarios (if such ex-ist) (can be provided to learners or kept visible only for the teachers)
6) Media and documentation, which include but are not limited to:
   a) written text (documents), images (graphics),
   b) multimedia content,
   c) tutorials and guidelines,
   d) original (or anonymized) documents (e.g. from companies),
   e) scientific literature (methods, scientific state-of-the-art-SotA),
   f) (raw) data, refined data & statistics, models, programmes,
   g) IT tools & software (data analytics, simulation), tool chains, databases, and repositories,
   h) virtual lab, virtual instruments,
   i) videos (e.g., interviews, machines, scenarios),
   j) Virtual Reality/Augmented Reality (VR/AR) experience.

Learners and researchers can be encouraged to create an original experience (e.g. company visit, expert discussion, VR/AR experience), own field research (observation, measurement, interviews, surveys), own experiments etc.

7) Literature repository, on the methodology, (SotA)
8) Assessment & evaluation, e.g. exams, tests, evaluation of the learning experience

9) Teamwork & project management: literature, guidelines, tutorials and tools for learners and researchers for organizing their work, e.g. in project-based learning.

3.4. Project Types

Part of the innovative core of CompIIT is the development of the different types of projects which will be offered to the students. The characteristics of these projects are as follows:

- Projects will be done on realistic cases, best case provided and supervised by companies. This fosters industry-university cooperation since companies can bring their real problems and benefit from an agile, fresh and dynamic mindset in student teams. Company staff can join the project in the role of the customer, the jury (e.g. pitches) or even as a team member.
- Projects are inherently interdisciplinary since the problems will require mixed competences, e.g. IT, engineering and business. Therefore, student teams will be mixed from different programmes.
- Projects will be – if possible – done by students from different consortium universities. This will form real cross-border teams with a realistic intercultural and international learning experience. The Virtual Project Campus will allow to do this online, same as for example in typical cross-border software development projects.
- Projects will be larger curricular elements which integrate different competences (technical, professional, global) in a holistic learning setting. Therefore, they form a kind of capstone projects. Typical runtimes will be 1-12 month; the standard is one semester. Such projects are integrated into the curricula of the EuroPIM universities.
- Challenge-based and problem-based learning will be supported since student teams run in competitions. During CompIIT runtime it is planned to give the team leaders the chance to pitch their projects at the EU partners in adequate setting, e.g. project faire or a student's conference.

Students are prepared for the projects with the respective eLearning modules ("Scrum & Kanban", "Agile Management in Virtual Project Environments") and use the "Project Management Tools Box". Teachers should attend the Train-the-Trainer. It is planned to integrate 3 project formats into the curricula:

- Innovation projects will focus on the development of new solutions, e.g. products or services. The transdisciplinary aspect is in the foreground with company cooperation and working on real company tasks. Additional methods, e.g. design thinking is applied.
- Cross-border projects focus on the international cooperation aspect and are complemented with respective trainings from the ProCom Language & Communication School. Such projects are also a research object to investigate about online communication in such projects and to derive tailored training.

- Start-up projects are stressing the business aspect (while possibly being derived from ideas from the innovation projects). They should create the typical atmosphere of a business accelerator. Again, pitching is planned in the both Armenia and the EU, creating realistic situations with a jury from industry.

These projects are conducted in waves (e.g. 10 projects of the different types during one semester).

3.5. Project Setup & Execution

Launching a virtual cross-border project can be conducted in the following steps:

1. Forming a community of teachers (and maybe industry experts) who will supervise the virtual cross-border project.
2. Aligning on the goals and learning outcomes (which takes place in a kind of an own virtual cross-border project conducted by the teachers and experts).
3. Selecting a topic or a case study for the project. If appropriate: definition of challenge, e.g. by students or by industry experts.
4. Tailoring the VPC for the specific type of project.
5. Train-the-Trainer for the teachers.
6. Information session for the students.
7. Preparatory courses for the students. Assessment of required competences.
8. If required: language and intercultural trainings, digital tools trainings.
9. Kick-off event and team forming (see 1) in section 3.1).
10. Student presentations and interim reviews during project runtime.
11. Coaching sessions for the students.
12. Final presentation and project review. If possible: pitch presentation in front of a jury, maybe combined with a competition and a reward.
13. If required: additional exam (oral, online).
14. Lessons learned workshop or Retrospective.

3.6. Evaluation & Assessment

For project-based learning, the evaluation and assessment can be done with typical project progress assessment methods:

- Project kick-off presentation
- Project reviews
- Milestone review and release process
- Final project review
- Customer review
- Project progress reports

4. Components of the Virtual Project Campus

4.1. Project Spaces

such project spaces can be:

- Atlassian Confluence
- Nextcloud
- Git
- Microsoft SharePoint

The project spaces are the joint data storage and access point for the Digital Tool- and Co-Production Environments of the VDC.

4.2. Project Management Tools

The provision of project management tools puts the focus on agile management as the main approach for virtual cross-border projects. Due to the cross-border character, cloud-based tools are preferred:

- Atlassian Confluence for documentation and joint work on documents
- Atlassian Jira for the management of Kanban and Scrum boards, ticket management
- Redmine as an open source alternative to Jira
- MS Planner in combination with MS Sharepoint (as alternatives to Confluence and Jira)
- Atlassian Trello as a light-weight alternative to Jira

AI-based tools are mainly used for the preparation of presentations and documentation.

For traditional project management, the following tools are possible examples:

- MS Project for project planning and controlling, in combination with MS Project Server
- OpenProject as an open source alternative to MS Project
- Oracle Primavera as a programme and project portfolio solution

Specific tools (e.g. for risk management, requirements management) a complementing the project management tool suite.

For all tools, tutorials, documentation and training materials are provided.

4.3. Project Tools

Project tools are the tools which are required to execute the project tasks, apart from the project management tools. Such tools need to be usable in virtual collaboration settings. Typical examples are software development tools, e.g.

- Git with the respective software development tools
- Microsoft Azure

- Eclise
- Apache Allura

For the engineering domain, examples are:

- TeamCenter

4.4. Data Spaces

Virtual project collaboration requires digital data space where information can be stored, researched and jointly edited. For the VDC, such spaces are:

- Nextcloud (file storage)
- MS SharePoint (as part of the MS365 tenant)
- Atlassian Confluence
- (possibly) google docs

4.5. Collaboration Tools

Collaboration tools are online tools for communication and joint editing of documents, e.g.:

- MS Teams
- Zoom
- Cisco WebEx
- Miro
- Discord
- BigBlueButton (open source)

5. Integration into the Digital Education Ecosystem (DEE)

5.1. Introduction to the Digital Education Ecosystem (DEE)

The Digital Education Ecosystem (DEE) is described in detail in the respective "Specification of the Digital Education Ecosystem". In this chapter, a summary of the description is provided in order to make the integration aspects for the VPC more understandable.

A Digital Education Ecosystem (DEE) is a digital learning & teaching infrastructure which supports all aspects of digitally transformed educational system, e.g. a university or school [20]. The goal of the DEE is to support a virtual, cross border Master School and virtual cross- border projects (in combination with the VPC).

According to the 3-layer-model [20] the DEE has to support:

- The community of teachers and experts in the co-production of content, methods and teaching (input)

- The delivery of the competences including the teaching and learning with didactic formats (output)
- The provision of the content and the generation of the competences (outcome)

The components of the DEE (IT services) support production, delivery and representation in a virtual learning and teaching environment. It is composed out of several service layers, starting from the IT systems, the basic IT services, the Digital University services and on the top layer the actual applications which support production, information, teaching and learning. The services can be configured and tailored into a DEE which serves specific needs (e.g. the virtual cross-border Master School). Services can be defined and agreed in service-level-agreements (SLA). This specification describes the different service layers and specific services with respect to their integration with the Virtual Project Campus (VDC).

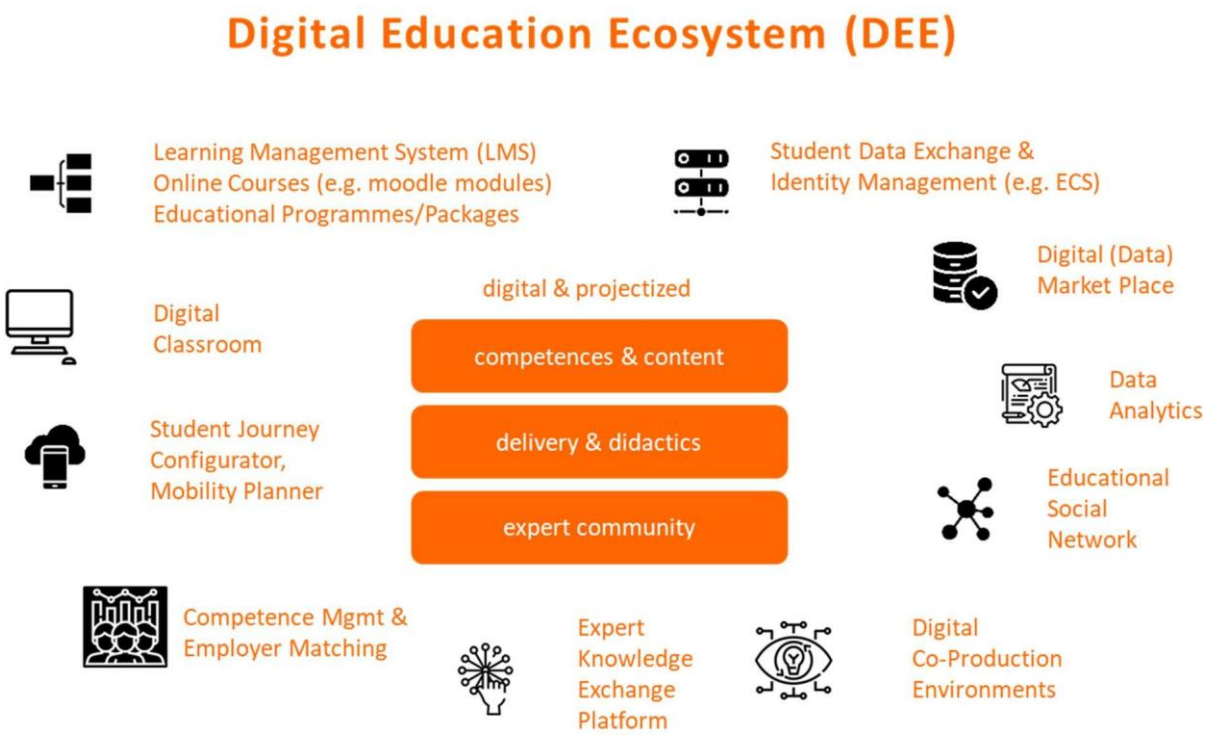


Figure 4: Components of the Digital Education Ecosystem (DEE) [20]

5.2. DEE Architecture

This chapter will provide an overview of the IT Architecture of the DEE.

The DEE is a hybrid IT System with a Docker-based Microservice architecture for the DEE basic services (e.g. user service, student journey configurator), a KVM/Kubernetes based infrastructure of virtual machines, e.g. for Moodle, WordPress webservers etc., and a collection of cloud-based tools which are linked into the DEE and accessed via the LDAP-based identity management system (IDM), including Microsoft 365, Atlassian Confluence and Jira, and Nextcloud and Git.

This includes a layered view with:

- The IT system layer which describes the server setup, including operating systems (e.g. VMware, KVM) and other (rented) systems, e.g. cloud services or hosted servers/VMs
- The Basic IT Services layer which describes the IT services like VMs, VDI-Desktops, Docker Containers, external cloud services, IT services
- The Digital University Services layer describes general educational services e.g. digital classroom (e.g. Big Blue Button, MS Teams, Discord, …), Learning Management System (Moodle, both development and productive environment), user administration (students, teacher, Identity Management), Web Servers, etc.
- The Application layer describes services like Educational Programme Management/Delivery, OER Repository, OpenCoP Portal, Student Journey Configurator, Conference Portal, Co-Production Environment

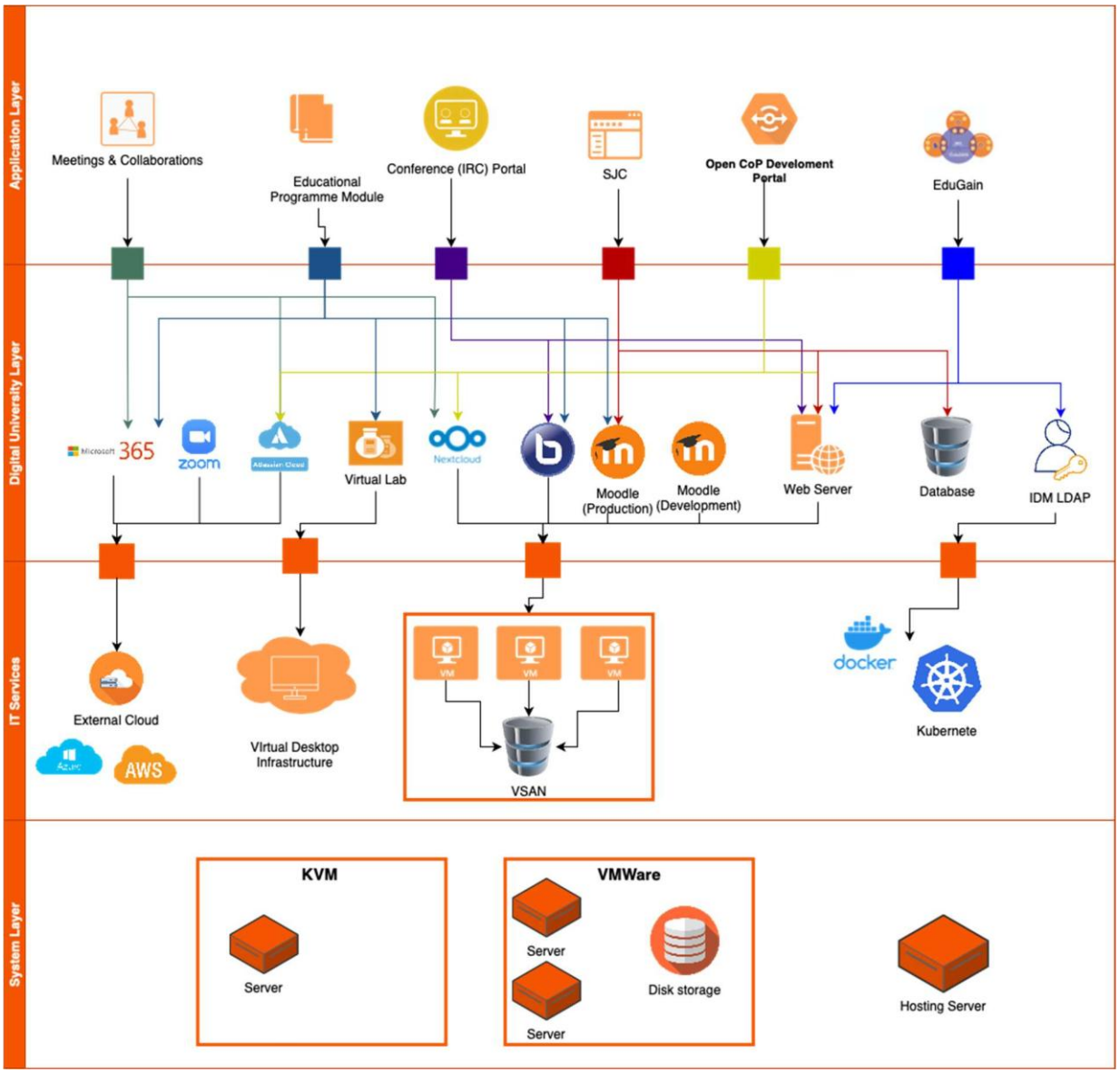


Figure 5: DEE System Architecture [own illustration]

5.3. IT Systems

This chapter describes the basic IT systems which are involved at the Armenian HEIs (as an example), their setup, their management. The IT Systems layer of DEE consists of the components described below.

1 x Physical Server per HEI

- Intel Xeon high performance server (e.g. from DELTA):
- 2U rack chassis with 700W power supply
- Chassis: 1 x SuperMicro LA26AC12-R1K03LP1
- CPU: 1 x Intel Xeon Gold 5412U, 24 Cores pro CPU, 2,10 GHz
- RAM: 8 x Micron MTC40F2046S1RC56B = 512 GB, 8 x 64 GB
- SSDs: 2 x Micron 5400 MAX MTFDDAK3T8TGB = 7,6 TB (2 x 3,8 TB)
- Network: 1 x Broadcom P210TP+, 2 Ports, 10GbE, RJ45, Broadcom 57416
- U.2/U.3 NVMe SSDs: 1 x Micron 7500 PRO MTFDKCC960TGP = 960 GB

Digital Project Lab

- 1 x Video Projector, e.g. Epson, EPSV11HA03020, PowerLite 118 3LCD XGA Classroom Projector with Dual HDMI
- 1 x Logitech Group conferencing system with additional speakers/mics
- 12 x Laptop (e.g. Dell Latitude 5450, 16 GB RAM, 512 GB SSD)
- 8 x Tablet Computer (e.g. Galaxy Tab S6 Lite LTE)

5.4. IT Service Layer

The setup of the IT Service Layer is based on a Kubernetes/Docker infrastructure:

Docker Containers can be used to employ a microservice-based architecture where the services are loosely coupled, easily portable and easily deployable. Docker is based on a client-server architecture model and comprises of the following components:

1) Docker daemon: The Docker Daemon also known as Dockerd listens for Docker API requests (REST API) from the docker client. Based on the request call, the daemon will build, run, or manage the docker images and containers. Docker daemon is also responsible for managing docker objects.
2) Docker client: Using the docker client (docker), is how users can interact with docker. When we execute docker commands, (such as “docker build”), the client sends them to the daemon over a docker API request.
3) Docker registries: The docker registry is a place where Docker images are stored
4) Docker objects: Docker objects include docker images, containers, volumes, networks, etc.

The containers can be configured to run on a server, a VM, or cloud instances. In our project, the Docker client and the docker daemon in the same instance was configured. It is also possible to install them in different instances. In DEE project, the Gitlab container registry was used to store the Docker images. Once the docker image has been developed for each service, it is pushed to the GitLab registry. When a deployment is required, the image will be pulled from this registry before a container is created. A container configuration requires some prerequisites, such as ensuring the required ports of the host machine are open, ensuring the paths which will need to be mounted through docker volumes, ensuing specific configurations are added as config maps, etc.

The next step is to create a container incorporating all of these as needed. In order to persist data, volumes should be created especially for the data directories of databases that are created in the containers. For example, in the SJC configurations, PostgreSQL has been used, hence we have mapped its data directory as a volume. Additionally, containers can also have multiple volumes. For instance, there is an additional volume for the journey service to persist data of the server directory. Similarly, the server directory of the User service is also mapped to a volume. Once, all the scripts and processes are in running state inside the container, we can check the webpage for validation. The webpage is reachable due to the host and container port mapping.

5.5. DEE Service Layer

IDM/LDAP/OAuth 2.0

The LDAP (Lightweight Directory Authentication Protocol) is an open and cross-platform protocol used for directory services authentication. LDAP makes the possibility to store the users, passwords, and computer accounts, and share them within the network. In the DEE project, LDAP authentication was used from the existing authentication provided in the IDIAL institute. As a start, the LDAP was used on implementing on-premises Atlassian Jira system as a task management system.

IDM/LDAP => single sign on, but later on extended to: Digital Twin of the Student/Teacher

Core Service (User Service)

The user service provides authentication service to the other services that require authentication by matching login credentials with the institution's LDAP directory or with eduGAIN. The user service upon successfully verifying the identity of the user generates a JSON Web Token (JWT) which allows authorization by the services the user intends to use.

The user service is responsible for handling all necessary functionalities shared between all Laravel projects within DEE. For example, one of the main functions within dee-core is authentication by sharing one account and login between all other DEE services. Using the PHP-Laravel Passport server, which implements all required functionalities (Login, Register,

and Forget Password) and all users' information are stored in a central database within dee- core, we achieved the OAuth 2.0 protocol between services.

Instead of storing the username and password of any user each time the user logs in, the dee- core service is responsible for creating all required APIs and internal APIs for other applications, especially the OAuth/token API responsible for creating a token that is stored in each project and used to authorize the app. And the User flow can be described as those necessary steps:

- Users open any service that belongs to or authorised using DEE.
- The service will redirect unauthorized users into the dee-core Laravel app.
- Users will enter login details and then be redirected to service as a result of the login if it is successful.

Each service will store the details inside the dee-core oauth_clients database table, allowing the dee-core to know where to redirect the users after being successfully authenticated.

Third-parties' applications/services should register within the dee-core system. Each application will be required to enter a callback URL that dee-core redirects into when the user login using dee. In addition, all clients will get a generated secret token and should store it internally within each application.

The DEE services communicate with each other via REST APIs. The API available in each of the services provides a contract based upon which other services can interact with it. Newly integrated services ought to make their API accessibility known to other services to ensure smooth interactions.

eLearning Community Server (ECS)

E-Learning Community Server (ECS) remove restriction from registration of students and teachers in the Moodle systems in partner universities. The goal is to allow for inter-platform access to courses within the various universities, that is, providing a transparent forwarding of the user from his or her home platform to a remote learning platform. Sharing is not limited to courses, but also other sharable eLearning content.

ECS is installed and deployed on virtual machines on IDiAL local network with the specifications of 8 GB minimum RAM, a minimum of 100 GB storage capacity, a virtual CPU of 4 cores, and runs on Debian 9 operating system. The installation of ECS involves the installation of "ecs4" package, Apache 2 web server and a database, in this case "postgresql". Figure 5 shows the various deployment components in the ECS.

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