D2.2 Specification and Design of the Technical Components

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PART A: STATE OF THE ART ANALYSIS ON ACTIVE LEARNING IN ENGINEERING EDUCATION

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A1. INTRODUCTION

The aim of project ALIEN: Active Learning in Engineering is to improve the quality of higher education by providing more motivating, stimulating, and effective learning contexts that prepare students for their professional life by allowing them to actively develop the required competences.

To achieve that, the ALIEN consortium designs, implements, and validates an active learning framework based on problem- and project-based learning methodologies addressing real-life issues related to science, technology, engineering, and math (STEM) concepts.

Active learning is an approach to instruction that involves actively engaging students with the course material through discussions, problem solving, case studies, role plays, and other methods (What is active learning). Active learning approaches place a greater degree of responsibility on the learner than passive approaches such as lectures, but instructor guidance is still crucial in the active learning classroom. Activities may range in length from a couple of minutes to whole class sessions or may take place over multiple class sessions.

When it comes to learning a new concept or skill instruction that is essential, the belief is that practice makes perfect (What is active learning and why does it work). Traditionally, lectures teach students new concepts and active learning helps students master them. Active learning works because it engages students in the learning process.

Active learning in the classroom has distinct advantages. Through active learning teachers and students get more one on one interaction. Students receive frequent and immediate feedback from instructors. Students learn through collaboration and interaction with peers, engaging more deeply with the course content and building invaluable social skills. Teaching is more inclusive, allowing students with different learning styles to get a personalized experience.

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In the ALIEN project, the active learning methodology is supported through a virtual learning environment integrating a set of digital tools that allow teachers and students to experiment, collaborate, and communicate in an extended and multinational learning community that may also include other stakeholders, such as educational managers and researchers.

As a first step in this process, the ALIEN partners conducted an extensive state of the art analysis on existing best practices on the deployment of active and problem-based learning focusing on institutional and pedagogical levels. The analysis highlights teachers' and students' needs and provides a basis that will guide the design and implementation of the proposed virtual learning environment and supporting project activities.

This section presents the results of the state of the art analysis conducted in all countries in which the ALIEN consortium has project partners, namely in Greece, Portugal, Estonia, Bulgaria, the United Kingdom, Malaysia, Pakistan, Nepal, Vietnam, and Cambodia.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

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A2. RESEARCH METHODOLOGY

A2.1 Objectives

The ALIEN project aims to design, implement, and disseminate an active learning approach in engineering faculties in Europe and Asia. The purpose of the proposed active learning framework is to better prepare engineering students for their future role of active problem solvers that have the necessary knowledge and skills to address the challenges of the 21st century. The project aims to introduce a vertical learning intervention that addresses the challenges that hinder the deployment of active learning in higher education today. More specifically, the problem aims to implement:

- Physical problem-based laboratories at 12 Asian partner universities in Malaysia, Vietnam, Cambodia, Nepal, and Pakistan.
- A digital learning environment that supports the structuring, publication, deployment, and sharing of problem-based learning activities that deploy digital games, applications, or simulations.
- Instructor capacity building through training and community building.

The project mainly targets teachers and students engaged in higher education in engineering and technical careers. It also targets the organizations themselves, aiming to introduce institutional strategies that build their capacity to adopt problem-based learning as a strategic educational approach. Through ALIEN teachers will be able to apply the proposed active learning methodology and the tools to be developed in the project. Students will benefit from a more motivating pedagogical context and will be more attracted to these subject areas. Universities will benefit from adopting a more active pedagogical approach that allows them broaden their student base by establishing closer links with the society and the labor market.

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To establish problem-based learning as a key educational framework in engineering the ALIEN project will produce:

- A strategic plan to be adopted and adapted by each partner institution on the deployment of active learning and problem/project based learning.
- A validated pedagogical methodology that promotes active learning through the deployment of digital technologies.

The present report is based on:

- Desk research regarding the national situation and best practices conducted by each partner.
- Field research organized when necessary to complement the data from the desk research.

Research resulted in a series of 17 national reports on the state of the art on the use of active and problem based learning in engineering higher education, one for each country in which the consortium has project partners. This report integrates the findings of the national state of the art report.

A2.2 Research guidelines

The state of the art analysis aims to identify the needs of students and teachers in relation to adopting active learning design in engineering. It further focuses on how current infrastructures and practices will inform the design of the proposed virtual learning environment in a manner that allows its integration into existing educational activities.

A2.2.1 Scope of the research

Research is conducted in the scope of Work Package 2 of the ALIEN project, which focuses on the specification, design, and development of the proposed vertical active learning intervention in engineering education. More specifically, the work scope is to produce:

- A state of the art analysis on existing best practice in the use of active and problem-based learning at the institutional and pedagogical levels.
- An institutional strategy for adopting active and problem based learning.
- Definition of the pedagogical methodology and possible models of use of the platform.
- A validation methodology.
- The design the proposed problem-based learning environment, including needs and functional requirements.

The work results into 3 reports:

- The ALIEN state of the art report (the current document).
- The ALIEN institutional strategy on active and problem-based learning.
- The ALIEN platform specifications and design.

A2.2.2 Research methodology guidelines

The present guidelines contain the methodological framework for the research that conducted for producing the national reports on the state of the art on the deployment of active and problem based learning in countries in which the ALIEN project has partners.

The research methodology is based on the following steps:

1. The desk research stage conducted at all partner countries (compulsory).
    a. Generating individual reports by each project partner.
    b. Compiling partner work into national state of the art reports (please note that the consortium includes several partners in Malaysia, Pakistan, Nepal, Cambodia, and Vietnam.
2. Field research in all partner countries (voluntary).
    a. Adding to national state of the art reports.

3. Compiling the national state of the art reports in global document, which constitutes this report.
4. Publishing the final version of the state of the art report:
    a. Validation and editing by partners.
    b. Publishing of the final report.
    c. Publishing of report content in scientific articles or book chapters (optional).

In their research partners collected and analyzed information on the following:

- Overview learning design in engineering education at the national level.
- Existing national, local, or institutional initiatives on active learning, preferably at the university level and particularly in engineering.
- Best-practice cases in the use of active and problem based learning, with a focus on practices that are supported by digital technologies.
- Deployment of active learning at partner sites.

Partners adopted scientific approaches in the collection of data namely using standard systematic research techniques, such as the PRISMA systematic review approach (The PRISMA Statement, 2020). Partners were free to use any quality resources available at the organizational, national, and worldwide levels, such as journal and conference articles, organizational or governmental reports, textbooks, web resources, and more.

The results are summarized in the following sections.

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A3. OVERVIEW OF CURRENT UNIVERSITY TEACHING/LEARNING MODEL IN RELATION TO ENGINEERING HIGHER EDUCATION

A3.1 Bulgaria

According to the Strategy for Developmen*t* of Higher Education in the Republic of Bulgaria for the 2014-2020 period (European Commission Observatory, 2020) some of the problems related to the quality of higher education are:

- Lag of teaching/learning methods behind the innovative trends in the development of students' skills and modernization of curricula.
- Lack of motivation of young university lecturers.
- Ageing academic staff.
- Mismatches between existing curricula and labor market and industry demands.

National reports and strategies regarding higher education in Bulgaria highlight the inadequacy of teaching and learning model at the tertiary level. They stress that globalization, Industry 4.0, and the new type of young learners, the so called net-generation, require a new learning environment where the traditional roles of lecturer and student are updated. They further highlight the need to update the physical learning environment and the teaching and learning methodologies as the latter are of vital importance for the successful acquisition of both professional and employability competence, being the bridge between the person who teaches and the person who learns. A number of recommendations have been introduced on how that change could be implemented. They include the introduction of innovative teaching methods, such as case studies, project work, discussions, career guidance, learner-centered learning, etc., further training of university lecturers, broad introduction of digital technologies into the classroom, and more.

However, the implementation of the strategies in practice demonstrates a completely different picture. Even though Bulgarian academic staff, especially educators in the field of engineering sciences, speak everyday at work, at home, or at conferences about emerging digital technologies such as cloud computing, Internet of Things (IoT), and cyber-physical systems (CPS), the predominant teaching and learning model in the classroom still follows traditional patterns. A professor delivers his lecture to a large audience of passive note takers for approximately 40 minutes followed by a 5 minute question and answer session, in which however student participation is typically low. In relation to laboratory work, while activity and excitement are higher among students that are evident in "question-and-answer" moments and spontaneous brief discussions, individual assignments prevail over team project work.

The situation described above is confirmed by an on-line survey conducted by the Ministry of Education and Science in 2017 within Erasmus+ Project "Innovative tools to improve the skills of university lecturers so as to enhance the quality of higher education in Bulgaria". The research engaged 1,425 academics and 1,826 university students from different Bulgarian universities. Of those, 22.2% of academics are active in engineering sciences, including computer science. Furthermore, 36% of academics are aged 50+. In addition, 19.6% of the students follow an engineering degree course, including computer science. The results show that 88.5% of university educators deploy traditional lecture techniques in their classroom. Nevertheless, half of them expressed an interest to improve their teaching competence by getting trained in innovative teaching and learning methods as well as developing their foreign language skills. On the other hand, 97.3% of university students report that in most cases they are exposed to courses in the form of traditional lectures.

Some tools of active learning such as case studies, problem solving, structured discussions, team projects, and more have recently been introduced as useful teaching instruments in a number of Bulgarian universities, mainly in the areas of computer science, medicine, business, and management, social science, law, and humanities. Engineering, which is an applied science field, lags behind the other applied sciences mentioned above, namely computer science and medicine, regarding the introduction of active and problem-based learning since. This is a paradox as engineering inherently involves problem solving and interdisciplinary team work. Identifying the reasons for which problem-based learning is not adequately deployed in engineering is not simple. An analysis follows:

First, the eight technical universities in Bulgaria that provide engineering degree courses are public universities. In general, they are characterized by strict hierarchy of several layers. Most of the academic staff is aged 50+. The ageing of the university lecturers is due to the fact that less young people are interested in following an engineering degree program since, on the one hand, engineering has become more interdisciplinary and demanding and, on the other, engineers are often underpaid. The decreased number of engineering students results in the pool of potential academic candidates for staffing universities which results to the continuous decrease young lecturer recruits. Another negative factor is the inadequate salaries of young university lecturers, which leads to an unwillingness of young candidates to apply for a lecturer position even if one is vacant.

Second, traditionally Bulgarian society is marked strict hierarchy and power distance. This holds true, even to a greater extent, in academic circles. University lecturers, especially those aged 50+, are afraid that they will lose control of their audience, class, or group if they are not the main agents of teaching and the primary transmitters of knowledge in the lecture room which, in turn, reflects on the lecturer-student relationship. Most of them still provide students with almost no choices, no shared responsibilities, no collective decision making powers, and no opportunities to discuss current controversial and societal issues. Therefore, it is not common for a student to have a close and familiar relationship with educators or to question educator knowledge and experience. To sum up, it is hard for lecturers who are used to teaching in an authoritative manner in a country of high levels of power distance to embrace the change in power structure by agreeing to transfer authority and responsibility to their students, which actually is one of the underpinning principles of learner-centered learning design such as active and problem-based learning.

Third, most academics, especially those teaching engineering subjects, do not have any pedagogical training. They have completed engineering degree courses which aim to provide graduates with a career as engineers in industrial settings. It turns out that engineering educators are self taught on learning delivery methods, tools, and environments through a trial and error basis. Furthermore, the Bulgarian Evaluation and Accreditation System for universities and the universities' attestation systems for academic staff assigns higher priority to scientific research in comparison to teaching. As a result, academics are under pressure to achieve research results and publish scientific articles in journals indexed in Thomson Reuters and Scopus. Hence, educators have neither the time nor the motivation to invest in innovative teaching and learning methods in their classrooms.

Fourth, many 50+ university lecturers lack foreign language skills, in particular English, which prevents them from delivering lectures in other overseas universities where they might observe alternative methods for managing engineering classes and gain experience in up-to-date teaching approaches such active and problem-based learning.

Fifth, the assessment methodologies deployed for evaluating students' progress are mainly based on end-term written and oral exams, which generally require memorization of information. In this sense, active and problem-based learning classroom activities are not involved in the assessment process thus being often neglected by academics.

Sixth, limited financial resources prevent universities from buying cutting-edge equipment for active and problem-based learning labs. Of course, equipment could be bought through various EU programs, but related initiatives are very rare.

To conclude, the need for the application of innovative teaching and learning approaches, such as active and problem-based learning, in higher education has already been identified and the

Ministry of Education and Science is already implementing initiatives to promote modernization of teaching processes in higher education. However, active and problem-based learning is not a seen as a strategic teaching method in Bulgarian universities and its potential is still not well recognized by academics. Any existing initiatives take play through personal interest of individual lecturers and have a limited scope, although exceptions do exist. Private universities are doing better in introducing non-traditional teaching and learning methods. Active and problem-based learning tools are mainly used in pilot learning sessions in social sciences, computer science, and medicine. However, open-learning environments that require students' own initiative, planning, experimentation, elaboration, and self-evaluation still seem to be rare. Most technical universities offering engineering degree programs lag behind with respect to the latest pedagogical and methodological developments. Thus, active and problem-based learning approaches are seldom applied by few young lecturers.

A3.2 Estonia

Estonia's higher education system follows the Bologna treaty. Bachelor level studies are organized around 3 year programs. Master's level studies are completed over a period of 2 years. This structure is justified by the rapid changes in the job market which require that time spent for education be limited. The Bologna treaty is heavily criticized by some experts who argue that this devalues the quality of higher education.

Universities enjoy a lot of freedom in coordinating their teaching practices. However, rectors of bigger universities have signed a quality agreement, which is a document that describes best teaching practices at the university level. Work in different universities is arranged differently, however in most cases universities are organized around smaller units, such as schools, institutes, or faculties, that are semi-autonomous in decision making and mostly independent in matters that concern teaching practices.

Unfortunately the most dominating teaching methodology is presentational-based learning, which includes lectures and slide shows. Some university regulations and terminology reflect the focus on traditional training methods. For example, attending classes can't be mandatory because study materials, such as presentations slides, should be available for students. On the other hand, a learning program must offer 3 exam periods, allowing students to choose when to undertake an exam.

There is a trend to include more and more active learning approaches in the framework of higher education. For example, especially on more technically oriented programs, practice-based subjects are delivered for the past several decades through internship programs or design and development-based learning activities. In general, society and industry representatives appreciate the high value of more practice-oriented teaching methods. Internship programs in which students implement projects and design prototypes are for the most part widely accepted stakeholders. Other more unconventional methods such as gamification, game based learning, and flipped classroom don't generate consensus among different players.

A3.3 Greece

Higher education institutions in Greece aim to promote knowledge through research and teaching, to prepare students to use the acquired knowledge in their professional life, and to boost arts and culture. In addition to offering higher education programs they contribute to lifelong learning using modern teaching methods, such as distance learning, on the basis of high quality scientific and technological research which follows international criteria. Higher education programs build both foundational knowledge and higher order thinking skills, such as critical and analytical thinking, entrepreneurial thinking, and collaboration capacity. Educational programs are designed for preparing students to transition into world of work. They aim to create the appropriate conditions for the emergence of new researchers. Higher education organizations strive to develop knowledge that corresponds to labor market needs and to the country's development needs. They further aim to promote knowledge dissemination, uptake of research results, and innovation focusing on scientific ethics, sustainable development, and social cohesion. On the other hand, higher education in Greece aims at promoting cooperation among universities and research organizations in Greece and abroad. This is pursued through student and staff mobility in the context of the European Higher Education and Research Area. Finally, higher education aims to develop responsible and active citizens that have the knowledge and skills for addressing societal and industry needs with scientific, professional, and cultural sufficiency as well as to respect values such as justice, freedom, democracy, and social solidarity.

Greece is a country whose historical heritage has had the propensity of enticing many overseas students to pursue their university education within its shores (Higher Education Greece). Students of EU origin are not required to pay tuition fees. According to the constitution of Greece, higher education in the country is provided by the state and is made available to all citizens at no cost until the completion of undergraduate studies. Beyond this level the payment of tuition fees is left to the discretion of decision makers in the upper echelons of higher education institutions. This effectively means that the universities offering graduate level courses determine the level of fees paid.

Greece enjoys a high number of university graduates. University education typically has a duration of 4 years in diverse areas that range from pedagogy and humanities to science. Engineering studies have a duration of 5 years. Medicine studies have a duration of 6 years. Students who wish to study special subjects such as fine arts take specialized exams and graduate after 5 years of studies. Courses in higher education institutions in Greece typically are delivered through lectures or workshops. Most courses have duration of 1 semester, or 13 weeks. Most university departments in Greece offer 1 or 2 year postgraduate, master's level, programs as well as the opportunity to pursue a doctoral degree. Students may also enroll in the Hellenic Open University for undergraduate or postgraduate studies, in which they are admitted through an annual lottery system and pay tuition fees.

Educators in Greek universities enjoy complete freedom in the organization and delivery of their curricula. Active learning is not formally and widely adopted at the higher education level. Integrating active learning in educational contexts takes place at the initiative of individual educators. In engineering education, active and problem-based learning are evident throughout curricula in projects and activities that encourage students to build knowledge and practice by doing, as opposed to listening and observing. For example, in programming courses students design and build digital services individually or in teams, in circuit design courses students construct electronic boards that perform specific tasks, and in data mining students design and develop systems for the organizations and extraction of information. Most of the time educators deploy active and problem-based learning principles without having been formally trained to do so and, in many cases, unconsciously as they perceive the benefits of more direct student engagement in achieving educational goals. There is a need in engineering education for formally training educators in emerging pedagogical design, such as active and problem-based learning and encouraging the systematic and conscious deployment of innovative learning practices for enriching student educational experiences and for building skills in demand by industry and society.

A3.4 Cambodia

Higher education plays a crucial role in human resource development and it is a key contributor to socio-economic development of each nation. This is particularly true in Cambodia. Realizing its value, Cambodia has deemed higher education as a strategically important sector for building human capital which promotes the rapid development of Cambodia towards prosperity in the future. High level strategies have led to reforms for improving quality of life and equitable access to higher education with the objective of producing graduates who will become both economically competitive and socially responsible. Globalization, regional integration, and proliferation of widespread understanding of science and technology have significant impact on all sectors of Cambodian economy. Higher education development is required to adapt and conform to global and regional trends. In this context, the Ministry of Education, Youth, and Sport has formulated Cambodian Higher Education Vision 2030 aiming at identifying long-term direction and a clear roadmap for modernizing higher education practices.

Over the last decade the higher education system in Cambodia has transformed exponentially. This is evident in the considerable increase in the number of private universities. This trend allows students to have increasingly more opportunities for jobs as well as further education. It reflects the rapid growth in higher education demand. However, this trend also highlights the intricate challenges faced by parties involved in the overall quality assurance of higher education. Higher education management in the country remains a challenge and requires clarification and strengthening of practices across several key dimensions, including institutional and organizational capacity. As a developing country, Cambodia faces significant challenges in staying in par with other countries in the region in terms of economy and education growth. A major factor that contributes to this challenge is the lack of human resources.

In relation to the predominant method of teaching and learning in Cambodia, although there is a lack of quantitative research on classroom teaching and learning processes, qualitative research studies have found that teachers in Cambodia primarily focus on presentational teaching and note learning, especially in primary and secondary education (Altinyelken, 2015).

After the fall of the Khmer Rouge, today’s modern educational system was rebuilt from the ground up. Education in Cambodia today starts in grade 1, at age 6, and is completed in grade 12, which corresponds to 12 years of public general education.

The methods of teaching adopted by each educational institution in Cambodia, especially at the university level, may differ significantly. Two noticeable approaches that are now widespread across Cambodian academic sectors are innovative and traditional methods.

In primary and secondary education, especially outside of the capital Phnom Penh, the traditional approach of learning seems to dominate. Teachers generally adopt this long-established custom that society traditionally used in schools. Traditional, teacher-centered methods focusing on note taking and memorization are still in use by many teachers in the rural areas as well as in the cities. The adopted reforms of teaching and learning recommended by the Ministry of Education emphasized a shift from teacher-centered approaches to child-centered pedagogy, referred to as student-centered pedagogy, active learning, or learner-centered education in different contexts. Despite its benefits, the transition from traditional methods to more innovative ones is sluggish. Furthermore, in rural areas where digital technology uptake is limited students may not benefit from the advancement of information technology in learning. The lack of facilities and expertise in basic technology is one of the main problems that limit the effectiveness of teaching in primary and secondary education. However, teaching methods in some high-class and expensive private schools in Phnom Penh are somehow different from what those deployed in public schools. Thanks to sufficient budgets and conducive environments, those private schools may go one step further from public ones by introducing various approaches to boost their student academic performance and social skills.

At the university level, the situation is to certain extent different from lower education. As science and technology are dramatically and broadly adopted the evolution of learning methods at the university level is a hotly debated topic that deserves ultimate attention. With the rapid rise of the digital age and innovation in teaching, university students use smart phones, tablets, and laptops as learning tools. There is a phenomenal wealth of information available on-line which could lead to traditional lectures becoming obsolete.

Innovative teaching techniques are introduced shifting priorities away from traditional models of teaching and passive learning and highlighting greater focus on active learning. In active and problem-based learning students actively interact with others and participate in the lectures. The majority of educators in Cambodian universities agree that the collaborative way of learning in higher education, in which students are engaged in synthesizing solutions to given problems, helps build high level thinking and problem solving abilities.

A3.5 Malaysia

In 2007 the Malaysian National Higher Education Strategic Plan beyond 2020 (NHESP/PSPTN) (Kementerian Pengajian Tinggi, 2007) was launched. Its main objective is to enrich the quality of human capital towards turning Malaysia into a high income developed nation in par with “first class” world citizens through the enhancement of national higher education. The plan introduces 7 strategic thrusts to improve knowledge acquisition capability, realize the nation's innovative potential, and inspire first class mentality. Thrust 2, the 2nd of the 7 thrusts, is Improving Teaching and Learning Quality. It introduces a strategy for the transformation of teaching and learning approaches in higher learning institutions in Malaysia.

Based on the spirit of Thrust 2, it is imperative for higher learning institutions to continuously improve the teaching and learning quality so that their curriculum is always innovative, dynamic, up-to-date, and relevant to market demands as well as meeting the standards of intellectual development. Attention is directed to supporting facilities and other ecosystem components, such as teaching and learning infrastructure, teaching and learning methods, and up-skilling of teaching staff building their qualifications and professional ability on undertaking effective teaching and learning processes (Kementerian Pengajian Tinggi, 2012). These 3 areas are strategically planned and implemented collaboratively through Critical Agenda Projects between the Ministry of Higher Education and all 20 public universities in Malaysia. Through the

Critical Agenda Projects for Teaching and Learning, 5 strategic objectives are dedicated to active and student-centered learning as follows:

- To improve the quality of academic programs.
- To ensure that the Generic Student Attributes are achieved.
- To enhance the quality of lecturers in implementing teaching and learning activities.
- To enhance the quality of non-academic staff in supporting teaching and learning activities.
- To improve the quality of physical facilities so that they are conducive to effective teaching and learning.

Public universities were given 6 key performance indicators during the 1st phase of the Malaysian National Higher Education Strategic Plan in the period 2006 - 2010 to ensure that the above objectives were met. Within these 6 indicators, active and student-centered learning are specifically mentioned as in the list below:

- Percentage of the final year students with a minimum average of 6 in the Generic Student Attributes system (My3S).
- Number of facilities at each higher education institution that are dedicated to student-centered learning.
- Number of lecturers with the ability to conduct at least one type of student-centered learning.
- Number of programs that adopt the student-centered approach.
- Number of curricula developed based on outcome-based learning.
- Number of non-academic staff attending training courses related to teaching and learning for at least 2 out of 7 training days in a year.

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When the key performance indicators were first introduced, the initial data collected showed that the practice of active and student-centered learning was not totally alien to the higher learning institution community. However, it was necessary to improve and expand the practice. The preferred active and student-based teaching and learning method at that time included problem-based learning, project oriented problem-based learning, case based learning, interactive lecture, e-Learning, industrial training and practicum, and integrated design. At the end of the 1st implementation phase of the initiative the activities as set in the above key performance indicators were implemented by all 20 public universities with the performance of each exceeding the national targets for the Teaching and Learning Critical Agenda Projects.

The effort in emphasising active learning and student-centered learning practices continued in the 2nd phase of the Malaysian National Higher Education Strategic Plan in the period 2011 - 2015. Public universities were expected to embed student-centered learning in their individual strategic plans. Hence, specific key performance indicators related to student-centered learning set by the Ministry of Higher Education were reduced to one: 100% of the lecturers were expected to be competent in implementing student-centered learning in teaching and learning activities by the end of this phase. The 2 main action plans laid out include the following:

- Conduct training directed to strengthening lecturers' capacity in conducting student-centered learning.
- Produce innovative methods in teaching and learning based on student-centered learning.

Each university was required to report the outcome of these two plans to Ministry of Higher Education:

- Increase in the number of student-centered learning trainers at each institution.
- Increase in the number of publications and instruments related to innovative student-centered learning.

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At the national level, the Malaysian Higher Education Leadership Academy started in the period 2010 - 2015 the Master Trainers training program and had published 15 master trainer teaching and learning modules. The training modules and Master Trainers programs directly dedicated to active learning and student-centered learning include the following: problem-based learning, project oriented problem-based learning, case teaching, interactive lecture, e-Learning, and industrial training. With the introduction of the National Teaching Award in 2007 the culture of innovation in teaching and learning through active approaches has been officially recognized.

In addition to Thrust 2 of the Malaysian National Higher Education Strategic Plan the emergence of active and student-centered learning was also driven by the need for the Malaysian academic programs to be officially accredited. The launching of the Malaysian National Higher Education Strategic Plan was indeed the starting point of the Malaysian Qualification Framework with the establishment of the Malaysian Qualifications Agency that regulates and accredits the courses of all the institutions of higher learning in Malaysia. The implication of the Malaysian Qualifications Framework in teaching and learning is this: the main emphasis of the educational system is outcome-based learning and active and student-centered learning is no longer an option. Under Thrust 2, the Malaysian Qualifications System and Critical Agenda Project are driven and monitored closely by the Ministry of Higher Education. These are the 2 critical factors behind the transformation of classroom instruction from the transmissive model to active and student-centered learning.

A3.6 Nepal

The history of Nepalese education has been developed from the root of the Gurukul Education System in which learners used to be taught certain knowledge and skills under the guidance of their gurus (teachers) with the purpose of preparing them through particular knowledge and skills to be applied in their practical life (Prakash, 2018). In traditional Nepalese educational practices textbooks are regarded as curricula. For this reason, teachers are more focused on teaching contents prescribed in a textbook. As a result, curricular objectives are shadowed (Devkota & Giri, 2016).

The Nepali education system can be differentiated into two types (Paudyal, 2016):

- School education.
- Higher education.

Higher education consists of bachelor, masters, and PhD levels. School education is categorized into basic / elementary level, grades 1 – 8, and secondary level, grades 9 - 12.

In Nepal, higher education is provided by central departments, constituent campuses, and affiliated campuses of fully autonomous non-private universities. With the exception of newly established universities, all institutions have affiliated campuses. Currently 14 fully autonomous non-private universities and medical academies are established for providing higher education in the country. Among those 14 autonomous institutions 10 are full universities and 4 are medical academies.

Most teaching and learning methodologies in Nepalese universities are program-dependent. Social sciences programs adopt teacher centered methodologies in which faculties deliver lectures to students in assigned lecture hours and students show their understanding of subject matter by taking an exam with bounded time frame.

In practice, the exam-centered teaching and learning strategy is adopted throughout all private colleges of the country (Paudyal, 2016). Most of the private colleges have developed internal policies that help achieve high graduation rates in order to satisfy parents and to be covered by magazines and national newspapers. In advertisements, they equally promote research culture, students' involvement in the governmental sector, and good physical facilities as their quality features, which normally very rarely are close to reality.

In active learning students and educators are collaboratively and creatively involved to achieve concrete outputs as a result of group discussion in a classroom. Educators play the role of

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facilitator. Active learning classes mainly focus on small groups of 4 - 5 students. Students are actively engaged for achieving better understanding and synthesizing accurate solutions to a particular problem.

In Nepal's educational context many programs follow the traditional lecture and tutorial approach, in which students from their very early school days have to be seated independently and need to work quietly on a singular task. The teacher plays the role of the mentor and is the only entity that controls the class. Nepalese schools only use course books recommended and offered by the government. These books are supposed to be the only source of knowledge. Students and teachers hardly have the opportunity to interact with each other. This trend is evident until the higher secondary education level. As a result, when students reach higher education they lack self-confidence and motivation to explore their abilities in a large group. Students need to spend more time and effort than usual in order to apply their knowledge and skills to solve any problem if they really want to adapt to active learning methods. But most students never bother to put in the additional effort as a result of being overburdened with course work.

Active learning, being an emerging learning approach for both teachers and students, introduces a high possibility of raising social issues for a lecturer. It is common knowledge that even mentors won't be able to solve all the queries of learners during group discussions in classes. Active learning requires lectures to invest time and hard work on a particular subject. However, lack of motivation, student's overall performance, and lack of quality control may lead to the sloppiness of instructors. As a result, instead of making classes interesting and interactive active learning may instead turn classes into very hectic and tiresome experiences for both teachers and learners.

Finally, some difficulties may arise while implementing problem-based learning classes as a result of large class sizes that may inhibit proper knowledge flow among students.

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A3.7 Pakistan

The Higher Education Commission was established in Pakistan in 2002 to comprehensively reform higher education with the mission to "facilitate institutions of higher learning to serve as an engine of socio-economic development of Pakistan (Higher Education Commission [HEC] Pakistan, 2017)." The Higher Education Commission was established just over 10 years ago. It has led to an increase in the number of higher education institutions from 59 to 178 universities in academic year 2014 – 2015. The establishment of a number of new institutions also increased the number of student enrolment from 276,274 in 2002 to 1.3 million in 2014 - 2015. This was made possible through the significant increase in the investment in human resource development by the Government of Pakistan with the objective of improving the quality of faculty members, instructional facilities available at the institutes, and research culture in the universities. The Higher Education Commission of Pakistan has introduced Vision 2025 for the long-term sustainability of achievements in Pakistani higher education institutions since 2002. The vision is intended to initiate and bring both qualitative and quantitative reforms in Pakistani higher education institutions. The Higher Education Commission of Pakistan plans to implement the process of developing human capital that is not only professionally competent but also ethically committed and support Pakistan to become an emerging Asian Economic Tiger (HEC, 2017).

Pakistan is a developing country with limited resources available to higher education institutions. It is often difficult for higher education institutions to incorporate the use of new technology throughout their institutes. This is also the case for the implementation of active learning.

The use of active learning in different universities of Pakistan has increased over the last decade. Active learning has been highly used in medical education as compared to other higher education fields, such as engineering and business. This can be seen by a systematic review paper written by Mahmud and Hyder (Mahmud & Hyder, 2012) that reviews research in undergraduate medical education in Pakistan, evaluates problem-based learning programs, examines outcomes and competencies influenced by problem-based learning, and compares problem-based learning with typical classroom teaching by an instructor, also known as lecture-based learning . The work failed to find any specific problem-based learning laboratory in which the research or learning on a specific subject matter using problem-based learning takes place. However, it did reveal a number of studies which provide an application of problem-based learning towards retaining instructional content on different subjects, including electrical engineering, mathematics, social sciences, and humanities. Additional studies on the deployment of problem-based learning in these areas are very limited in comparison to medical education. The scope of this document is limited to the use of problem-based learning in engineering education. Therefore, only studies related to engineering are discussed below.

Sultan (Sultan, 2018) discussed the use of the flipped classroom for promoting an interactive and challenging learning environment for students. Flipped classroom is an active teaching and learning strategy based on a pedagogical model that can be easily deployed inside and outside the classroom environment, often with the support of technology. The learning tools applied outside the classroom typically include video lectures, handouts for reading, and practical problems. The tools used inside the classroom include group-based discussion and problem solving activities. Instead of using the whole time of the class to conduct a lecture, time is spent on the collaborative discussion and activities that engage all the students. This increases interactivity in the classroom and allows students to discuss real-time issues, examples, and challenging activities that encourage them to think out of the box to synthesize solutions. Flipped classroom allows teachers to record videos of basic concepts that were supposed to be discussed in the classroom and use actual classroom time to engage students in activities based on the recorded videos. Teachers using this strategy ask students to go through the recorded videos and other shared material before coming to class. Flipped classroom is an opportunity for teachers to move from the role of “sage on the stage”, through which they transfer knowledge only through lectures, to the role of “guide on the side”, through which they support students to explore the topic of discussion independently or in a group. Flipped classroom is based on the theory of constructivism and behaviorism. According to behaviorism, the teacher is a focus point that uses different types of content such as demonstrations, tutorials, and lectures. On the other hand, constructivism is based on the idea that students use their existing knowledge and experience to develop new concepts.

Khan and Abid (Khan & Abid, 2017) discuss the tools to design laboratories. They further discuss the effectiveness of laboratories on the learning of students in the 1st year of an electrical engineering course. Project-based learning is one of the models in which students tend to work on a real-time problem as a part of project and tend to identify a solution conducting discussions with other students, asking questions and receiving answers, discussing ideas and possible solutions, designing experiments and scenarios to validate hypotheses, gathering data, and performing analysis. This is different from problem-based learning where students acquire knowledge and practical experience by working on open-ended problems. Both models have their pros and cons. The authors combined both the 2 models by integrating their positive aspects. The authors used the project-based learning in the linear circuit analysis laboratory at Riphah International University, Pakistan to support 1st year students in the spring of 2015 in activities related to design and simulation, physical implementation, analysis, and measurement of electronic circuits. A survey study was conducted with the students to compare the use of project-based learning as compared to classical laboratory work. The results demonstrated improvement in the abilities of students using project-based learning.

Research has shown that traditional classroom lectures may constrain the learning of students (Bonwell & Eison, 1991). It has been found that students are attentive in first 15 - 20 minutes of a lecture but tend to lose concentration afterwards (Milton, 1986), (Verner & Dickinson, 1967). This is the case for both non-motivated as well as motivated students. This shows that there is a need to reconsider the lecturing approaches of a typical classroom. Malik (Malik, 2011) has investigated the impact of using active learning strategies on the motivation and communication skills of 1st semester graduate students in the Masters of Education program of the International Islamic University, Pakistan. The research was conducted in the context of course Research Methods in Education, which offers 2 credits towards the degree and was attended at the time of the work by 53 registered students. The purpose of the study was to determine the impact of active learning on the motivation, communication skills, and academic achievement of students. The students were taught through traditional methods for the first 2 months of the course. Subsequently they were exposed to active learning. The motivation of students was determined using a questionnaire designed by Pintrich and De Groot (Pintrich & De Groot, 1990). Academic performance was calculated based on midterm and end-term scores. A different questionnaire designed to measure communication skills was further used twice during the study. The results demonstrated that students were motivated, academic performance improved, and communication skills were enhanced.

The deployment of active learning has increased in high school education. Majoda, Dad, and MAhmood (Majoka, Dad, & Mahmood, 2010) highlighted a shift in the mode of teaching from being passive to active. The authors argued that students become more responsible through active learning. According to Hung (Hung, 2006), a lot of work takes place on actively developing thinking and learning strategies and constantly formulating new ideas and refining them through their conversational exchanges with others. Among different active learning strategies the authors highlighted the Student Team Achievement Division, a cooperative learning strategy in which students are divided into groups with different abilities to collaborate and achieve common learning goals. The authors conducted a study to investigate the empirical use of Student Team Achievement Division among the students of class 10, at the secondary level, to teach mathematics. Students in the class were divided into groups. The control group students build knowledge in a traditional competitive situation. The experimental group was exposed to Student Team Achievement Division. Both groups engaged in a pre-test, the scores to which demonstrated a balance in terms of mathematical foundations. The learning experiment had a duration of 10 weeks. During the 10th week both groups were observed for 3 days in terms of the level of their engagement. Upon completion of the 10th week of learning students of both groups engaged in a post-test. The observational data demonstrated a high level of engagement among the students of the experimental group. Furthermore, the post-test scores of the experimental group were significantly better than the control group while the retention rates of the experimental group were slightly better than those of the control group.

A3.8 Portugal

An inspiring learning context provides opportunities for students to proactively seek knowledge and technical proficiency according to their capabilities of learning, monitoring their own learning process. According to Colombo, "active learning enables an enriching learning context, where technical and transversal competences can be widely exercised and developed" (Colombo, 2014). However, adopting traditional curricula and widely introducing this methodology is not an easy task due to pre-existing bias regarding this methodology. Usage of active learning demands a change in the way subjects are taught and contents are prepared and transmitted to students, directly impacting teachers' attitudes towards these new methodologies. According to Lima, "traditional learning is mostly an end-term process in which the fundamental acquired competency would be the competency to pass final exams. A more contextualized, autonomous, interdisciplinary learning and student-centered process, continuously assessed, could contribute to a more effective learning process" (Lima R. e., 2007).

All these difficulties may help explain why Portuguese universities are slowly but positively implementing and developing projects and actions that disseminate the importance of active learning among their student and teacher communities.

In terms of the engineering academic community progress, some studies discuss the difficulties encountered when adopting traditional curricula. Colombo (Colombo 2014) states that the work developed is usually "(1) straightly patterned into the curricula; (2) loosely coupled or arbitrarily scheduled amongst a number of degree courses; or (3) essentially absent". It is simply a question of adapting what already exists; rather, what is important is reconfiguring existing practices in a logical form, guaranteeing the quality of knowledge developed, and empowering learning experiences.

In spite of a slower progress, throughout the years some good examples can be highlighted and, more recently, some cases of officially adapting course curricula in engineering are already registered. The link between digital technologies and education is crucial in this context. Education should be linked directly to technology, calling upon teachers and students to help create a better and more flexible educational experience in an environment that maximizes the positive outcomes that can be achieved through active and technology-based learning design. By observing the upward tendency on the application of digital technologies in emerging teaching models and methodologies it is evident that growing emphasis is given to the role that technology plays in education. Furthermore, technology facilitates the learning process and fosters the achievement of better results by students (Gonçalves, 2002), (Tavares, 2002).

According to a study conducted by GEPE (GEPE, 2008), technological modernization in Portugal faces two main obstacles:

- Insufficiency in gaining access to the necessary equipment and internet connection.
- Qualifications and competences.

This, in turn, results in a reduced usage of digital tools in learning as compared to that in other countries in the EU at the time of the study. Moreover, the report calls upon a crucial necessity in applying new emerging learning methodologies in contrast with traditional ones and creating applications, content, and software in the Portuguese language to efficiently promote and consolidate a knowledge-based society. The study suggests the deployment of virtual platforms

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of knowledge and learning as a possibility for promoting technology-enhanced learning for both teachers and students.

A3.9 United Kingdom

For many years, Universities in the UK followed a very traditional approach to teaching and learning with the norm being a lecture or tutorial structure in which students were taught to in large lecture theatres, often sitting 200 - 500 students. Another alternative in teaching and learning were small, in office space tutorials in which 7 - 12 students came to discuss some preset work (Gibbs, 1982). As technical subjects crept into the curriculum laboratory classes or workshops were introduced, in which students would be timetabled to work through linear problems.

Pre 18+ education was quicker than higher education to incorporate new models of learning. Two stand-out initiatives were the Nuffield Science Program (Nuffield Science Program) and the School Mathematics Project. The Nuffield Science Courses (1962) were characterized by their reliance on practical work carried out by students and the spirit of inquiry that infused teaching. One consequence was that a great deal of effort was invested in developing new practical activities and the associated apparatus. Much of the equipment developed for the courses is still in use in schools today. The guidance on practical work in the guides for teachers was exceptionally detailed and unusually well illustrated making it easy to adopt. The School Mathematics Project began as a research project inspired by a 1961 conference at the University of Southampton which itself was precipitated by calls to reform mathematics teaching in the wake of the launch of Sputnik and against a political backdrop which was to advance the learning of UK children, so the UK could compete with Russia in terms of science and engineering. The School Mathematic Project dwelt on subjects such as set theory, graph theory and logic, non-Cartesian co-ordinate systems, matrix mathematics, affine transforms,

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vectors and non-decimal number systems. It laid the way for a new approach to mathematics teaching, which was inquiry based and problem based.

A3.10 Vietnam

Vietnam's higher education system has been steadily developing as a result of reforms that started in 1990. The number of higher education institutions has increased and the training quality has gradually improved. The higher education landscape has evolved from a system consisting of only narrowly specialized universities offering only bachelor and PhD degrees following the former Soviet model to a network of multi-field, multi-disciplinary, comprehensive universities offering associate (college), bachelor (university), master's, and PhD programs.

Vietnam's higher education sector consists of the following 5 types of institutions (Vietnam's Law on Higher Education, 2012):

- Colleges.
- Universities.
- Academies.
- Local universities, national universities.
- Scientific research institutes eligible for PhD training.
- Foreign-invested universities.

At present, there are 498 higher education institutions out of which 93 are private.

In terms of public universities, 2 national institutions exist: Vietnam National University, Hanoi (VNU) and Vietnam National University, Ho Chi Minh City (VNU-HCM). They both have several member universities, 7 and 5 respectively, research institutes, 5 and 1 respectively, some schools, and a number of centers. The model of national universities has been stabilized by the government's decision which stated that the 2 national universities operate according to their own Regulation on Organization and Operation promulgated by the government. Moreover, they are clearly stated in a separate article in the Vietnam's Law on Higher Education as comprehensive, high quality training, and research and development centers which are given priority for development by the government.

According to Vietnam's Law on Higher Education, Vietnam’s higher education institutions are organized into state-owned public and private. State-owned public higher education institutions are established by the government and receive budgets for their infrastructure, facilities, and operational expenditures. Private higher education institutions are owned by social organizations, socio-professional organizations, private economic organizations, or individuals. Their operation is funded by social organizations, socio-professional organizations, private economic organizations, or individuals. The government supports public higher education institutions to ensure that they always play a key role in the national educational system.

Following is a description of the different levels of education offered by universities in Vietnam:

- Associate (college) programs have a duration of 2 - 3 years depending on each discipline. They target students with upper secondary education certificates. Programs with a duration of 1.5 to 2 years on the same disciplines target students with secondary vocational certificates.
- Bachelor (university) programs have a duration of 4 - 6 years depending on each discipline. They target students with upper secondary education certificates.
- Master’s programs have a duration of 2 years. They target students that have a bachelor degree.
- PhD programs have a duration of 2 - 4 years. They target students with bachelor and master’s degrees respectively.

Colleges normally offer 3 year programs and award associate diplomas. About 2/3 of Vietnam’s colleges specialize in training teachers for lower levels of the educational system. Colleges are

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small in terms of student body size. College students make up a small percentage of the total enrollment in public higher education institutions.

Higher education management is characterized by a very high level of centralization. The Ministry of Education and Training (MOET) has significant power over higher education and determines the curriculum, student enrolment, academic assessment, awarding of degrees, staff appointments, budget decisions, infrastructure, and facility maintenance (Hayden, 2005). Universities have little experience in managing their operations or pursuing their own goals. A severe lack of close links between higher education institutions and scientific research, businesses, industries, and employers is still evident. However, it is worth noting that Vietnam's higher education institutions are not only managed by the Ministry of Education and Training but also by various authorities, such as the Ministry of Public Security, the Ministry of Defense, and by provincial people's committees. It is worth noting that 40 out of 63 provinces and cities have universities accounting for 63.3% of all provinces. 60 out of 63 provinces have colleges making up 95.2% of all provinces. Most of Vietnam's college-level institutions are managed by provincial people's committees.

In relation to teaching and learning styles in Vietnam, the teaching style is, as indicated in a study by (Kramsch & Sullivan, 1996), authoritarian and based on Confucian moral lessons. The role of teachers in classrooms is like fathers in traditional families or leaders of institutions. Students are considered as their children or subordinate members. Hence, teachers are treated with deference and expected to transmit authority and knowledge to students in order to help them pass their course. Teachers tend to dominant and hold superior power over students in classroom activities and academic matters. The relationship between lecturers and students is unequal. Lecturers are used to being ranked just after the king as a proverb says; students should respect and follow what lecturers say. In this context, teachers' duties are believed to include delivering their lectures and helping students to take notes, accept, and memorize knowledge rather than interpreting or questioning it. In addition, the practice of students asking questions during the class can be regarded as showing a lack of understanding or respect for their teacher. The teaching style is, therefore, still based on what would be considered a traditional or teacher-centered approach (Harman & Nguyen, 2010).

Correspondingly, the learning style of Vietnamese students is largely considered as passive (Harman & Nguyen, 2010). It is argued that this is a manifestation of Confucian values which place more emphasis on the importance of harmony over conflict and of collective rather than personal self-expression. Students are less likely to voluntarily express personal opinions, beliefs, and feelings openly or directly. Many would not consider questioning or challenging their teachers' knowledge and ideas or those of their classmates in fear of either being seen as unknowledgeable or humiliating others. This is often related to being afraid of losing face, which inflicts extremely serious personal damage and is thus best avoided (McCornac & Chi, 2005). Additionally, limitations in curricula, programs, and teaching approaches, such as excessively academic curricula, heavy teaching loads, and the teacher-centered approach may disrupt active learning (Harman & Nguyen, 2010). As a result, students seem to be quiet, passive and lacking in contributions and responsibilities for their learning (Le, 2013). They rarely initiate or engage in learning activities. Instead, they mainly listen and memorize provided information in order to reproduce the knowledge.

A number of recent studies have investigated Vietnamese students' learning styles in the context of globalization and internationalization of education. For example, Dang, Nguyen, and Le (Dang, Nguyen, & Le, 2013) studied how Vietnamese students can become active learners in the context of their training as English language teachers by English speaking teachers in Vietnam. The authors demonstrated that being taught by English-speaking teachers prompted the pre-service teacher students to adopt some characteristics of their teacher's style. Nguyen (Nguyen C. T., 2012) investigated autonomous learning of Vietnamese students in Australia. This study focused on how Vietnamese international students can become more autonomous in their learning. The Nguyen (Nguyen C. T., 2012) study looked at one particular characteristic of active learning: autonomous learning. The study was based on interviews of Vietnamese international students on the ways through which they gradually became independent learners. The study demonstrated that with relevant support, Vietnamese students moved towards being more independent and autonomous learners than they were at the beginning of their university studies.

A4. NATIONAL, REGIONAL, AND INSTITUTIONAL INITIATIVES ON ACTIVE AND PROBLEM-BASED LEARNING

A4.1 Bulgaria

Following are some examples of initiatives that promote active and problem-based learning in Bulgaria:

Erasmus+ Project Innovative tools to improve the skills of university lecturers so as to enhance the quality of higher education in Bulgaria, was implemented in the period 2016 -2019. The project was led by the Ministry of Education and Science. It aims to study the needs of academics in relation to improving their teaching competence. Work will result in a good of good practice recommendations.

Active learning seminars are also popular. An example is the seminar titled “How to improve teaching skills and education in Bulgarian universities” that was delivered on May 30, 2017 in Sofia. The seminar was led by the Ministry of Education and Science. Presenters from Norway and Bulgaria communicated best practices.

Strategies are designed at the regional and national level. An example is the strategy for the Development of Higher Education in the Republic of Bulgaria for the 2014 - 2020 period. One of its aims of the strategy is to “improve the quality of higher education for providing opportunities for further qualification of university lecturers.” Furthermore, distance learning strategies are being developed, supported by corresponding on-line materials, by all universities with operational programs.

Individual universities develop active learning initiatives. An example is the program for adapting the educational system to the needs of the Net generation, 2017, introduced by Russe University.

Finally, educators and researchers in Bulgaria are active on the authoring of scientific papers on active and problem-based learning, which are often presented at national conferences.

A4.2 Estonia

While higher level education is not regulated by state laws, learning activities at the primary and secondary school level are coordinated by the state learning program, a regulation that is mandatory to all schools. The latest version of this regulation puts extra effort on increasing the number and quality of active learning initiatives. It suggests replacing traditional presentation, drill, and practice based activities with techniques that support learners' creativity and collaboration. Diverse national and European initiatives were initiated in order to provide support to teachers who do not have the competences and skills to adapt to the new circumstances. For example one initiative among others was the iTec project (FP7 2010 - 2014), which aimed at promoting innovative teaching strategies, such as outdoor learning, asking students to design teaching models, learning games, educational stories, etc. (ITEC, 2010).

At the university level the use of active learning methods is promoted by different institutions and experts. Following is just a short example of supportive materials and guidelines created for this purpose:

- Tallinn University course on Teaching at Higher Education Institutions, including cooperative and problem-based methodology (Tallinn University Koolituskalender, 2017).
- Tartu University's tips to students on how to be actively involved in their studies, including how to use effective memory strategies, such as taking notes, using mind-maps, using check-lists, etc. (Tallinn University Tudengiveeb).
- Mari Karm's book on higher education teaching methods, such as active presentation, questions based guidance, discussions, debate, group work, case study, problem-based learning, role playing, infographics, etc. (European Commission, EPALE).

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- Mari Karmi, Triin Marandi, Einike Pilli, Katrin Poom-Valickise, and Lehti Pilti's book on active learning methods.
- Tatjana Baum-Valgma and Anastassia Šmõreitšiki book on Active learning methods to teach Estonian language and culture (Baum-Valgma and Smoreitsik 2010).
- Arno Baltin's book on groupwork methodologies (Group Work Methods).
- Jaan Mikk and Hiie Hasser's book on problem-based learning in higher education institutions (Mikk and Asser).
- Maia Lust's book on problem-based methods in e-learning (Active Learning Methods in eLearning).

A4.3 Greece

Problem-based learning is an effective model for producing gains in the development of social skills. It offers a wide range of benefits to students. Some of these benefits can be listed as below:

- Grouping students of all academic levels, mixing the males and females, the athletes, the popular, and the socially awkward, breaks down the social structure of cliques often found within schools and leads to higher self-esteem and better communication skills.
- Students, working both individually and cooperatively, feel empowered when they apply critical thinking to solve problems. In this productive work, students learn and strengthen their work habits and throughout this process, students learn new knowledge, social skills and positive.
- Student activity revolves around a complex series of interactions between team members and draws on a range of key transferable skills such as communication, planning and team working.

Moreover, the teacher's role is less that of an instructor who transmits information and organizes activities for practice and more that of a guide and a facilitator, which it is a critical

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role. Projects require that teachers know their learners' interests. Teachers must listen when learners become excited about a topic, and start asking questions. Facilitating problem-based requires the kind of leadership skills that allow teachers to help a group of learners to move in the direction that they want to go without getting defensive when students decide they like their own ideas better. It is of great importance if teachers possess a tolerance for ambiguity some skills in helping learners negotiate conflicts and enough self-confidence not to give up when a project peters out or refuses to come together.

Problem-based learning is practiced to a certain degree in both school and higher education. In school education, problem-based learning is practiced in the context of mathematics, science, and technology (STEM) courses. Often, problem-based learning is implemented through pen and paper, with the use of digital tools being limited. This is a result of the lack of availability of infrastructures, such as up-to-date laboratories, and the lack of open educational content that can support educational processes in active learning. As a result, the deployment of problem-based learning is deployed through initiatives that take place beyond the formal academic program of a school. In some cases, mostly in private schools, afternoon classes engage students in innovative learning design, such as active learning. These classes may focus on diverse topics that range from mathematics, digital competences, science, art, physical education, and more. It is not uncommon in these contexts to expose students to activities that deploy digital tools. Examples include programming courses or complementary STEM courses through which learners build critical and analytical thinking skills as well as digital competences for the modern age.

Higher education institutions in Greece are autonomous. There is little, if any, interference by educational authorities, such as the Ministry of Education, in the operation of higher education institutions. In this respect, no high level guidelines are provided for the integration of active or problem-based learning.

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Most of the time no formal strategy at the institutional level on the deployment of emerging pedagogical design, such as active and problem-based learning, exists. However, educational institutions do follow European initiatives towards the modernization of education, such as the Education and Training 2020 goals. In this respect, higher education institutions strive to integrate emerging pedagogical design, such as active and problem-based learning, into their training practices. Innovative educational methodologies are often supported by digital technologies in-line with initiatives for bringing education into the digital age.

Problem-based learning is deployed, particularly in medical and engineering studies, through hands-on laboratories that address a wide range of courses and practical activities. One of the challenges faced by higher education institutions is the lack of adequate physical infrastructures, such as laboratories, for supporting problem-based learning. While most higher education institutions do have laboratories, often there is still a need for additional ones for addressing diverse curricula subjects and educational needs. For example, while engineering schools do have well-equipped computer laboratories they may lack energy laboratories that are needed in related courses.

Some examples of deploying problem-based learning in higher education include:

- Designing and developing digital solutions in programming courses.
- Designing and developing digital circuits in engineering education.
- Designing and developing database systems in computer science education.
- Practical training in the industry through apprenticeships.
- Deploying algorithms for artificial intelligence or machine learning for solving specific problems.
- Practical skill development in medicine through direct engagement in university hospitals.
- And more.

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Finally, private initiatives do exist that deploy active and problem-based learning. A good example is after school clubs that engage students in robotics. These initiatives target mostly primary and secondary school learners. They encourage participants to build constructs and program them to achieve a desired behavior. Activities are voluntary and in most cases require a tuition fee. They do provide a sound basis for developing problem-solving and programming skills. In some cases, the clubs further form teams of learners that participate in related regional competitions.

A4.4 Cambodia

The majority of active and problem-based learning activities implemented in Cambodia are related to primary and secondary education. Education reform requires novel initiatives that apply sound policies and procedures. One of the initiatives closely related to active learning is known as “Child Friendly Schools”. It is defined in the official policy document of the ministry of education (Ministry of Education, 2007). A Child Friendly School is defined as a school that values and nurtures what children are able to achieve with their basic rights. Child Friendly Schools collaborate closely with external groups, including parents and other contributors that help build inclusive conditions and conductive environment for all children to attend school. These lead to overall effective and quality learning for children by focusing on the current and future needs of each child. The Ministry of Education clearly defines that the learning environment of Child Friendly Schools is defined by equity, balance, solidarity, freedom, and the outmost care for physical, mental, and emotional health. These lead to the development of knowledge, skills, attitudes, values, and morals so that children can live together in a harmonious way. In 2009, two government officials from the Ministry of Education that were interviewed expressed their delight in the support Child Friendly Schools provide to children and particularly their focus on active-learning and child-centered instruction. Child Friendly Schools represent an example of a very important active learning initiative implemented by the Ministry

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of Education that led to optimal outcomes. Through Child Friendly Schools students are fully engaged and empowered to successfully reach the 4 pillars of learning, namely remembering, knowing, reflecting, and applying.

Another significant initiative was funded and assisted by USAID in 2003. The initiative aimed at providing basic education for children in grades 1 to 9 (Bunlay, Wright, Sophea, & Bredenburg, 2009). The purpose of this initiative is to promote the development of competency-based learning, active learning student-based approaches, and life skills curricula for students. It further aims to enrich teachers' capacity through training. In order to achieve this objective USAID encourages the relevance and quality of basic education by introducing active learning student-based approaches. The program focuses on reform and positive change, supports the recruitment and training of teachers from minority groups, and is integrated into key government education initiatives, including the 5-year strategic and operational plans. This national education reform effort towards active learning yields valuable information concerning the agency's perspectives and efforts related to policies on the enrichment of active learning pedagogies. While USAID does not have existing strategies on active learning pedagogies, USAID-Cambodia fully supports the policy of the Ministry of Education, Youth, and Sport on Child Friendly Schools and requires NGOs to include this strategy in implementing projects funded by the USAID Mission in Cambodia.

Another initiative has been undertaken by a team of researchers from the Royal University of Phnom Penh on a review of selected teaching training materials related to active learning as part of a study for UNESCO on inclusive education (Zimmerman & al., 2009). All reviewed curricula emphasized the necessity of active learning, student-centered approach. However, they have identified some limitations in the methods used. The main methodologies in focus by this initiative are cooperative and collaborative learning, problem-oriented teaching, and individual educational planning and support. In 2009, observation of teacher training at the Kandal Regional Teaching Training Center gave evidence that a significant amount of active-learning and student-centered instruction can be identified in the center’s activities. However, there is a need for more action to increase achievement in active learning. The director of the center reported during a formal presentation to education delegates from other countries in the region that “the practice of the learner-centered approach in learning and teaching has not been efficient enough yet" (Nuon, 2009). When asked later to elaborate, she said that there is a shortage of materials that the center can use to train students in learner-centered contexts and thus active learning is still underutilized. She said, however, that approximately 80% of the center’s trainers are skilled in learner-centered instruction and use it and model it in their own classrooms.

Although active learning and problem-based learning have been applied in university education, concrete information such as official reports or survey results concerning active learning and problem-based learning activities in individual institutions and universities have not been gathered. However, active learning strategies have been widely used not only in public but also in private institutions and in particular in language learning. Teachers select an appropriate active learning strategy differently, depending on the size of the targeted group of students. Possible strategies include but are not limited to reflection papers, debates, peer reviews, and case studies. Furthermore, teachers utilized problem-based learning when real issues require discussion among students. This generates realistic experiences for students by extracting ongoing issues facing Cambodian society and fictional case studies derived from official reports as well as scientific journals. Students involved in problem-based learning are challenged to explore possible solutions to problems, plan actual investigation, clarify controversial ideas, and propose credible and rational resolutions. Further investigation is required for fully documenting the scope of active learning and problem-based learning in Cambodia as information collected is inadequate to clarify ongoing activities in Cambodian educational sectors.

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A4.5 Malaysia

The need for the inclusion of problem-based learning in engineering classes in Malaysia has been the result of broad feedback and complaints received from stakeholders of higher learning institutions, especially the job market (Ministry of Human Resource Malaysia, 2005). Unsatisfactory remarks and complaints of poor quality and performance by a significant number of Malaysian graduates are imminent and have raised concerns in the government, industry, and parents. In consequence, this has led to the gradual process of curriculum review, not only at the primary, but the tertiary level as well.

The Engineering Faculty of the University of Malaya (UM) was amongst the first to introduce problem-based learning in Malaysia through selected courses. The extent of problem-based learning implementation was gradually introduced to students. Problem-based learning content in 1st year courses is low and amounts to approximately 20% of material. This is because 1st year undergraduate students at the faculty were admitted to the university with a Higher National Education Certificate (STPM) qualification or equivalent level, which corresponds to knowledge on core science subjects such as mathematics and physics. Therefore, the types of problem-based learning activities that can be assigned to students are limited to simple problems, which can be solved using high school knowledge. Other fundamental subjects in electrical engineering and telecommunications taught in the 1st year, such as engineering mathematics, circuit theory, and electromagnetic theory, are still taught using the conventional method in order to establish solid ground of theoretical and fundamental knowledge.

In the 2nd year, the implementation of problem-based learning may be more extensive. Commencing in the 2003 - 2004 academic year a course on thinking and communication skills was taught to all 2nd year undergraduate students at the University of Malaya. This course is based on the premise that thinking and communication skills can be enhanced if taught in an organized approach (University of Malaya, 2003). With regards to problem-based learning, it is hoped that these skills can be utilized in tackling problem-based learning assignments in other faculty courses. By the 2nd year, the undergraduates' knowledge in engineering is increased. Therefore, the number of courses that may be taught using problem-based learning may be increased to approximately 40%. With the same understanding, the number of courses taught using problem-based learning may be increased even more in the 3rd year to 60%. By the time students reach their 4th and final year of study, they have developed enough engineering knowledge and independence to allow most of the 4th year courses to be taught using problem-based learning approaches.

A4.6 Nepal

Active and problem-based learning has been practiced in Nepal for 30 years. Practices evolve every 10 years (B., E., MR., & H., 2012). The first institute to introduce active and problem-based learning in Nepal was the Institute of Medicine, Tribhuvan University.

In 2011, with the great support of faculties of Harvard University, active and problem-based learning were introduced to the 1st batch of MBBS students in Kathmandu University School of Medical Sciences. The university has been applying problem-based learning academic programs during the pre-clinical stage, i.e., the first 2 years of studies in the MBBS program. During this period, approximately 1 / 3 of the total academic hours deployed to engage students in approximately 40 cases are covered using problem-based learning.

In Kathmandu University School of Medical Sciences, problem-based learning may be used either as the mainstay of an entire curriculum or for the delivery of individual courses. In practice, problem-based learning is usually part of an integrated curriculum that uses a systems-based approach, with nonclinical material delivered in the context of clinical practice. A module or short course may be designed through mixed teaching methods, including problem-based learning, to achieve the desired learning outcomes in knowledge, skills, and attitude development. A small number of lectures may introduce topics or provide an overview of difficult subject material in conjunction with problem-based learning scenarios. Sufficient time

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should be allowed each week for students to engage in self-directed learning required for problem-based learning.

The activities deployed by Kathmandu University School of Medical Sciences in problem-based learning (Mansur, Kayastha, Makaju, & Dongol, 2012) are problem-based learning cases, problem-based learning groups, problem-based learning sessions, problem-based study sessions, and wrap-up sessions.

Following is a discussion of each method.

Problem-based learning cases:

During the class, the faculty member - tutor selects or creates cases or problems relatable to regional health problems. The format of each problem simulates professional practice or a real life situation involving a real or standardized patient or a paper case. It is the tutor's or facilitator's job to prepare clinical-based cases that can introduce basic concepts on a particular problem. Before introducing a case into a class, faculty members discuss in a group the benefits of the case and come up with concrete results to share among tutors and co-tutors. On average, 3 cases are introduced in a 4 – 5 weeks block of studies and 4 - 5 cases in a 6 – 8 weeks block. Since problems and cases cannot be concluded and solved in the very first attempt, class participants are allowed to use other forms of media, such as video, the internet, and digitized computer applications to synthesize solutions. Cases are constructed in a manner that allows students to explore what they already know until it becomes evident to them that they do not have enough information to make a decision towards a solution, making imperative the need for additional research.

Problem-based learning groups:

Problem-based learning provides a logical approach in training students for practicing medicine in a complex environment by exposing them to simulated problems that reflect real life. The adoption of problem-based learning by medical schools is a positive development. Generally,

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problem-based learning groups consist of 6 - 8 students. However, in the case of Kathmandu University School of Medical Sciences problem-based learning group may have up to 10 students, where one student has the role of the chairperson and another the scriber. Each group is assigned at least one tutor, who is an MBBS doctor, and one co-tutor.

Problem-based learning sessions:

Problem-based learning sessions have a duration of 2 hours and are delivered 3 times per week. During a problem-based learning session participants identify problems as a primary source of learning. The sessions start with the tutor creating a group setting. Problem-based learning sessions focus on a learning process in which students are encouraged to initially analyze problems by themselves before accepting help from tutors. In problem-based learning sessions the tutor has the role of a process manager and not necessarily an “expert”. The tutor is only considered to be except in the process.

In Kathmandu University School of Medical Sciences problem-based learning is based on clinical and relevant cases through which each group identifies and clarifies unfamiliar terms. Students first define problems; subsequently they analyze them to develop an understanding of underlying causes. Their job is to summarize and discuss the analysis. Each group formulates learning objectives and then each student is assigned self-study on related topics. Upon completion of this process group members brainstorm collectively building their understanding of a given problem.

Problem-based learning study sessions:

After each problem-based learning session a 2 hour problem-based learning study session time is allotted. Students use this time to prepare for problem-based learning. During study sessions, students use available resources among their peers, available books in library, journals, internet resources, and research results.

Wrap-up session:

At the end of each block a wrap-up session takes place. It lasts 1 hour. In the wrap-up session students select and present different topics related to the problem-based learning cases that they worked on. All faculty members are present in the audience.

A4.7 Pakistan

Examples of active and problem-based learning in Pakistan include peer teaching and peer assessment for policy studies. Peer teaching focuses on policy studies (Sarwar and Shah). In peer teaching students teach their peers and learn from each other. It has been extensively applied in education to increase students' involvement and learning. Peer teaching aids students by encouraging an in-depth immersive study of material in order to analyze and select key concepts that they present in their own words to teach their fellows in higher education. Peer teaching empowers students and promotes their active engagement in learning and responsible attitudes in peer assessment. In Pakistan, assessment is limited to examinations that may prove to be biased. However, studies have shown that there is a strong positive correlation between peer and teacher assessment, which enhances the dependability of peer assessment. The researchers concluded that at the university level peer assessment may be used in addition to teacher lecturing for students' learning. Students' involvement in active learning through peer-teaching and peer-assessment is found active, operative, and effective. The authors found that through peer teaching, learning experiences are more autonomous, interactive, independent, and reflective.

Furthermore active and problem-based learning is related to the pedagogical practices of cognitivism and constructivism (The pedagogical practices) for ADE/BEd (Hons.) programs. A study was conducted to establish the degree to which active learning strategies applied in lectures provide increased student engagement and improved learning outcomes. Cognitivism and constructivism are the foundation for active learning. Students are involved in reading, writing, and discussions in the classroom. These activities help build higher order thinking skills

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and enable students to analyze, synthesize, and evaluate. Active learning techniques emphasize the undeviating and direct involvement of students with the learning material. Related activities may include brainstorming, quick surveys, think-pair-share, short writes, debate, role playing, cooperative learning, collaborative learning, formative quizzes, and simulations. A passive teaching and learning environment can be transformed to active by simply changing traditional lectures through the incorporation of active learning strategies.

A4.8 Portugal

A series of national initiatives promote active learning in Portugal. The majority of universities apply active learning in engineering but also in sciences and health.

The Games Interaction and Learning Technologies (GILT) Research & Development Group, located at the Engineering College (ISEP) of the Porto's Polytechnic Institute (IPP), focuses on the analysis, design, and development of scientific and technical knowledge in the fields of serious games, assistive technology, learning technology, interaction, and health technology. This mission is integrated with post-graduate programs at the MSc and PhD level instigating students to learn in a proactive form once they are part of the team that designs, develops, and tests ongoing projects. Emphasizing the relevance of collaboration, GILT is also part of leading international collaborative projects and joint initiatives with other academic and commercial institutions that promote these innovations in the education field.

A practical example worth mentioning and provided by GILT is the case of a haptic simulator titled Forces of Physics, developed to help learners understand the relation between theoretical physics concepts and their practical application. The simulator aims to complement the traditional educational process providing students with hands-on experiences, implementing an experimental learning methodology (Vaz de Carvalho & Santos, 2013).

Another successful example is the eCity Serious Game, in which the main objective is to design, develop, and validate a problem-based learning oriented online collaborative virtual learning environment platform based on a city-development simulation engine that stimulates the integration and continuous exploitation of problem-based learning. The game targets secondary education students but demonstrates the importance of disseminating these practices in Portugal.

Still focusing in the engineering field, another example of problem-based learning involves the integration of new students in the Systems Engineering Course. This program was designed following the principles and recommendations established in the Conceive-Design-Implement-Operate initiative. During the initial 4 weeks of the 1st semester students are engaged in a single subject, Engineering Labs I (LENG1), where a problem-based learning methodology is implemented. The study presented refers to the 2016 - 2017 academic year, in which 48 students attended the program. The study presents 2 different student projects, including their objectives and results. The students' comments regarding their acquired competences and motivations are also presented (Magalhães, 2018). According to the study, "problem-based learning and teaching provided a context of design and project, an active and experiential learning in a multidisciplinary environment. Thus, students obtained a set of ethical, social, and technical skills, such as teamwork, research, inter, and intra group communication and report writing, which will be useful for the rest of the course and their professional future. Projects worked out were motivating for the students to learn different areas of engineering and integrate them in the class, ISEP campus and city and established good principles of commitment in teamwork." (Magalhães, 2018).

Expanding outside the engineering field, Algarve University makes use of a simulator in the Bachelor Degree in Enterprise Management. In the last semester of the degree students may choose the curricular unit Entrepreneurial Games, which explores a business simulator named Cesim Global Challenge for learning purposes. It explores various areas of management and facilitates the development of diagnostic, analysis, and decision-making skills in the context of overall management (Kikot & al., 2013).

Conclusively, Portuguese higher education institutions, particularly in medical sciences and engineering, are starting to apply active learning methodologies with excellent results which are the basis for a systematic adoption of these methodologies.

A4.9 United Kingdom

Innovation in teaching and learning in UK universities tends to lag behind innovation in compulsory education. Political or altruistic drivers for change are not the same in the two sectors. Innovation instead is primarily driven from two positions:

- The natural inquisitiveness of academics.
- An economic desire to keep the UK higher education system competitive and effective.

In the UK higher education system there is no national curriculum and so the individual lecturer typically has considerable flexibility to structure their teaching by determining the mix between lectures and workshops by asking for certain rooms and by suggesting certain physical spaces. Within that, and given that the academic can then also structure each learning event as she thinks fit, obviously constrained, to some extent, by the rooming. Over several years enthusiastic staff in universities have explored many active learning methods, especially the use of clickers on lecture theatres (Abdulwahed, Jaworski, & Crawford, 2012), the use of flipped classrooms (Bryson, 2016) and the use of problem-based learning (Seery, 2015). There are many papers that document these initiatives.

External influence in UK Universities comes from two instruments that are not entirely independent. They are the National Students Survey (NSS) and the Teaching Excellence Framework (TEF). The National Students Survey is an annual survey that was started in 2005. This survey opens between January and May each year and asks a set of questions that are then scored so that a rating can be given to each course in a university. The NSS scores directly influence the positions of universities and courses on league tables. Given the importance of league tables on recruitment universities are extremely anxious to maximize National Students

Survey scores and so spend a lot of money and time on trying to improve their National Students Survey scores. Questions in the National Students Survey that might encourage universities to think about learning spaces and learning paradigms include:

- The digital resources and facilities provided have supported learning well.
- Students have the right opportunities to work with other students as part of their course.
- Staff has made the subject interesting.

Other questions provoke responses that could also be enriched by having better learning experiences:

- The course has provided opportunities to explore ideas or concepts in depth.
- The course has provided opportunities to bring information and ideas together from different topics.
- The course has provided opportunities to apply new knowledge.

As well as the National Students Survey, a more recent innovation is the Teaching Excellence Framework (TEF). This is another government driven initiative designed to rank and score universities on their teaching quality. The Teaching Excellence Framework was initiated in 2017 and awarded universities with a bronze, silver, or gold status. From 2020, Teaching Excellence Framework will start to score subject areas in a similar way to how research has classically been ranked using the REF exercise. Teaching Excellence Framework uses three of the results from the National Students Survey, teaching, assessment, and academic support, together with data on student dropout rates and data on graduate destinations.

These two scoring systems initially encouraged universities to invest heavily on monitoring feedback on assessments as well as focusing on improving student support, the low hanging fruit of the National Students Survey and Teaching Excellence Framework orchard. More recently, as all universities have upped their game in these areas, there has been a nationwide

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push towards enhancing the entire learning experience so that there are simply happier students.

A4.10 Vietnam

In Vietnam, problem-based learning has not been formally introduced but there is a trend towards active learning. In Vietnam, Intel is involved in engineering education and according to their report the learning methods are mostly passive. There was little to no active or student-centered teaching approaches and especially project-based ones (Intel, 2013). More broadly, the Higher Engineering Education Alliance Program (HEEAP) recently audited the country's current engineering education system. Vietnamese and American Universities and several international corporations worked towards supporting the systematic transformation of Vietnamese engineering education through a joint alliance. It is worth highlighting 2 action items of the alliance that took place in the 1st pilot, HEEAP 1.0 (2008-2013):

- Designing multidisciplinary and problem-based curriculum.
- Training Vietnamese academics to new active learning and teaching methodologies.

Outcomes from this phase indicate early success and positive feedback. Active learning techniques, such as cooperative learning, were well received by students. The students were also reported to enjoy the new activities and projects as well as learn in HEEAP classes (Intel, 2013). Following these initial outcomes, it is reasonable to say that there is a demand for active learning methods at national level.

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A5. BEST PRACTICES IN THE USE OF ACTIVE AND PROBLEM-BASED LEARNING

A5.1 Bulgaria

Following is a discussion of best practices in the country.

The Medical University of Pleven uses a hybrid teaching model combining traditional with problem-based learning. The teaching model integrates problem-based learning sessions based on clinical cases, lectures, and laboratory classes.

Teaching deploys problem-based learning sessions in which students work in small groups of 6, guided by a tutor. Students are given a clinical case for a discussion, where hypotheses are presented. The unanswered questions are left to be further researched at home. Students collect data and analyze the new information. When back in the classroom, the clinical case is discussed again. In case new questions arise during the second session, students continue to execute the subject-related research at home.

The benefits were measured through the engagement of 101 students and 33 lecturers. The learning results of the hybrid method are compared against those of the traditional teaching and learning model.

The following benefits are identified for students:

- Better presentation skills.
- Overcoming the power distance between the lecturer and students; building trust and friendship.
- Critical thinking.
- Better communication skills.
- Team work.

- Higher requirements towards the lecturers.
- Systematic and regular preparation for classes every week.
- Lower level of stress.
- Better group dynamics.

The following benefits are identified for teachers:

- Improved teaching competence.
- Overcoming the power distance between the lecturer and students; building trust and friendship.
- Becoming aware of innovative teaching methods and content in similar subjects.
- Reconsidering their teaching practices.
- Increase satisfaction from their professional practices.
- Lower level of stress.

The Technical University of Gabrovo uses a teaching model that is problem and project-based. This model is incorporated in the 3rd and 4th year curriculum in the degree course in Mechatronics. The university further uses problem-based learning in an apprenticeship cluster for industry-ready engineers of tomorrow.

Problem-based learning is one of the teaching methods identified in the curriculum of individual study programs. Students work on real-life industrial problems in teams under the coordination of lecturers. Project-based learning is incorporated in apprenticeships in which students work at enterprises on projects involving them in teamwork with company engineering staff, guided by academic and company mentors.

The following benefits are identified for students:

- Higher motivation to learn and develop their skill sets.
- Successful teamwork.

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- Enhanced analytical and critical thinking.
- Better communication and presentation skills.
- Higher level of creativity.
- Regular preparation for class work.
- Overcoming the power distance between the lecturer and students; building trust and friendship.
- Time and priority management.

The following benefits are identified for teachers:

- Improved teaching competence.
- Overcoming the power distance between the lecturer and students; building trust and friendship.
- Becoming aware of innovative teaching methods and content in similar subjects.
- Reconsidering their teaching practices.
- Increase satisfaction from their professional practices.

A5.2 Estonia

Garage 48® is a startup hackaton series for turning ideas into prototypes (Garage48, 2020). The group organizes series of events focusing on different problems and objectives, such as how to support elderly people with the help of innovation and technology. In the beginning of each event participants present their ideas. Small teams are formed around most promising ideas. Teams work intensively over 48 hours to develop an initial prototype. In the end of the event prototypes are presented and winners are selected. Meanwhile teams get support from mentors and experts. Hackatons have proven to be an efficient method for creating new products and services, for starting new companies, and for building networks.

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Hackatons are active learning events similar to Garage 48®. The main difference is that they are coordinated by a different organization and in different formats. The common aspect of every hackaton is that people who don't know each other gather together, form teams, and design prototypes or solutions to specific problems during a limited time period. Every hackaton can be different in duration, ranging from half a day to one week, price list, or follow-up activities. Hackatons are coordinated by different organizations and institutions like universities, research institutions, non-profit organizations such as IGDA Estonia (IGDA, 2020), and more.

Game Founders (Game Founders, 2020) is a global game accelerator, established in Estonia. It is an incubator for game startups and indi studios. This is a business initiative that invests in promising game startups. It is a unique arrangement of game related learning activities. Teams and studios selected for this program physically change their location and work next to each other over a period of 3 months. The organizers further provide a mentoring program and organize regular design and development sessions. Team members learn from each other through practice. They further learn from different game industry experts. Attendees have provided as feedback that 15 minute discussions to introduce answers to current development, design, or marketing needs with an expert are as valuable as a 1 year study at a university.

Mektory (Mektory, 2020) is a Tallinn University of Technology innovation and business centre. Its objective is to bring together scientists, students, and entrepreneurs to solve practical problems and generate new ideas. It contains several laboratories for testing and demonstration such:

- Wood lab.
- Metal lab Welding lab.
- Paint lab, Automaticum.
- Electronics lab.
- Mechatronics lab.
- Cool Tool studio.

- 3D Printing Innovation Lab.
- App lab.
- LEGO lab „Playful learning“.
- Smart Lab.
- Virtual reality lab „Re:Creation“.
- eHealth lab.
- eRiik.
- Space Centre.
- And more.

Mektori offers training, consultations, and support for students, startups, and other target groups interested in R&D and Innovation.

Bank of ideas is one example among several others how industry partners cooperate with Mektory (Bank of ideas, 2020). This is a seminar room sponsored by the Swedbank®, a leading finance institution in the Baltic and Scandinavian area. This is an example of collaboration between universities and private companies. In the current case Swedbank® is interested in developing innovative solutions for supporting the financial literacy among youngsters and young adults. They offer meaningful problem statements and financial support for university students who are interested in developing innovative solutions.

Game Lab (Game Lab, 2020) is a community of game development enthusiasts who coordinate game design and development events in different Tallinn universities and game industry institutions. All activities are based on the effort of volunteers and the main learning strategy is community-based learning. Participants learn from each other and from industry experts. The Game Lab target group is not limited by age. Game Lab organizes different game development events, including hackatons.

A5.3 Greece

Following are examples of problem-based learning practices in engineering courses in the Department of Electrical and Computer Engineering of the University of Thessaly.

The Programming course (ECE115 Programming I) exposes 1st year students to the main concepts of programming and problem solving with computers. It introduces C, a classic, powerful procedural programming language. The course includes a mandatory lab in which participants apply in practice in a series of exercises the material taught in class in order to familiarize themselves with the concepts and techniques. After successfully fulfilling the requirements of the course, the student is capable of:

- Analyzing the requirements of problems which are to be solved with a computer and synthesizing a solution.
- Producing solutions which strictly comply with given specifications.
- Knowing the main characteristics and structures of the C programming language and applying the most appropriate on a case-by-case basis to implement algorithmic solutions.
- Applying the basic principles of software engineering in order to organize code efficiently in terms of structure, readability, and design.
- Verifying the correctness of programs and identifying errors.
- Using program development and debugging tools.
- Working both individually and synergistically in small groups, with specific time limitations.

The Numerical Analysis course (ECE220 Numerical Analysis) aims to provide students with the necessary knowledge and tools to solve known mathematical problems arising directly from hardware and telecommunications, including solving of systems of linear and nonlinear equations, differential equations, data approximation, and more. The MATLAB® software suite,

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which is well known and used by engineers and computer scientists, allows students to apply theoretical work in practice. The course builds skills such as:

- Building a good understanding on how to solve linear systems by direct and iterative methods and will be able to choose the proper method per problem.
- Building knowledge on basic methods of solving systems of nonlinear equations.
- Building knowledge of data approximation and interpolation methods using polynomials, splines, and trigonometric functions such as Fourier.
- Building knowledge on basic numerical methods of finite differences differentiation and integrations.
- Being able to understand the effect of finite arithmetic errors and errors of methods in numerical results.
- Building basic knowledge on the use of MATLAB® and its toolboxes.

Additional good practices on the deployment of problem-based learning involve the organization of workshops and seminars that engage both higher and secondary education stakeholders. Participants in these workshops are both educators and students. Related initiatives are often organized by secondary education authorities, professional societies such as the Hellenic Mathematical Society, and higher education institutions, such as the University of Thessaly. Audience members have an opportunity to reflect on the benefits of problem-based and active learning towards building 21st century problem-solving skills for society and industry. They further have the opportunity to be exposed to specific digital solutions that support problem-based learning, such as digital learning platforms, learning management systems, digital applications or simulations, and more. Related initiatives were organized in the spring of 2019 by the University of Thessaly in the form of 2 separate workshops that engaged a total of 160 individuals. The 1st event took place on April 4, 2020 and focused on design thinking. The 2nd took place on May 5, 2020 and focused on problem-based learning in secondary education. The audience feedback was in both cases very positive. Participants had the opportunity to

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apply problem-based learning hands-on by engaging in workshops that deployed both digital tools and off-line problem-based learning activities.

Finally, another good initiative for problem-based learning is project HERA (HERA, 2019) that focuses on the development of a learning game that targets higher education students in engineering and economics and aims to build problem-solving skills. Through the HERA game students are engage in non-trivial problems inspired by real world scenarios. The problems are open-ended, meaning that there is not only one correct solution. To solve a given problem students need to integrate knowledge from across the curriculum in a manner that simulates problem-solving practices in industry. The HERA game is a city-builder multiplayer application in which students work in teams to achieve a specific objective. Furthermore, each student in a team has individual objectives, which may be conflicting with those of other team members. For example, team members may share a common budget and need to make decisions on how to allocate common resources. The HERA game allows educators broad flexibility in designing educational activities through a scenario developer facility through which they define the overall objectives, the roles of team members, and the individual objectives of each role. Furthermore, educators may design a pre-built city plan on which students are challenged to work. The game offers rich features for city plan development including a variety of residential buildings, public buildings, commercial buildings, energy production options, parks, vehicles, and more. It further supports terrain formatting, diverse weather conditions, and day-night cycles. This variety allows the design of rich scenarios that address diverse educational objectives. Furthermore, the game offers functionality for planning the timeline of the implementation of a solution that students may use for project management purposes. Finally, the game offers a joint brainstorming area in which team members may share ideas on a common canvas that may be simultaneously updated by team members that work either in the same room or remotely.

A5.4 Cambodia

According to Ginsburg (Ginsburg, 2010), USAID has introduced initiatives and organized activities and workshops in Cambodia in order to promote active learning pedagogies. Moreover, the Cambodian government seeks to revise some of the primary and secondary curriculum to stimulate active learning. This is pursued through foreign aid. Currently, instructors do not routinely practice active learning pedagogies and the quality and intensity of programs varies widely depending on international assistance. Despite unpromising response, teachers participating in USAID-supported initiatives reported that they have significantly improved their knowledge and understanding of active learning and the cooperative learning approach. As students are directly involved in problem-based and active learning, they are likely to become more confident to express themselves and participate in discussion. What is still unclear in this initiative is the degree to which teachers apply problem-based learning towards building critical thinking skills.

A5.5 Malaysia

While the use of problem-based learning in courses such as medicine and management is quite common in Malaysia its adoption in engineering is limited. An exhaustive literature review performed found a total of only 6 published works that described problem-based learning implementation in engineering and related courses. The review focused on journal articles and conference proceedings on the implementation of problem-based learning in Malaysian institutions of higher learning available in bibliographic databases that specialize on education and social science research. Works that describe case studies on the use of problem-based learning in engineering related courses at institutions of higher learning in Malaysia are described below:

The 1st study was performed at the Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn (UTHM), one of the public IHLs in Malaysia (Hashim et al, 2006). In the first semester of the 2005 - 2006 academic year the Faculty of Civil and Environmental Engineering introduced problem-based learning in the Solid and Hazardous Waste Management course. Two topics were selected for this purpose:

- Proper Management in Hazardous Waste Handling.
- Treatment and Clinical Waste Disposal: Comparing the Technology.

Each topic was covered for a period of 2 weeks. During problem-based learning sessions students were divided into 3 groups of 6 individuals. Assessment was based on their workload, nature of problem-solving project, individual and group participation, and aspects of creativity in their presentation.

Evaluation was performed at the end of the semester. It was found that students achieved better grades topics in which problem-based learning was deployed. Improvement was evident in interim tests and the final examination as compared to the previous semester when problem-based learning had not yet been implemented. Students enjoyed the experience of working in teams compared to learning conventionally through lectures. The problem-based learning sessions also gave students the opportunity to better familiarize themselves with inquiry-based learning and searching for materials via the internet, books, and journals within limited time. The findings reveal that the benefits gained by students are not limited to only the content of the subject; rather, problem-based learning addresses the equally crucial aspect of human resource development building soft skills such as leadership, analytical thinking, conflict management, decision making, and more.

The 2nd case study was performed at the same university, UTHM, but at a different faculty, namely the Faculty of Electronics and Electrical Engineering. The problem-based learning method was first implemented in the Microelectronics course. The objective of problem-based learning was to enable students to design a 4-bit carry-lookahead adder using both top-down and bottom-up approaches. Ten undergraduate students were involved working as a team to accomplish the task. Each team member were assigned specific tasks towards achieving the common goal of coming up with the required carry-lookahead adder design. Over a period of 2 months students developed familiarity with new computer-aided design and electronic design automation tools, determined the most suitable methodology flow, and prepared documentation and a presentation on their project.

The feedback provided by the students was positive throughout the course. Students commented that they benefitted significantly both through theoretical and practical aspects of the course. The assigned problem generated excitement and fostered student curiosity to know more. Students explored new ideas and synthesized solutions through the deployment of newly introduced software and techniques that they were exposed to. Furthermore, students brainstormed and exchanged ideas in groups. They improved their study skills, including conducting library research, referencing, and executing simulations. At the end of the session the results of student work, which involved 4-bit carry-lookahead adder codes and a 4-bit carry-lookahead adder layout were made available to all. Simulations on both end products were presented and validated against initial specifications, minimum area used, fastest speed, and least amount of transistors used. In general, the problem-based learning project encouraged students to become proactive, creative, innovative, and more responsible towards their academic development. The project enhanced students' problem solving skills, management and communication skills, leadership skills, teamwork capacity, and other soft skills required of competent engineers.

The 3rd study involved the Universiti Teknologi Malaysia (UTM), another public institute of higher learning in Malaysia that applied problem-based learning and cooperative problem-based learning in the teaching of Process Control and Dynamics at the Faculty of Chemical and Natural Resources Engineering (Mohd-Yusof, Hassan, Jamaludin, & Harun, 2011; Yusof, Hassan, Jamaludin, & Harun, 2012; Yusof, Tasir, Harun, & Helmi, n.d.). This was a pilot implementation of problem-based learning that resulted to its wider deployment in the campus by other

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faculties, such as Faculty of Mechanical Engineering, the Faculty of Electrical Engineering, and the Faculty of Civil Engineering. Combining cooperative learning with problem-based learning at the Universiti Teknologi Malaysia emphasized learning and problem solving in small teams consisting of 3 - 5 students. The opportunity to learn in small groups greatly improved students' focus and understanding. In general, it was concluded that a medium size class can effectively support up to 60 students overlooked by one floating academic staff member or facilitator (Yusof et al., 2012). In conclusion, students appreciated, enjoyed the experience, and benefitted from cooperative problem-based learning over a period of one semester.

A5.6 Nepal

Active learning for teaching learning was initially deployed by Professor Dr. James M Widmann from the California Polytechnic State University and Fulbright Scholar in association with Mr. Binay KC in the fall semester of 2012.

The Strength of Materials course offered by Department of Mechanical Engineering to 2nd year undergraduate was taught through active learning. The class consisted of 60 students. Activities included a 3-hour lecture and a 1-hour tutorial each week. Each class period was divided into 2 sessions, each led by a different instructor. Approximately half of the sessions deployed active learning; the other half deployed a traditional lecture format or an example-problem format. Activities delivered in traditional lecture formats used a deductive approach. General theory and concepts were presented through lectures, followed by application examples. The course instructor used the Socratic Method to encourage student attention and thinking during class.

In sessions that deployed active learning, changes were introduced in the lecture mode. The sessions started with the presentation of problems that were communicated to students in advance on-line through email. Furthermore, students were asked to review the problem presentations prior to joining the class. In class the instructor used the following active learning techniques:

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- Think-pair-share activities.
- In-class group problem solving.
- Ranking tasks.
- Liberal use of the Socratic Method.

A survey was conducted to assess the student's attitude towards active learning. 49 students completed the survey. The survey results demonstrate that students found the course conducted through active learning interesting, motivating, and helpful towards understanding educational content. Out of the 4 different active learning techniques deployed, students found ranking tasks and multiple-choice concept questions to be the most interesting and motivating (Widmann & K. C., 2013). Students also reported that these two activities helped them in building new knowledge. The survey also showed that the traditional lecture format was ranked the second lowest by students in terms of helping them understand course material.

Active learning was further deployed in the Department of Computer Science and Engineering. In 2016, the Department of Computer Science and Engineering (DoCSE) initiated the deployment of engaged learning, which is a method of student-centered learning. This project was implemented in collaboration with the United Nations Asian and Pacific Training Centre for Information and Communication Technology for Development (UN-APCICT/ESCAP). The objectives of incorporating engaged learning were the following (Shrestha, Gupta, & Colle, 2016):

- To evaluate the effectiveness of engaged learning on knowledge development.
- To identify faculty members' perceptions regarding the effectiveness of engaged learning.
- To identify the community's perceptions towards the developed system.
- To demonstrate how university level credit-based courses can be carried out by incorporating community service.

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The activities carried out during engaged learning were differentiated into 3 parts.

Pre-engagement activities included:

- Selecting 3rd year undergraduate students from the Department of Computer Science and Engineering to participate in the pilot program.
- Studying engaged learning toolkits provided by the United Nations Asian and Pacific Training Centre for Information and Communication Technology for Development by students and faculty members.
- Delivering initial training and awareness raising sessions to students regarding the community to be visited and the methodology of the content to be delivered.
- Identifying the sources for getting information related to foreign employment.
- Collecting information and having discussions with group members.
- Developing the SMS-based query response system and Android® based mobile application Saarthi.
- Testing the application in a simulated environment.
- Developing an operating manual for Saarthi mobile application.
- Conducting student evaluations by project supervisors through a mid-term examination.

Engagement:

- Field testing the developed system by reaching to the community people to identify its effectiveness and drawback.
- Preparation of Video while undergoing field test.
- Writing the reflection by students and involved faculty members to share their experience during the field test.
- Conducting an evaluation of the pilot implementation of the project by a project supervisor.

Post-engagement activities included:

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- Preparing student reports on their experiences from and understanding of engaged learning.
- Preparing faculty member reports on their experiences from and understanding of engaged learning.
- Developing a final 15-minute video.
- Conducting an evaluation of the pilot implementation of the project by an external examiner.

Both students and faculty members provided feedback on their experiences in engaged learning.

Following is a summary of faculty member feedback:

- Engaged learning provided an opportunity to work for a social cause.
- It allowed educators to take a closer look at student learning and to identify student problem solving capacity.
- It helped establish a strong bond with students towards achieving common goals.
- It helped underscore the importance and impact of the effective use of ICT to communities.
- It helped enhance student communication skills during interactions with community members.
- It helped identify community challenges that can be addressed through engaged learning.

Following is a summary of student feedback:

- Engaged learning helped students build communication capacity with the public. In the past students used to avoid involvement with large groups. Through engaged learning they became more comfortable in their communication and became determined to further improve their communication skills, which are as important as technical skills.

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- It helped students explore new grounds and develop field work experience.
- It facilitated the reinforcement of existing skills and the acquisition of new ones.
- It facilitate knowledge development through the design of digital solutions to community challenges.

Following is a summary of community member feedback:

- Engaged learning is very effective on gaining useful information regarding foreign employment.
- It helped build knowledge on the effective use of mobile devices for retrieving information.

Furthermore, the engaged learning modality was piloted in the Department of Computer Science and Engineering. a group of 12 students was selected for undertaking the engaged learning course. During the course students held weekly meetings with their supervisor to discuss their progress. The course content was delivered to students from educators through a group email account. Students used Github® for sharing their software code among team members and with their supervisor. They used Google® docs for sharing documents among group members.

A5.7 Pakistan

Following are examples of AL active and problem-based learning in Pakistan.

One example involves the deployment of flipped classroom principles in medical education. A study was conducted to explore the benefits of flipped classroom in medical education. The teachers reversed the order of school work and homework. They achieved this by either recording their lectures or using previously available video lectures from the internet. Before coming to class students watched the video lectures and discussed the related topics in the classroom in a social learning style with the help of a facilitator. The results revealed that

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students were inclined to use technology and favored this mode for teaching and learning. Students felt content and relaxed while learning in experimental social situations. The study suggests that it is vital to seek ideas on applying digital technologies as effective promoters for active, self-directed, and deeper learning. Results further demonstrate that flipped classroom is an effective active learning method for enhancing student involvement and learning.

The next study involves the deployment of visual aids in the Education Department at District Dera Ghazi Khan. A study proposed the use of visual aids for stronger, clearer, and easier understanding of lessons. Visual aids used include:

- Models.
- Actual objects.
- Charts.
- Pictures.
- Maps.
- Flannel board.
- Flash cards.
- Bulletin board.
- Chalkboard.
- Slides.
- Overhead projector.
- And more.

Of these, the blackboard and chalkboard are common tools used in traditional teaching environments. The authors used a blended approach to integrate textbooks with audio visual aids as additional or supplementary resources in the classroom. The results revealed that that students and teachers demonstrated positive attitudes towards the use of visual aids.

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Another study involves experiential learning in business schools in Karachi. The study was conducted to explore the use of experiential learning in Marketing, Human Resources Management, and Finance courses at 5 leading business schools in Karachi (Higher Education Commission Vision-2025, 2017). The researchers used an experiential learning scale (UELS) developed to document results. Findings indicated that experiential learning, though comparatively a new concept in business education in Pakistan, has found its way into business education.

Another example involves the use of models for investigating the learning style preferences of medical students. A related study used the visual, auditory, read/write, and kinesthetic sensory modalities model (VARK) for determining learning styles. The model delivers enables learners to build insight of their favored sensory modalities in receiving and understanding information. For better processing information visual learners favor seeing; auditory learners listening; read/write reading; and kinesthetic learners practicing. The learning style of a person is her preferred method to gather, process, and deduce, consolidate, and examine information. A variety of tools exist for determining a student's learning style, including Honey and Mumford, VARK by Fleming, and Kolb's learning style inventory. These tools are based on different principles of learning, learning theories, and psychological constructs.

Another study involves the use of active learning practices at the Suleman Dawood Business School (SDBS). The primary teaching methodology used at the Lahore School of Management Sciences (LUMS) is case-based learning that encourages student participation in active learning. It develops a remarkable ability to analyze theoretical frameworks, to debate and develop arguments, and to make quick decisions in challenging, uncertain situations. The Suleman Dawood Business School is a pioneer of case-based education in Pakistan. This avant-garde method of studying aids students in discovering solutions to real-life business issues in a classroom setting by placing them in decision making roles. Students are involved in real life managerial situations where they debate the odds of businesses and create innovative solutions

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through the exchange of perspectives. Through case-based learning students are exposed to business scenarios inspired by real life and undertake the role of decision maker. They are divided into study groups that collaborate in a discussion room prior to joining their peers in the classroom.

Discussion groups take place before the class session. They deploy collective learning and interaction to augment individual preparation. Intensive interaction with group members enhances team spirit. Groups meet between sessions to prepare for the next class. Each member contributes her individual analysis and personal point of view on the issues of an assigned case. Through sharing of diverse views and insights the overall collective understanding of the case is enhanced, validity of arguments is determined, and new dimensions are introduced to the challenges and prescribed solutions. For mandatory discussion groups students must ensure punctuality, attendance, and active participation. Failure to do so results in disciplinary action. For optional discussion groups students are strongly encouraged to use the allocated time for group discussions but are allowed individual discretion regarding attendance.

Discussion group preparation leads to a class session, which is a collective classroom discussion under the guidance of an instructor. Contribution to classroom discussion is extremely important and constitutes a significant percentage of the course grade. Effective class contribution requires active listening by students.

An important component of the MBA program is the weekend assignment, which involves a written analysis of a case (WAC). Students receive the assignment through email usually on the last working day of the week. Student deliverables must meet the requirements specified in the weekly schedule. Both content and style are important in grading a student response to the assignment. In addition to case analysis, students also need to pay attention to elements of style such as grammar, spelling, structure, and presentation of the report. A late report is not accepted.

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A5.8 Portugal

An example of active learning in Portugal involves the informal network Active Learning in Engineering Education (ALE), a community of students, engineers, educators, and other individuals dedicated to improving engineering education through active learning techniques. The network was established in 2001 by the University of Minho. According to its creators, “ALE creates opportunity for practitioners and researchers of engineering education to collaboratively learn how to foster learning of engineering students” (Lima & al., 2017).

Another example of active and problem-based learning at Minho University involves the curricular unit of Child and Adolescent Health Nursing that is part of the 3rd year studies towards the Bachelor Degree in Nursing. Active and problem-based learning was initiated in the university in academic year 2010 - 2011. The problem-based learning experience included the description of a given real-life situation by one or more observers. The case had to be discussed and analyzed in small groups of students, with the teacher undertaking the role of facilitator of learning encouraging individual study and group discussion (Silva & al., 2015).

Finally, the Integrated Master Degree in Medicine at the Beira Interior University also offers a problem-based learning approach that deploys practical and multidisciplinary activities (FCSUBI, s.d.). This methodology allows students to receive personalized support while avoiding repetitive and isolated teaching techniques.

A5.9 United Kingdom

With over 100 higher education institutions in the UK there are many examples of effective active learning promoted in the literature and on university websites. Some of the initiatives focused on the lab spaces and technological solutions, others on curriculum design.

Learning spaces is a concept used across the sector. Universities have been investing heavily in spaces. As examples, City University in London and the University of Central Lancashire have invested in modernizing teaching spaces introducing furniture that can be moved around and arranged to suit different classroom configurations. City University in London advertises its labs as a special attraction to students (City University London, 2015).

Liverpool University has an active learning laboratory that is illuminated with LED lights and is a landmark building in the city. The University changes the color of the lab to suit local events.

The Liverpool laboratory is the showpiece of the Engineering Department. It contains 2 large, flexible spaces allowing full-size models to be exhibited and tested. This is considered to be the best such lab in the UK.

Active learning spaces have the flexibility to foster active learning within groups and are a move away from the traditional lecture format. Lectures are widely criticized for their ineffectiveness in a teaching context and even main stream media have queried their educational value (BBC news 2016) in today's society. More recently an article by the Times Higher (The World University Rankings Connect, 2020) provoked that active learning is more effective than lecturing.

The University of Glasgow has created technology enhanced active learning (TEAL) spaces, that are classrooms that have been adapted to encourage interactive learning in small groups supported by technology.

Some of the key features of this classroom are:

- 60-seat interactive teaching room, ideal for group work.
- Clusters of 6 or 8 swivel base chairs grouped around media tables, each with two screens, allowing collaborative teaching methods.
- Centrally positioned lectern allows lecturer to have close interaction with all groups.
- Additional projection screens positioned around the perimeter.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

Edinburgh Napier shows images of its own active learning classrooms at (Edinburgh Napier University).

This apace is augmented with an 85” Samsung interactive display which allows finger-touch annotations to the on-screen content, and device mirroring to display the contents from laptop and tablet devices. There are four 55” Samsung displays which are inter-spaced with traditional white boards to support group working activities.

Despite the introduction of these facilities staff still needs support to make the transition to active learning. Using a phased approach and providing staff support appears to be a key for successfully integrating active learning into the classroom (White et al. 2016), as after a pilot project in active learning, only three out of nine staff agreed that they understood what makes for an effective active learning exercise. Without this support it is likely that the labs and technology being integrated into them will not necessarily promote an increase in the adoption of active learning.

Building spaces is not sufficient. It is important to get staff involved. Staff needs to understand what to do with the new spaces and the new technology. This being understood, attempts to change the way University education is done have needed some initiatives and projects. SCALE-UP is one such project that was funded by the Higher Education Funding Council of England to address barriers to student success and is based on a belief that active learning can be a core component of this. Nottingham Trent University (NTU) claims to be a world leader in active learning with its 12 Student-Centered Active Learning Environments with Upside-down Pedagogies (SCALE-UP) rooms.

The SCALE-UP approach that the NTU staff adapted from (Beichner, et al., 2007) offers an engaging, inclusive alternative to traditional lectures through the following components:

- Room design and equipment to promote collaboration, including circular tables, shared laptops and mirroring technology.

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- Upside-down teaching in which content is encountered outside class and sessions are devoted to applying ideas.
- Collaborative learning via problem-solving tasks in tutor-assigned groups with roles.

When used with physics students in the USA, results of applying the Student-Centered Active Learning Environment with Upside-down Pedagogies approach were convincing. A 50+ page handbook has been designed for tutors aiming to introduce them to active learning. It includes detail on redesign of modules, on redesign of individual classes, and on the management of groups and the promotion of collaboration. It is a fantastic document for anyone looking to initiate AL. This document describes how in Student-Centered Active Learning Environment with Upside-down Pedagogies lectures are replaced by problem solving and inquiry-based activities carried out in strategically assigned groups. To foster collaborative learning, the re-designed classroom environment incorporates bespoke circular tables, shared laptops, and mirroring technology for students to share their work with the class. Flipcharts and whiteboards function as additional public thinking spaces (Beichner, History and evolution of active learning spaces, 2014) . These physical aspects are supported by a threefold upside-down pedagogy comprising backwards design in which the curriculum is designed backwards from the learning outcomes; students as teachers; and flipped learning, where content may be encountered outside class and sessions are devoted to applying ideas.

Other universities have taken a more ad-hoc approach to initiating active learning, encouraging staff in competitions and small projects. The University of Bristol, for example, describes a series of case studies on active learning including one using clickers in Math (The University of Bristol) and one using the flipped classroom idea in aeronautical engineering. Flipped classrooms are a common strategy for active learning and classically introduce students to a problem that they work on before the tutor lectures and brings together the knowledge. A flipped classroom is defined as one in which '"students gain first exposure to new material outside of class, usually via reading or lecture videos, and then use class time to do the harder work of assimilating that knowledge, perhaps through problem solving, discussion, or debates.”

Imperial College London had a summer active learning challenge where staff were asked to revisit lectures they had done the year previous and see where they could bring more ‘activeness’ into their work (Imperial College London).

Solutions that were suggested included the use of class polling in a probability class as well as research inspired problems in a physics class.

In relation to studying and promoting active learning in the UK, whilst active learning clearly features in many educational conferences, there was a specialist UK based Active Learning Conference in 2017 held at the Anglia Ruskin University (Anglia Ruschkin University, 2020). This was a showcase of projects from HEFCE’s Catalyst fund which was the fund that paid for the Active learning work, and more specifically the Student-Centered Active Learning Environments with Upside-down Pedagogies, at Nottingham Trent University. This fund, which topped £7.5 million, was set up to initiate innovations that tackled barriers to student success. Mike Sharples keynote (Sharples, 2017) for this conference, as well as the paper on the use of spaces (Roger, Bryant, and Ney, 2017), are both stand out contributions.

The active learning conference has been followed by a 2018 conference in June in Brighton and a 2019 conference is planned for Tuesday 11th June at University of Sussex. The conference series is now managed by the Active Learning Network (The Active Learning Network) a network set up by the group of participating universities. This was initiated by Wendy Garnham and Tab Betts from the Technology Enhanced Learning group at the University of Sussex.

Other academic contributions from the UK include the innovations series from the Open University (Innovating Pedagogy, 2020), the Sage Journal of Active Learning in Higher Education, which is edited by a UK scholar and the engineering resources at which outline many ways to make engineering education more active.

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A5.10 Vietnam

This section presents examples of applying active and problem-based learning models in universities in Vietnam.

One example of best practices on active and problem-based learning involves Duy Tan University and the sector of information technology. The number of universities and colleges that offer information technology training programs in Vietnam has increased from 192 in 2002 to 277 in 2010. The enrollment quota for digital training programs has also been continuously increasing from about 30.000 in 2006 to over 60.000 in 2010. However, the quality of information technology engineers is another critical and crucial subject. According to recent forecasts by year 2020 the information technology labor market of Vietnam will need at least 600.000 new workers while the training system can only provide approximately 400.000. In addition, the percentage of graduates who can meet the real-world requirements of the IT industry without any retraining is expected to be low (Nguyen, Truong, & Le, 2013).

Based on reports from information technology businesses the current information technology labor of Vietnam has many limitations, including:

- Lack of expert knowledge on project deployment or systems implementation.
- Lack of experience with large-scale and/or complex information technology projects.
- Lack of professional work practices, poor language ability.
- Weak soft-skills, insufficient knowledgeable on customers and their cultural values.
- Inadequate management and project-management capability.

Meanwhile, the majority of new graduates in information technology in Vietnam are not able to quickly adapt to the work environment because of the big gap between their training and the needs of the real world. Most Vietnamese college students do not have adequate soft skills, including project-management, teamwork, negotiation and communication skills, and more. As a result, many information technology businesses in Vietnam complain that they face challenges in recruiting personnel with the desired skill sets, and most of the time they have to spend a couple of months or more to train new recruits.

Being an institution specializing in information technology training in Central Vietnam, Duy Tan University recognizes that there should be immediate change to the IT education in Vietnam. In particular, institutions need to reinvent how the assessment of learning outcomes, to evaluate IT curricula, to utilize new technologies in teaching and learning, and to raise public awareness on quality standards in information technology training with the objective of bridging gap of information technology practices in academia to those deployed in industry. In addition, there is a need to develop a new generation of information technology workers in Vietnam with the knowledge, skills, and professionalism that stakeholders demand. A number of solutions exist to this challenge, including restructuring information technology curricula to include on-the-job training, integrating and building interdisciplinary knowledge, utilizing new technologies for teaching and learning, and more. However, a comprehensive solution would include setting up comprehensive Capstone projects that help integrate diverse knowledge that originates from real-world stakeholder by using problem-based learning. According to the ACM curricula for Computer Science and Software Engineering in years 2001 and 2004, respectively, the Capstone project is always emphasized as a very important component for students to bring together the skills and knowledge learned in order to resolve some problem.

Another example of problem-based learning involves RMIT University, in which problem-based learning enables industry-authentic projects to increase students' exposure to the real-world working environment. The problem-based learning approach was introduced in the early 70's. However, when used in different disciplines challenges arise in designing collaborative interdisciplinary activities and, most importantly, aligning student assessment with learning outcomes. A pilot project was conducted at RMIT University Vietnam in 2015 on deploying problem-based learning courses in the Bachelor of Information Technology (BIT) and the Bachelor of Electrical and Electronic Engineering (BEEE) programs. The goals of these programs are to provide students with knowledge and skills in hardware, software, and project management. The affinity in the learning outcomes of the 2 programs, as stipulated in their curricula, and the lack of requirements of prerequisites allowed their integration into one module.

Finally, problem-based learning is deployed at Thai Nguyen University for the training of mathematics teachers. The activities involve preparation, planning of teaching practices, evaluation, and reporting findings (TRAN, 2017).

A6. ACTIVE LEARNING AT ALIEN PARTNER UNIVERSITIES

A6.1 University of Thessaly

Active and problem-based learning is deployed in several courses at the Department of Electrical and Computer Engineering (ECE) of the University of Thessaly (UTH). Examples follow:

The Education Technologies undergraduate course (ECE329 Education Technologies) focuses on the deployment of technology as an educational tool in lifelong learning contexts that target specific groups including pre-school learners, school learners, adult learners, professionals, and others. The course analyses traditional and emerging learning methodologies including collaborative learning, explorative learning, active learning, mobile learning, problem-based learning, project-based learning, and more. Subsequently the course focuses on how technology, and most importantly information technology, can be combined with emerging pedagogies towards the enhancement of learning processes and experiences in formal, informal, and non-formal learning. Specifically, the course analyses the deployment of technology as a tool that can be integrated into blended learning practices that involve instruction, practical applications that use technology and other activities in and out of the classroom.

Technologies in focus include knowledge and information management systems, synchronous communication technologies in learning, simulations, digital experiments, serious games, communities, mobile learning, touch screen technology, digital narration, and more. The course further analyses how technology can be applied towards addressing challenges faced by individuals at risk of exclusion, such as individuals facing learning difficulties, and others. The course furthermore focuses on how technology can contribute, in combination with pedagogical models, towards the development of basic, transversal skills including analytical thinking, critical thinking, entrepreneurial thinking, problem solving, ability to work in a team, ability to work autonomously, ability to work in an international environment, etc. Finally the course focuses on emerging research areas including gamification, learning analytics, and others. Specific research activities and good practices are presented in the context of the course. Upon completion of the course the learner should be able to:

- Be able to analyze learning needs of specific target groups in specific learning contexts
- Know and understand concepts related to basic competencies such as analytical thinking, critical thinking, entrepreneurial thinking, problem solving, ability to work in a team, ability to work autonomously, ability to work in an international environment, etc.
- Know and understand emerging learning methodologies including collaborative learning, explorative learning, active learning, game-based learning, mobile learning, problem-based learning, narrative learning, project-based learning, and more as well as learning theories such as constructivism and constructionism.
- Know, understand, and be able to apply learning evaluation processes based on specific learning objectives
- Know, understand, and be able to apply emerging information technologies in blended learning settings; technologies in focus include knowledge and information management systems, synchronous communication technologies in learning, simulations, digital experiments, serious games, communities, mobile learning, touch screen technology, digital narration, etc.
- Be aware of and understand the context of emerging research in learning including gamification, learning analytics, big data in education, etc.
- Be able to develop and present to a live audience end-to-end solutions on learning interventions that deploy technology towards addressing specific learning needs and towards meeting specific learning goals.

Active learning practices involve research by students on innovative digitally-enabled learning design. Students analyze the needs of end-users with respect to building knowledge on a specific subject, the current practices for knowledge development, the benefits of technology-enhanced learning for meeting learning objectives, and potentially research findings on the deployment of specific technologies in educational contexts. Student projects further involve the review of research projects and initiatives on technology-enhanced learning. Students present their work for the benefit of the entire class. In addition, students are challenged to evaluate the effectiveness of digital technologies and tools in educational contexts. Active learning is further practiced in the class in student assessment, which is performed not only by the teacher but also in peer-evaluation contexts in which participants provide constructive feedback to their fellow students.

In the Software Design and Development/Software Engineering (undergraduate/postgraduate course) students participate in a software development project in groups of 4 – 6 individuals. In the context of the project students have to opportunity to attain hands-on experience on the technical and management issues related to software systems development, as well as to use modern tools used in this context. The main goal of the course is to provide students with the technical and management skills necessary to develop large-scale software projects by diverse groups. After successfully fulfilling the requirements of the course, students are able to:

- Understand the main stages of the software life cycle.
- Understand and be able to use in practice the main software development process models, traditional and agile.
- Deploy UML notation and develop models that demonstrate user requirements.
- Produce the respective deliverables, including software code and documentation, necessary in each phase of the software life cycle.
- Evaluate the quality, correctness and complexity of software projects producing a development schedule and estimating the cost.
- Exploit computer-aided software engineering tools, as well as technologies taught in other courses, to develop large-scale software projects.

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- Collaborate in groups towards implementing software development projects under specific time constraints.

Active learning is an inherent part of the project. Students engage in the hands-on design and implementation of real-life software engineering project. Students have the flexibility to select the focus of their project. They are required to develop a complete prototype that demonstrates the desirable functionality and demonstrate how their solution goes a small step further that existing services towards addressing user needs. Upon completion of their work students present the results to the class and receive feedback by the educator and their peers. Students further answer questions by class participants highlighting they key benefits of their suggested solution.

Finally, the Creative Technologies Learning Lab of the Department of Electrical and Computer Engineering (CTLL, 2020) focuses on the design and development of educational solutions that combine emerging learning design, such as active and problem-based learning, with innovative digital technologies for introducing effective and rewarding educational experiences that address learning needs of diverse groups that range from primary to secondary, higher, vocational, and professional education. The groups implements learning games and applications recognizing the fact that one of the factors that inhibits the broad deployment of active learning is the lack of quality open educational software that can be freely used in broad learning contexts. The digital tools developed do not aim to replace educators. Rather, they are designed as complementary digital learning content that may be used in blended-learning initiatives that may combine lectures, practical work, visits to site of interests, and other activities. The group has developed digital learning applications that may support knowledge development in programming, language learning, problem-solving skill development, professional communication skills in international and intercultural environments, mathematics, and more.

A6.2 Porto Polytechnic

A characteristic case of problem-based learning is the LEAP Project, developed ate GILT R&D Group, which aims at building knowledge through experience among higher education students on emerging lean and agile industry practices. The project empowers students to develop skills for their smooth transition from the academic environment into the professional world, with a focus on engineering disciplines. To achieve that purpose, the project included an output focused on a learning game developed in the form of 3 learning applications that promote the development of agile and lean skills. The following digital tools were created in the context of the project:

- The Technical Debt game, which exposes learners to the concept of technical debt, namely the fact that an implementation team must invest early on a good implementation plan.
- The 5S game, which simulates a model that is often applied in lean processes for reducing production costs by streamlining and standardizing production. The model refers to the actions sort, set in order, shine, standardize, and sustain. An educational scenario encouraged students to deploy the 5S model in context that go beyond the automotive sector for which it was initially designed to reap its benefits in sectors as diverse as pharmacy organization, office space organization, and scrap yard organization.
- The SCRUM game, which simulates agile practices that aim at the design and implementation of solutions that closer address the needs of users. The model is useful in situations in which user requirements are not well known in advance or they evolve. The scenario demonstrated how SCRUM can be deployed beyond the Software Engineering sector for which it was designed to benefit broad engineering sectors, such as urban and agricultural design.

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A6.3 University of Central Lancashire

Resources in the UK come from many areas. The Royal Academy for Engineering (RAEng) funds much of the research in engineering education. This body produces reports, like the one on experience led engineering, that directly speaks to active learning in engineering (Royal Academy of Engineering Reports, 2017). The RAEng has a fantastic set of resources, mainly from external sites, on engineering teaching (Royal Academy of Engineering On-Line Resources, 2017). The Royal Society (The Royal Society, 2020) innovates on Science teaching and touches technology in general and information technology in particular. This organization directly speaks to government on ways to improve science and technology education.

A6.4 University of Malaya

The University of Malaya strongly emphasizes research and innovation. The mission and vision of the university have always been associated with high quality teaching and learning activities. All these educational priorities can be seen from its quality statement pertaining to teaching and learning (TnL), according to which aspects of research and innovation are the cornerstone of training, which is in line with the Malaysian government's aspiration for its higher education system. As one of the public universities under the Ministry of Higher Education (MOHE) Malaysia, now known as Ministry of Education (MOE) Malaysia, UM's strategic planning and teaching and learning approaches are governed by national policies laid down by the Ministry of Education and other relevant ministries.

Accordingly, the University of Malaya has incorporated the above mentioned policies in its own internal governing practices that are administered by various agencies of the institution, including:

- The Strategic Planning Unit.
- The Quality Assurance Unit (QMEC).
- The Academic Development Centre (ADeC).

While the Academic Development Center offers plenty of training related to active and student-centered learning internally to the University of Malaya academic staff, the institution's top management realizes that active learning practices need to be supported by appropriate infrastructure. It is recognized that the learning experiences of students must be similar to real-world scenarios they will encounter in the workplace. As a research university, the University of Malaya is committed to produce positive and forward-thinking graduates with the skills needed in their future work environment. Collaborative learning is and will always be the hallmark of the university's education.

The founder of the Academic Development Centre is Professor, Raja Maznah, is an instructional designer who set up the experimental Interactive Learning Room in 2008. This concept is in-line with the national agenda and was later adopted by university management in the form of a Learning Space Policy in 2012. The management committee agreed that all faculties, centers, and academies must comply with learning space, student-centered criteria for any renovation work (Minit Mesyuarat JK. Pengurusan: 4.7.2012; Perkara: 17; MP75/2012). The management committee further reinforced the implementation learner spaces in the renovation of classrooms in the context of the TheCUBE's project in 2012 that was implemented in several faculties. Since then, budget has been allocated at the central level to upgrade more than 35 existing spaces into learning development spaces throughout the campus.

The increasing number of learning spaces, however, did not result in their effective use in the context of active and problem-based learning. Realizing this shortcoming, the management committee opined that there was a need to empower academic staff to embrace new ways of teaching. This was achieved by changing the university's training strategy into active, student-centered, and experiential learning. Lecturers build experience on active and student-centered learning engaging in related activities themselves in the actual learning spaces. Since 2016, the Academic Development Centre has insisted that its training program must be held in learning spaces in various parts of the campus and the trainers are expected to use active learning

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methods in delivering training programs. Whenever possible, the learning space facilities should be utilized.

Lecturers were further empowered to effectively use the learning spaces for active learning by being appointed as active partners in the process of designing and using the new spaces. The Learning Space project in 2016 was launched for University of Malaya faculty members to design their own learning spaces that suit their disciplines. The main objective of the project was to improve students' learning, upgrade lecturers' quality of teaching, and explore the potential use of learning spaces in improving students' active learning.

The Academic Development Centre organized a National Learning Space Seminar in 2016, which was attended by academics from both public and private universities. University of Malaya realizes that active learning in the cyberspace plays an important role in this era. The university has introduced and executed a program called the E-learning Week, during which no face-to-face lecture is carried out in a normal classroom. In this manner, lecturers and students actively teach and learn via e-learning platforms or other digital means.

A6.5 University Tenaga Nasional

A conscious effort is evident at the University Tenaga Nasional to enhance teaching and learning experiences by moving away from the traditional and monotonous delivery of learning materials through one-way lectures. However, the approach is more generic without focusing on any specific method of active learning. The term used is blended learning, which refers to an education program that combines online digital media with traditional classroom methods. It requires the physical presence of both lecturers and students, with some elements of student control over the time, place, path, or pace. The aim is to diversify the teaching and learning methods by blending the traditional methods with online ones using tools such as learning management systems (LMS) but without significant reduction to the allocated face-to-face time with the students. From one perspective, blended learning can also be regarded as a form of active learning in which students have more control on the pace of learning. Furthermore, it specifically involves the use of digital technologies, such as online digital media, which is currently lacking in most problem-based learning implementations in Malaysia.

The university's commitment on this matter is manifested through the implementation of the blended learning initiative, which is set to be one of its core initiatives under BOLD 2025. BOLD 2025 is a 10-year program that aims at uplifting the university status and rank internationally. The program has 3 strategic goals:

- Teaching and learning excellence.
- Research excellence.
- Financial sustainability.

Eleven strategic objectives and 29 initiatives are defined to achieve these goals. The adoption of blended learning falls under the 3rd strategic objective (SO3), which focuses on attaining globalised on-line learning through the following sub-initiatives:

- The use of learning management systems and web-based technology such as Moodle®.
- The purchase of audio-visual equipment.
- Training for academic staff.
- The setting up of the education technology unit.

Under this initiative lecturers are encouraged to adopt the blended learning approach in their classrooms. The implementation is closely monitored by the university's Teaching and Learning Center (TLC). A group of pilot courses have also been identified for this purpose. The Teaching and Learning Center is responsible for promoting the adoption of blended learning among lecturers by disseminating information and organizing training to provide the lecturers with the necessary knowledge and skills to use blended learning in their classes. Furthermore, the Teaching and Learning Center is responsible for monitoring the progress and achievement of blended learning in the university. In this regard, the Teaching and Learning Center is assisted by respective units at each college. Four colleges in the university are involved in the blended learning initiative. These are the College of Engineering (COE), the College of Computer Science and Information Technology (CSIT), the College of Business Management and Accounting (COBA), and the College of Foundation and Diploma Studies (CFDS).

A6.6 ISRA University

There is no active learning lab at any of the campuses of Isra University. However, most practical curses activities that are delivered through laboratories make of different active learning strategies, such as retrieval practice, one-minute papers, demonstrations, group discussion, sequence reconstruction, error identification, concept maps, brainstorming, icebreakers, case studies, and self-assessment.

The instructors teaching laboratory sessions prepare a laboratory manual for the entire course. The manual guides students on what to do during each session. Each course including laboratory-based work runs for 16 weeks with a midterm exam at the end of the 8th week and a final exam at the end of the 16th week. One 3-hour long laboratory session is conducted each week. Therefore, altogether 16 labs are conducted throughout each course. For each topic covered through laboratory work the instructor creates a detailed step-by-step solution of the task to be performed. This guide facilitates student learning on the selected topics. It further provides information and hints on how to solve the problem in focus. Students are asked to address multiple questions related to each concept. This series of steps helps evaluate the understanding of concepts among the students. Student responses may be provided in various forms: through answers on objective, multiple choice questions, through descriptive responses, through software code, by drawing maps or circuits, or by finding errors in the code or diagrams among others. The solutions are checked by the instructor and returned back to the students in the next session for discussion. This approach provides students with an opportunity to identify the mistakes they made and to discuss the correct approach or solution with the instructor for better understanding. Typically, students are assigned into small groups of 2 - 3 individuals.

Groups support teamwork, discussion, and peer learning. They encourage students to remain active throughout the course.

A6.7 Tallinn University

Learning in an Interdisciplinary Focused Environment (LIFE), is an initiative at Tallinn University which provides an alternative to subject-based education by inviting students to collaborate on interdisciplinary projects (Sillaots & Fiadotau, 2018). Learning in an Interdisciplinary Focused Environment, or ELU in Estonian, is a semester-long project-based course which invites students to solve real-life problems in interdisciplinary teams (Jõgi, et al., 2018). The teams generally are comprised of 6 - 8 members with expertise in least 3 different areas. The purpose of Learning in an Interdisciplinary Focused Environment is twofold. On the one hand, students can deepen their knowledge and apply it to a practical problem. On the other, they learn how to plan and run a project. Ideas for Learning in an Interdisciplinary Focused Environment projects can be provided by both students and teaching staff and are advertised through the Learning in an Interdisciplinary Focused Environment Portal (Tallinn University LIFE portal, 2020), which serves as a platform for team member recruitment. Learning in an Interdisciplinary Focused Environment is mandatory for all bachelor and master's level students.

The Digital Learning Games (DLG) master's program at Tallinn University (Digital Learning Games, 2020) aims to bring together individuals with different backgrounds that form heterogeneous teams, learn from experts and from each other, and build skills on making games. Making games requires an effort from different experts, including developers, artists, designers, and others, and is usually based on real life needs or problems, such as how to make teaching engaging. The Digital Learning Games program focuses on teaching game conceptual design. However, students have the possibility to focus on more technical or pedagogical aspects. All subjects at the Digital Learning Games program are more or less based on active and problem-based learning. For example, in the beginning of their studies students are asked to work individually and generate game ideas that provide solutions to some school related problems. This is a final outcome of the course of Basics of Game design and research. Students are asked to develop this idea further during the next course, Design of Gameplay and Mechanics, but this time working in pairs. In this course they design and test the game challenges and rules. In the next subject, Game Assets, each team grows to 3 - 4 members. Students design the sound and graphics for the game. In the Learning Game Design course each team grows to 4 - 5 members. Students are engaged with pedagogical aspects and test the game in educational conditions. For the Learning in an Interdisciplinary Focused Environment project each team grows to the size of 6 - 8 members. Each team implements the 2^{nd} iteration of a bigger learning game.

Tallinn University has several laboratories equipped with cutting edge technology in order to support students' creativity and teamwork. Some of the laboratories are (Tallinn University School of Digital Resources, 2020, Tallinn University DTI Labs, 2020):

- The Interaction Design Lab (IDLAB) is a research, design, and innovation unit contributing towards knowledge and skills in the field of Interaction Design (Tallinn University HCI, 2020). This laboratory is equipped with an endless list of hardware devices and software (Tallinn University HCI@TLU, 2020).
- The Software Development Lab (SDLAB) aims at supporting the exploration of current and state of the art software development approaches. The lab offers access to both expertise and resources necessary for implementing existing designs as functional prototypes or exploring new algorithms and enabling technologies for existing applications and services. The lab can support students working on their on-going study projects or thesis-related topics. It can further support teams engaged in current research projects and industry partners wanting to explore specific software development related challenges ((Tallinn University HCI@TLU, 2020)).

- The Technology Lab (TECLAB) supports teaching processes by providing necessary know-how and technical equipment for implementing projects in the field of robotics, Internet of Things, and automation. The laboratory also provides organizations and individuals who are interested in developing prototype solutions with access to instructors and working / study space. The laboratory supports teachers and students in their projects. It may also play a supportive roll in research projects that might need the available resources (Tallinn University HCI@TLU, 2020).
- The Game Lab (GLAB) is a meeting place for students who are interested in making games. It offers facilities for meeting and workshops and some high end gaming technology - Oculus Rift VR set (Tallinn University HCI@TLU, 2020).
- The Tallinn University Centre of Excellence in Media Innovation and Digital culture (Tallinn University MEDIT, 2020). Among other activities MEDIT coordinates a Creative Lab that focus on developing innovative audiovisual applications. The current technical focus of the Creative Lab is on Virtual Reality and Augmented Reality solutions, offering opportunities to test VR and AR gear and development platforms. The equipment available in the lab includes Oculus® Rift, HTC® Vive, Playstation® VR, Microsoft® Hololens, GoPro® 360, Ricoh® theta 360, Leap Motion®, and Samsung® Gear VR.

A6.8 Technical University of Gabrovo

In order to identify how active and problem-based learning is applied at the Technical University of Gabrovo 2 focus groups were organized in September 2018.

The first group involved 10 university lecturers, of whom 5 are aged over 50 and 5 are aged 30 - 49. Six are male and 4 female. Of these, 4 teach at the Faculty of Mechanical and Precision Engineering, 4 at the Faculty of Electrical Engineering and Electronics, and 2 at the Faculty of Economics.

The second group included 10 university students aged 19 - 23, of whom 7 male and 3 female. Four follow bachelor degree courses in Mechanical Engineering. Of these, 4 follow bachelor degree courses in Electrical Engineering, Electronics, and IT and 2 follow bachelor degree courses in business, administration, and management.

Findings show that active learning is a familiar concept only to academics in the Faculty of Economics and information technology teachers. In addition, only 5 students, and specifically 2 in Information Technology, 2 in Business, Administration, and Management, and 1 in Electronics, had a vague familiarity with the term active learning but were not able to provide a precise definition for the concept. The other lecturers and students were completely unfamiliar with the term active learning. However, all 20 participants were aware of the concept of problem and project-based learning but only 2 / 3 of lecturers and 1 / 2 of the students were able to clearly define it.

In relation to the application of active and problem-based learning discussions demonstrated that the 4 lecturers teaching Business and Management or Information Technology subjects used problem-based learning on a regular basis in their courses, yet in an unstructured way. Project-based learning was rarely applied in its proper form in groups, as most activities were individual. This was particularly the feedback provided by 8 lecturers form the Faculties of Mechanical Engineering, Electrical Engineering, and Electronics. Both types of learning were partially taken into account in the assessment process. In general, discussions among participants demonstrated that active and problem-based learning through discussions and student engagement is rare. When asked about their willingness to introduce active and problem-based learning, only the younger lecturers expressed positive attitudes.

The above data was further confirmed by students' responses. 80% of students were very positive on the prospect of introducing active and problem-based learning into the classroom, while the other 20% did not give a definitive answer.

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In relation to the lack of structured active and problem-based learning in higher education, the following reasons were given.

From the perspective of lecturers:

- Limited class time and density of curriculum.
- Size of students' groups. University lecturers of oversized classes tend to adopt lecturing as a main teaching strategy because they believe that they do not have enough time at their disposal to monitor and guide large groups students engaged in learner-centered teaching and learning methods.
- Inflexibility of classes. Stationary desks and tables resulting in inappropriate physical conditions.
- Lack of adequate material and equipment or resources.
- Fear of losing control over the class.
- An emphasis on research activities rather than teaching as a result of national attestation criteria for educators. A result of related policies is that educators are mostly devoted to authoring scientific articles and manuscripts, having as a result limited time to invest in enhancing their teaching qualification and expertise.
- Lack of knowledge and experience in active and problem-based learning.
- A passive learning culture among students, to which they have become accustomed. Listening to a lecture is not only a more familiar role for students but it is also a considerably easier one.
- Lack of motivation and initiative among students to develop themselves and to take responsibility for their own learning. Lack of motivation among students to move away from their comfort zone as a result of long standing passive learning approaches.
- Lack of self-confidence by students. Students are used to the traditional teacher-centered model deployed in secondary education. It is easier to continue following this

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

behavior in higher education. Students are afraid of speaking in front of a group. They are further afraid of negative feedback and criticism from peers.

- Assessment methodologies are mainly based on standardized exams, which generally require memorization of information.

From the perspective of students:

- Reluctance by university lectures, especially those over 55, of losing control of the class.
- Lack of sufficient teaching skills on behalf of lecturers.
- Lack of open relationships among students and teachers, which would encourage students to freely express their views.
- Limited class time and density of curriculum.
- Misperception of class management.
- Passivity of lecturers.
- Lack of self-confidence. Students are used to traditional teacher-centered models deployed in secondary education. It is easier to continue following this behavior in higher education.
- Students' passive learning culture to which they have become accustomed. Listening to a lecture is not only a more familiar role for students but it is also a considerably easier one.
- Assessment methodology mainly based on standardized exams, which generally requires memorized information.
- Inflexibility of classes. Stationary desks and tables resulting in inappropriate physical conditions.
- Lack of motivation and initiative in students. Some students lack the motivation to develop themselves, don't take responsibility for their own learning or don't want to move away from their comfort zone because they have got used to sitting passively in class.

To sum up, the deployment of active and problem-based learning in engineering higher education at the Technical University of Gabrovo does not differ from that in other Technical Universities in Bulgaria. Curricula are still teacher-centered and theory-oriented. Most academics, especially those aged over 50, show resistance to change and focus only on students' academic success. However, young academic staff demonstrates willingness to further develop their teaching and methodological skills so as to apply active and problem-based learning at their classes.

A6.9 John Von Neumann Institute

John von Neumann Institute (JVN) directly belongs to Viet Nam National University of Ho Chi Minh City (VNUHCM). John von Neumann Institute operates as an Excellence Center in the domains of information technology, data science, and quantitative computational finance. The main mission of John von Neumann Institute is to build a high-quality and sustainable educational model that links post-graduate education, scientific research, and data-centric initiatives in enterprise innovation. This model is expected to create breakthrough value in developing new knowledge on information technology, data analytics, and computational finance to businesses to improve their operational performance creating a momentum for the increase of social investment in research and development. The key point of this model relates to the development of problem solving skills among students that are in high demand by enterprises. This is a difficult task considering the limited resources of higher education institutions and the maturity level of post-graduate education in Vietnam, which contribute to the passive attitudes of students towards knowledge development in educational environments.

To overcome this challenge John von Neumann Institute has introduced a fundamentally different viewpoint of post-graduate education by focusing on new skills and methods that encourage students to become more active in their learning. The active engagement of students stems from their ability to consciously create an adaptable learning path by selecting subjects to follow. It further is a result of a highly interactive environment built around the students. Finally, active engagement is encouraged through problem solving learning approaches.

To achieve this goal John von Neumann Institute needs to develop human capital, facilities, including basic equipment and studying space, and advanced methods and tools for increasing the effectiveness of active learning.

To best implement active learning, John von Neumann Institute has developed professional activities for students. The activities are delivered in laboratories, where lecturers, researchers and students work together beyond the strict classroom confinement. Students build knowledge through projects on specific curriculum subjects under the supervision of lecturers and researchers.

Currently, John von Neumann Institute has laboratories:

- A laboratory used in the context of master's degree courses.
- A laboratory dedicated to scientific or industrial research projects.

The laboratories deploy an open space design to foster collaboration and group work. During practical work, students can use the wall for takes notes and communicating ideas. This is very useful for fostering discussion because it removes limitations of traditional whiteboards that occupy a lot of space. The laboratories are designed as spaces for creative inspiration using light color palettes with green trees. In these spaces, participants often work on their personal computers and interact primarily through whiteboards and projectors. The spaces could be significantly enhanced through the introduction of flexible and comprehensive connectivity solutions for supporting an active learning and working environment.

Academic activities promote collaboration and the proactive engagement of students. Educational programs at the John von Neumann Institute are full time, in contrast with other post-graduate programs that are part-timed and designed to be delivered to working professionals. Full-time enrollment allows students to continue studying and working in groups throughout the week and beyond the completion of weekly class sessions. Students work collaboratively under the guidance of teachers and the support of researchers. John von Neumann Institute has implemented a registration and management process to allow students to work 24/7 in the laboratories. This policy helps maximize students' efforts for completing assigned exercises and projects.

In the context of the master's programs, John von Neumann Institute offers a rich collection of subjects that are delivered through a variety of teaching and learning approaches, such as individual research projects, thesis development, and tasks that help build emerging work skills. These courses are conducted in the form of direct work between teachers and students with a high degree of interaction. Work is heavily problem-based. Through their projects students do not only complete course requirements but also complete the implementation of specific products with real-life applications, attend conferences, and publish scientific papers.

John von Neumann Institute regularly organizes seminars on academic subjects, professional practices, and methods that help students study more efficiently. These seminars are held every Friday afternoon with the participation of lecturers, researchers, students, and especially industrial experts. This activity helps students not only expand their knowledge and ability to solve practical problems but also sharpen interactive skills, team work, career orientation, and work motivation.

Another factor contributing to the effectiveness of the active learning model at John von Neumann Institute is using English in training and the fostering the participation of foreign teachers and students from Europe in international cooperation. These lecturers and students not only bring freshness, higher quality, and efficiency in training activities but also create higher demands for modern, proactive, and problem-based learning methods. Emerging learning methodologies help achieve high results. They are not limited by culture even when foreign teachers and students only work at the institute for a short time that ranges from weeks to months.

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A6.10 Hanoi University

In 2006 Hanoi University established an interdisciplinary study program of information technology that focuses on software engineering, computer networks, and information systems. Approximately 200 students enroll in the program each year. To succeed in the program, a student needs to build knowledge diverse subjects, such as:

- Mathematics.
- Logic.
- Problem solving.
- Algorithmic thinking.
- Programming.

Unfortunately, many students struggle to achieve learning objects, particularly in subjects related to programming, discrete mathematics, data structures, and algorithmic analysis. This is a result of the teaching methods deployed in undergraduate courses and particularly the lack of practical activities following theoretical instruction. Research shows that problem-based learning meets 3 important criteria that promote learning:

- It provides an environment where students are immersed in practical activities.
- It allows students to receive guidance and support both from other students and a responsible teacher or tutor.
- It fosters learning that is based on solving real life problems.

Since 2014 problem-based learning has been applied to the teaching of programming courses at Hanoi University aiming to promote collaborative and motivating learning based on problem solving.

In relation to the implementation of the initiative, due to the large number of students per year, the university organizes a separate class of 30 students to experiment on the deployment of active and problem-based learning. Problem-based learning implementation aims at:

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- Connecting learning to specific problems and situations that may be encountered in practice.
- Activating prior student knowledge on specific subjects.
- Encouraging students to elaborate on newly introduced learning material.

In terms of course organization, students are divided into groups of 4 - 6 members. Each group is supervised by a tutor who is a faculty member. The primary role of the tutor is to act as a domain expert who can answer questions or steer discussions in the correct direction. The secondary role of the tutor is to act as a facilitator of the group process. If discussions are unbalanced or unproductive the tutor can try various approaches to improve the behavior of the group. For example, the tutor may require that each student sits in a different place in each meeting, does not bring books to the meetings, or contributes at least 5 ideas during brainstorming.

More specifically, active learning is deployed in programming. Since programming is a practical skill, it may be built through practical activities. In programming courses students are asked to execute programming assignments and a larger programming project. Implementation of the programming assignments is supported through weekly meetings between students and tutor assistants. In addition, students prepare reports and present concept maps on the key programming mechanisms they use in their implementation. Students use the material that they prepare throughout the course to develop a final portfolio in which they summarize and reflect on their learning. Students are evaluated based on the programming assignments, the programming project, and the portfolio.

Each group meets once a week in a 3-hour problem-based learning session. Each group needs a meeting room equipped with a white board and a projector. The meeting starts with the closing session of the previous case, if any. Then a new case is opened. The processing of the case goes through the sequence of sessions described below.

Opening session:

- Activity 1. Introduction of the case.
- Activity 2. Identification of the problem. Specifying key issues of the case with keywords.
- Activity 3. Brainstorming. Presenting associations and ideas on the problem to activate previous knowledge on the topic. Writing ideas on a white board.
- Activity 4. Sketching of an explanatory model for the case using concept or mind maps.
- Activity 5. Establishing the learning goals for the self-study session based on the explanatory model.

Self-study session:

- Working independently to accomplish learning goals. Student work includes information gathering from the internet or through literature reviews.

Closing session:

- Activity 6. Discussing and presenting. Equipped with newly acquired knowledge, the group reconvenes to discuss the case. The discussion includes explanation of central concepts and mechanisms, analysis of the material, and evaluation of its validity and importance.

A6.11 University of Battambang

Established in 2007, the University of Battambang (UBB) is one of the biggest public universities in Cambodia and the largest in the northwestern region of the country under the supervision of the Ministry of Education, Youth, and Sport, Cambodia. The University of Battambang has over 3.000 local students who are enrolled in programs that range from associate degrees to PhD degrees. The University of Battambang includes schools on Business Administration and Tourism, Science and Technology, Agriculture and Food Processing, Sociology and Community Development, Arts, Humanities and Education, Foreign Languages, and Graduate Studies.

The University of Battambang has introduced active and problem-based learning approaches in the university's mission, curricula, and course syllabuses. The organization's mission and

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strategies have been revised to modernize the teaching and learning environment. For instance, the University of Battambang educates and trains students in science, technology, arts, culture and languages at all levels through active learning pedagogies, problem-based learning, and digital technologies in accordance with the needs of the country, especially in the northwestern part of Cambodia. Currently, 3 selected faculties aim to:

- Introduce active and problem-based learning teaching and learning pedagogies in the faculty's strategic and financial plan, curriculum, and course syllabus to align with Cambodian government policy and strategy.
- Equip lecturers with professional training on active and problem-based learning.
- Modernize equipment to support teaching and learning activities.
- Provide students educational quality for addressing social needs and current labor market needs in Cambodia and its regions.

The ALIEN project methodologies contribute to the upgrading of lecturer qualifications in conformity with the Royal Government of Cambodia's Rectangular Strategy for Growth, Employment, Equity, and Efficiency and the Education Strategic Plan 2019 - 2023. Active and problem-based learning are gradually replacing traditional methods and contribute to the development of qualified graduates for industry 4.0 in the era of global advanced technologies and knowledge-based economy.

A6.12 Institute of Technology Cambodia

Active and problem-based learning are recently being introduced in higher education in Cambodia. As a result of the novelty of these approaches, initiatives for promoting active and problem-based throughout Cambodian universities are insufficient. The Institute of Technology Cambodia, in collaboration with the U.S. Agency for International Development Connecting the Mekong through Education and Training (USAID COMET), has been proactively involved in the 5 year project to boost the workforce orientation and deployment programs that allow students to acquire market demanded skills. This initiative also seeks to promote gender-balanced employment and increase technology-based learning in the classroom. More importantly, active and problem-based learning are core values of project, in which a number of lecturers participate.

The Institute of Technology Cambodia is not the only institution to participate in this collaboration. The project supports universities across USAID COMET's targeted areas, including Lower Mekong countries of Burma (Myanmar), Cambodia, Laos, Thailand, and Vietnam, with the objective of enriching higher education curricula and teaching approaches for taking education to the next level. By 2019, this collaboration had already begun to equip students with skills including adaptability to new technologies, group work, communication, and interpersonal skills. USAID COMET focused on participatory learning, work readiness skill development, learner-centered assessment, facilitation skills, instructional design, blended learning, and project-oriented learning. The ultimate goal of this project is to educate instructors at the Institute of Technology Cambodia and to build their capacity to introduce innovative teaching methodologies in real classrooms. Over the past 4 years, some lecturers have used some of the techniques in their classrooms. The outcomes are quite promising as students are more engaged in learning and they tend to work confidently and independently.

A6.13 Meanchey University

The university efforts to engage more teachers in routinely deploying active and problem-based learning through funding and material support have been faced with many challenges. In part, this reflects the reality of any change in any pattern of human behavior, reflecting the fact that teachers are not blank slates on whom reformers can inscribe new pedagogical approaches. Since Cambodia is in serious shortage of well-trained lecturers and professors it is essential that universities must use scarce human resources to their full capacity by exploiting digital technologies and connecting learners to virtual learning resources worldwide. The Ministry of

Education promotes the use of digital technologies in teaching and learning, research, and administration by creating a cyber campus consortium and linking this to virtual universities in other countries. It also promotes the digitization of the Khmer language books and the translation of foreign core books into Khmer. Cambodia is in need of professional development initiatives, mainly in-service, that can promote and reform innovative learning by adapting teacher perspective and their behavior and interaction patterns in the classroom. While it would be an overstatement to say that teachers involved in projects radically transformed their instructional practices it seems appropriate to conclude that real change occurred as a result of sustained training and supervisory support. The projects facilitate teacher and student training, introduce workshops, promote modern student-centered pedagogy, and make available funds for supporting and installing laboratories for practicing active learning.

A6.14 Tribhuvan University

In the case of the Institute of Engineering (IOE), Tribhuvan University (TU) active and problem-based learning have been introduced recently at Pulchowk Campus for masters, and bachelor level courses. Active and problem-based learning was first initiated in select courses offered by the Department of Electronics and Computer Engineering. However, more initiative have been introduced to deploy active and problem-based learning in other disciplines, such as operations research and management science, multi-criteria design analysis, and others, in the Department of Mechanical Engineering.

Problem-based learning methods were also applied in the Robotics Club at Pulchowk Campus, IOE. The club involves multidisciplinary teams of students and faculty from the departments of Mechanical Engineering, Electronics and Computer Engineering, and Electrical Engineering. Active and problem-based learning are used for designing and developing robots and automation mechanisms in the club. The club annually participates in the ROBOCON International Competition and National Competitions for robotics.

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A Centralized Visualization System (CVS) Lab for active and problem-based learning has been developed and implemented at the Institute of Engineering. Implementation of the Centralized Visualization System Lab started with pilot testing in the masters' program in Computer Systems and Knowledge Engineering offered at the Department of Electronics and Computer Engineering. The Centralized Visualization System Lab is used in student projects in the context of the Knowledge Engineering course offered in the 1st semester of the program. Typically, 20 students are enrolled in the course each year. The objectives of this course are:

- To familiarize students with the basic concepts of knowledge engineering.
- To teach basics of knowledge acquisition methods, IR, NLP and machine learning techniques.
- To teach concepts on knowledge representation, logic, and reasoning.
- To introduce students into the field of the semantic web and ontology engineering.

Implementation involves:

- Students are divided in 5 groups of 4 students each.
- Each group is assigned a mini-project in which team members implement a case study and develop a simple knowledge-based system that would be useful in the institute.
- Each group collects and reviews material on the web and campus intranet. Team members have meetings, interact with experts, and contact professionals of the knowledge domain in focus. They also collect necessary data and documents through interviews and internet-based research.
- Team members explore existing solutions through internet-based research and propose a knowledge-based system as a solution to the given project.
- Each group delivers a group presentation followed by feedback provided by other groups, the instructor, and domain experts.

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- Each group develops a solution prototype and demonstrates it in the final presentation to the entire class, the instructor, and domain experts.
- The groups are evaluated based on their presentations and the solution prototypes developed.

Some projects implemented through this activity include:

- On-line form photo validation system.
- Examination results and entrance score analytics.
- Online assessment marks entry system.
- Exam papers package handling system.

Similar activities have also been introduced in a learning pilot in the context of the big data application and analytics course offered in the masters' program of the Department of Electronics and Computer Engineering. A minimum of 6 students are enrolled in the course when this is offered. The objectives of the course are:

- To provide an overview of big data and latest trends in big data analytics.
- To introduce technologies for handling big data.
- To explore large, complex datasets and understand scalable big data analysis.
- To apply big data tools for advanced analytics disciplines such as predictive analytics, data mining, text analytics, and statistical analysis.

The Centralized Visualization System Lab is used in practical work in the context of this course. In the beginning of the course the laboratory is used to demonstrate the installation procedure of different big data tools. Students use the workstations and laboratory connectivity to collect required documents for the setup and strive to follow installation procedures sharing the issues encountered during installation with the entire class. Either one of the students or the instructor demonstrates ways to solve the issues that arise. Once the installation is complete students are asked to work groups to:

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- Define a real world problem to be solved using big data.
- Specify the sources from which the data will be collected.
- Specify the important features that will be taken into consideration in system design.
- Define data storage strategies.
- Define the basic components of the big data ecosystem design.
- Illustrate the system design in detail with a block diagram.
- Define the algorithms that will be used to process the collected data.
- Define data visualization methods.

Students research articles and explore existing solutions on the web to identify the problems that can be solved through big data. Based on this research, students propose a big data project and identify the appropriate use of big data tools for addressing the identified problem. Students deliver group presentations. Feedback is provided by other groups and the instructor. Each group develops a solution prototype. In the last session, each group demonstrates their solution in a presentation to the other groups and the instructor. Students are evaluated through the final presentation of the system that they have developed.

Implementation of the Centralized Visualization System Lab is also planned in the bachelor level course on computer graphics offered by the Department of Electronics and Computer Engineering. The Centralized Visualization System Lab can be used for practical project work. Typically, 96 students are enrolled in the course each year.

The objectives of this course are:

- To familiarize students with graphics hardware.
- To familiarize students with line and curve drawing techniques.
- To build knowledge on techniques for representing and manipulating geometric objects.
- To build knowledge with illumination and lighting models.

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Students can be taken to the Centralized Visualization System Lab to practice techniques on representing and manipulating geometric objects and on illumination and lighting models. Practical work takes place in groups over several sessions. Students can be asked to implement the techniques demonstrated sharing their solutions and any issues they encountered with the class on big screens. Students can also use the Centralized Visualization System Lab to demonstrate computer graphics projects to other students and to faculty members.

Similarly, implementation of active and problem-based learning takes place in an on-going manner in courses on computer graphics, image processing, operations research, and management science.

Tribhuvan University works on integrating the use of the Centralized Visualization System Lab in more existing and new courses in undergraduate and graduate programs. The organization evaluates feedback and suggestions by students and teachers on the effective use of the Centralized Visualization System Lab in preparation of designing and delivering capacity building activities for faculty and staff.

A6.15 Kathmandu University

Kathmandu University is comprised of 7 schools on Engineering, Science, Management, Law, Medicine, and Arts. All schools have developed their own way of teaching and learning that is suitable for their field of study. In the School of Engineering the teaching methodology is more focused on lectures and project-based learning. Students are required to attend lectures and exhibit their understanding of subject matter through projects. In every semester students enroll in a project, with the exception of the final semester, where students have to join an industry internship program through which they work full time over a 3-month period in a selected company.

The School of Engineering has introduced the concept of community-based learning in collaboration with Himal Partner through the joint Community Education Project, through which students visit the community to identify problems and come up with solutions. Some student groups implement community-related projects as part of their course work. Students and teachers get an opportunity to understand the problems faced by the community and how their education can be utilized for solving social problems.

Kathmandu University has not fully implemented active learning. However, it indirectly fosters the adoption of active learning by introducing project-based courses that deploy more student-centered methodologies.

Regarding university facilities related to project-based learning, students are allowed to access the university resources for completing their projects whenever the laboratory spaces are free. They further hold mandatory weekly meetings with their project supervisor to share their ideas and discuss project progress. These meetings are conducted in rooms with access to the internet.

The university also provides access to a video recording studio to educators who are interested in recording video lectures and disseminating them to students through the university e-learning platform, which is based on Moodle®.

The Kathmandu University School of Medical Sciences (KUSMS) uses problem-based learning as the main teaching learning methodology. Students use the knowledge gained in lectures to solve problems. The following problem-based learning practices are used (Mansur, Kayastha, Makaju, & Dongol, 2012):

- Problem-based learning cases.
- Problem-based learning groups.
- Problem-based learning sessions.
- Problem-based learning study sessions.
- Wrap-up sessions.

These practices, which are evident in different schools and departments, demonstrate preparedness towards the adoption of student-centered learning.

A6.16 National University of Future and Emerging Sciences

Literature shows only a handful of examples in which problem-based learning is used in the context of Software Engineering. Software Engineering is taught in most educational institutes through a series of lectures. It further includes a semester project through which students get hands-on experience on practical software development. However, the present system fails to adequately teach the software development process.

Lack of knowledge on software process among graduates results in major software failures and delivery of faulty software. The underlying issue is that graduates are unprepared for tackling industry challenges due to their lack of practical comprehension of concepts. Therefore, there is a need to provide learners with an opportunity to practice concepts in an environment that simulates real world software development activities.

Researchers have introduced simulations and game-based designs in problem-based contexts to allow students to practically experience key concepts they encounter in books or through lectures. Simulations have proved to be a successful way of gaining practical experience in several fields ranging from flying jets to driving cars. However, in the case of Software Engineering little attention has been paid to developing simulations and games for learning. Only a few examples are available, such as Calico® and SimSE®.

An example of deploying problem-based learning, and specifically using learning games in Software Engineering, involves a 3D game for building knowledge on object-oriented design. The game aims to equip learners to practically picture themselves in a working environment. The game provides practical experience within the timeframe of a course. Experimental research has taken place in order to gain insight on how learners utilize the proposed game object-oriented software design courses. Researchers recruited 36 undergraduate students enrolled in Software Engineering for conducting a learning experiment. The students were divided into two groups of 18 members each:

- The control group.

- The experimental group.

The distribution of students in the groups was random to avoid bias in the study. The experiment was designed to fit in the class standard structure of one semester that lasts 16 weeks and is delivered through 45-minute classes and 60-minute laboratory sessions.

Both groups attended classes to gain basic knowledge. Laboratory sessions were conducted separately. In the beginning of the semester the experimental group was exposed to the game and its usage followed by an interactive 50-minute session in which group members had an opportunity to clarify all aspects of the game functionality. The control group carried on with projects implemented in the conventional way. Both groups were divided in 6 teams of 3 individuals for conducting project work. Teams in both groups were assigned 5 projects each. Similar projects were selected for both groups for ensuring an objective assessment. The work demonstrated a significant advantage of problem-based learning approaches, which in this case were implemented through game-based learning, towards building knowledge and practical experience among learners.

A6.17 Hanoi University of Science and Technology

Hanoi University of Science and Technology (HUST) is one of the best universities in Vietnam. The vision of the institution is “to become a leading research university rooted in the technical and technological fields; to make significant contributions that develop a knowledge-based economy and maintain national peace and security; and to be a pioneer in growing and sustaining Vietnam’s higher-education system”.

In order to achieve above vision, one of the important tasks is to set up a training model in which students not only build professional knowledge but also practice soft skills such as communication, teamwork, problem solving, organization, and leadership. Specifically, the curriculum of all majors includes project subjects. In project related courses, the class is divided into groups of 1 - 3 students. Each group is guided by a mentor. At the beginning of the semester the mentor provides a list of problems for the students to choose from. These problems may be case studies or real problems suggested by companies. Students select a problem to solve based on their abilities or interests. The objective of the course is to encourage students to introduce a solution to the problem. Students meet weekly their mentor to report their progress or request guidance if needed. The mentor provides suggestions or directions towards the solution of the selected problem. At the end of the course, the mentor organizes a final presentation day to assess students' performance. Mentors may also invite experts from companies to participate in the presentation. These experts advise students towards building the professional knowledge and soft skills necessary for entering the job market after graduation.

Problem-based learning is used in several courses in the School of Mechanical Engineering (SME). The School offers a Global Problem-Based Learning program in the framework of cooperative activities between Hanoi University of Technology and Shibaura Institute of Technology (SIT), Japan. The goals of this program are:

- To build problem solving capability among students, making them internationally attractive in the job market.
- To build basic knowledge on design and production technologies.
- To build capability to work in international and / or interdisciplinary teams.

A total of 20 students from Shibaura Institute of Technology, along with students from Hanoi University of Technology in Mechanical Engineering, Mechatronics, participated in the program. The total number of participants in the program was 40. Students were assigned a specific problem and were challenged to introduce a solution in a specific, limited timeframe. The challenge was to design and create a vehicle that was able to store and use its own energy and was capable of running a distance of exactly five meters. There was no official class time. Instead, students received brief instructions from professors and professors and industry professionals. Students from the Hanoi University of Science and Technology took part in collaborative activities that were sponsored by both schools. During the course students were divided in 10 teams of 4 individuals. Each team included 2 students from Hanoi University of Science and Technology and 2 students from Shibaura Institute of Technology. Students were given access to Hanoi University of Science and Technology facilities and had just 11 days to turn out their ideas into fully functional energy self-storage vehicles.

Student teams competed and completed their inventions just in time. In one case, all teams managed to create vehicles that actually ran. However, the 1st place prize certificate went to the only team whose vehicle ran the required exact distance of five meters. Another certificate was awarded to the team with the best vehicle design.

Students built experience on how to collaborate in a global team, how to manage a project, and how turn ideas into concrete outcomes.

The project was a huge success. Both schools are planning to sponsor the collaboration again. Students were impressed with their participation in the event, in which they were able to engage in and learn through hands-on design engineering projects and programs.

Another example of problem-based learning stems from the School of ICT (SoICT). The School of ICT has been reviewed by experts from European universities and is considered to offer an educational program that is equivalent to those of European universities. The curriculum includes 4 courses in which problem-based learning is used: Project 1, Project 2, Project 3, and Final Project. In these courses, students can work alone or in a team, and are guided by a mentor. The focus of the courses is as follows:

- Project 1 helps students develop programming skills. Students are challenged to develop programs that solve a number of specific problems, using languages such as C, Python, Java, Javascript, html, and more.
- Project 2 helps students learn how to analyze and design systems. A mentor assigns a specific real problem and requires students to analyze and design a system. The final result of the course is a report which the system design suggested by students.

- Project 3 requires students to build a complete software product for solving a specific problem using a given technology. Students must analyze the problem, identify the functional requirements of a related product, analyze and design a software system, build knowledge on the necessary technologies, implement a program, run tests, and complete the software.
- In the Final Project, students build a complete application product, which can be used in the real world. Students identify actual needs, brainstorm on ideas towards a solution, analyze the requirements of the product, design a system, implement a program, test, and deploy.

Project courses are not organized in traditional classes. Instead, students and mentors meet and discuss directly. Students can execute their projects in laboratories. The School of ICT has 5 laboratories:

- The Modeling, Simulation and Optimization Laboratory (MSOLab) was founded in 2013 and is a community of theoretical computer scientists with interests in algorithms, complexity, simulation, high-performance computing, modeling, machine learning, semantics, security, logic, and databases. The mainspring of research in the laboratory is the study of theories which underline, or should in the future underline, the analysis and design of computing systems. Work has a core of theoretical research and a practical component which explores application and implementation of the theory. Several research groups exist in the laboratory: Algorithms and Optimization, High-Performance Computing, Data Science, and AI.
- The Software Engineering and Distributed Computing Lab (SEDIC LAB) undertakes research in a variety of areas related to Software Engineering, Distributed Computing, and Internet Technologies. Such areas include formal methods, massive content processing, network modeling and simulation, semantic computing, signal analysis and natural language processing, security technologies, data mining and knowledge

discovery, component-based systems, cloud computing, service integration, telemedicine, wireless sensor networks, P2P, social networking, and more. There are 4 main research groups associated with the laboratory: Software Engineering and Cloud Computing, Distributed Computing and Network Modeling, Semantic Computing, and Service Integration Technologies.

- The Data science Lab (DS Lab) aims to promote high-quality research at the international level in the field of data science, actively promote collaboration with businesses to create smart products or services, train engineers and data scientists, address market needs in Vietnam and internationally. Currently, the laboratory engages more than 10 researchers and more than 60 excellent students. Members work in specialized groups that focus on big data, deep learning, machine learning, data mining, the internet of things, computer vision, information retrieval, and natural language processing. The laboratory supports institutes, students, and partners in carrying out basic and applied research. Research has been funded by a variety of sources, such as AFOSR (USA), ONRG (USA), NAFOSTED, SAMSUNG, businesses, and more.
- The Computer Systems Laboratory (CS Lab) focuses on intensive research and technology transfer in Computer Engineering. The main research directions of the lab are embedded computer design, embedded system design and development, signal and speech processing, supercomputer design and applications, mobile application development, navigation services development, information systems development, and industrial education. The research directions set forth correspond to the research capacity of the laboratory, the coordinating units, and the policies of Vietnam.
- The Network and Communication Technology Laboratory (NCT Lab) conducts basic and applied research on issues of national and international interest in the field of data transmission and computer networks. The laboratory consists of several small research groups that focus on key topics such as advanced network technologies, network and

information security, multimedia communication technologies, mobile and distributed computing, and more. The laboratory further aims in technology transfer and the exchange of good practices on science and technology between scientists and enterprises with the objective of bridging the gap between research and its practical application in the field of computer networks in Vietnam and in the world. In addition, the laboratory overlooks activities supporting higher education and post graduate engineering training creating a favorable research environment for students and fellows and attracting students to study science from the start of their studies.

7. SUMMARY OF THE STATE OF THE ART ANALYSIS

This document presented the current status quo in countries participating in the ALIEN consortium in relation to the deployment of active and problem-based learning in higher education engineering practices. The report includes a review of practices at the national level and at the institutional level for project partners. The work was conducted at the University of Thessaly (Greece), Porto Polytechnic (Portugal), Tallinn University (Estonia), University of Central Lancashire (UK), University of Gabrovo (Bulgaria), University of Malaya (Malaysia), University Tenaga Nasional (Malaysia), Kathmandu University (Nepal), Tribhuvan University (Nepal), Isra University (Pakistan), National University of Computer and Emerging Sciences (Pakistan), Hanoi University (Vietnam), Hanoi University of Science and Technology (Vietnam), Von Neumann Institute (Vietnam), University of Battambang (Cambodia), Institute of Technology Cambodia (Cambodia) and Meanchey University (Cambodia). The review demonstrated that while active and problem-based learning are to some degree deployed at partner universities and beyond in the corresponding countries obstacles do exist for the broad deployment of the methodologies in engineering higher education. These include the lack of physical infrastructures, the lack of digital learning services and the need for instructor training. The ALIEN project introduces a learning intervention that aims to promote active and problem-based learning as strategic educational approaches in engineering HE by addressing all of the identified obstacles through the development of physical problem-based learning labs at Asian universities, the development of a problem-based learning collaborative digital platform, instructor training and the creation of a community of good practices for the promotion of active and problem-based learning.

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PART B. METHODOLOGICAL AND SYSTEM DESIGN

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B1. INTRODUCTION

The aim of project ALIEN: Active Learning in Engineering is to design, implement, and validate an active learning context based on problem- and project-based learning methodologies addressing real-life issues related to science, technology, engineering, and math (STEM) concepts. The methodology will be supported by a virtual learning environment integrating a set of digital tools that will allow teacher and students to experiment, collaborate and communicate in an extended and multinational learning community that will also include other stakeholders like researchers and managers.

This section presents the specification and design of that platform. It was established through desk research to assess development possibilities and through collaborative work between consortium partners.

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B2. DEVELOPMENT TOOLS AND RESOURCES

Two different development options were considered:

- Taking an existing open source online platform (VLE) and customize it for the ALIEN purposes.
- Developing the ALIEN digital services from scratch.

Following is an analysis of the work.

B2.1 Adaptable platforms

This option considers the use/adaptation of existing platforms for the purposes of the project.

B2.1.1 Learning management systems

E-learning platforms or Learning Management Systems (LMS) allow teachers to share information and to communicate with their students. These platforms are usually very static, too structured, and do not have the necessary flexibility to allow for personalized learning without customization of the software. Nevertheless, there are some Open Source LMS's that can offer the dynamic and flexible features needed.

Moodle

Moodle is one of the most popular open source LMS options available today. It features dashboards, learner tracking, and multimedia support. It also allows the creation of mobile-friendly online courses and the integration of third-party add-ons. One of the standouts of this tool is the user community and the online support database. Moodle code is open and fully customizable.

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ATutor

This open source LMS has a variety of features, from email notifications to file storage. ATutor is also user-friendly and accessible. It also offers themes to speed up the eLearning course development process, as well as eLearning assessment tools, file backups, analytics, and poll integration.

Eliademy

Eliademy is free for educators and eLearning facilitators, but a small fee per user is charged for the Premium version. It features eLearning course catalogues, eLearning assessment tools, and a mobile Android application for educators who wish to develop mobile learning modules for their on-the-go audiences.

Forma LMS

Forma LMS includes different features like skill gap analysis and detailed analytics and reporting. It also boasts certificates, competency management support, and a wide range of virtual classroom management tools, including calendars and event managers. Forma LMS is suited for corporate training programs and offers an active online community where it is possible to find advice, tips, and tricks.

Dokeos

Dokeos features a variety of eLearning templates and eLearning course authoring tools to create rapid eLearning. Their website also features useful information, including video tutorials that walk through every step of the process. The interface is user-friendly and intuitive.

ILIAS

ILIAS is SCORM 1.2 and SCORM 2004 compliant. It's flexible, versatile, and scalable and a full-fledged collaborative eLearning platform, allowing communication with the team and sharing of

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documents all in one place. It's free of charge for all eLearning developers and organizations, as well as educational institutions, regardless of the number of users.

Opigno

Opigno is based on Drupal and includes certificates, class calendars, online forums, eLearning authoring tools, eLearning assessments, and video galleries. It is possible to manage a virtual training program, track learner skill development, and integrate e-commerce using just one tool. Opigno also offers online surveys, instant messaging, and chat, which makes it a great feedback and collaboration tool.

OpenOLAT

eLearning assessment tools, social learning integration, and learner home pages are just some of the things that set OpenOLAT apart from many of the other open source LMS solutions. OpenOLAT also offers a class calendar, email notifications, eLearning course bookmarks, file storage, and certificates. OpenOLAT makes it simple and straightforward to add users and groups to an eLearning courses as well as develop comprehensive eLearning course catalogues. Another notable highlight is its browser check features, which gives you the opportunity to test the eLearning course on a wide range of browsers to make sure it is compatible. This is ideal for multi-platform eLearning courses that need to run on a variety of different devices.

B2.2.2 Project management software

Project management software allows the management of tasks and resources in a project therefore organizing and structuring the whole process.

GanttProject

Founded in 2003, GanttProject is ideal for small businesses that need project planning, resource management, and task management capabilities but that also have an IT staff that can oversee implementation and troubleshoot issues.

GanttProject is written in Java (requires Java RunTime) and is compatible with Windows, OSX, and Linux operating systems.

Capabilities include task management, resource management, and project planning using Gantt charts and PERT charts. Users can export data to .csv and generate summary PDF reports.

GanttProject product is fairly robust and it is quite clear what the product does and what it does not. In addition to FAQs, the vendor provides several support resources including video tutorials contributed by volunteers and a support forum.

Project tasks cannot be measured in hours, only days. While this isn't a con unique to GanttProject, it may deter teams that need to manage smaller projects where single tasks don't require a day or longer to complete.

OpenProject

OpenProject Community is a robust project management solution written in Ruby on Rails and compatible with Linux operating systems. Free capabilities in OpenProject Community include task management, time tracking, team collaboration, project planning using Gantt charts, budgeting, and reporting. It also supports Agile project management and offers task boards, backlogs, bug tracking, and road mapping.

Users can upgrade to a paid license if they want to use OpenProject in the cloud or as an enterprise. Paid plans offer additional capabilities, including customization, security, and support. OpenProject includes the entirety of their project management capabilities in their free version. But the price for businesses that want to upgrade to OpenProject Cloud or Enterprise for customization options, security features such as two-factor authentication, and professional support is reasonable.

OpenProject Community offers minimal support outside of user guides. Additionally, as with any self-installed desktop solution, you either need to be tech savvy enough to troubleshoot issues on your own, or have an IT staff that can oversee installation and system maintenance for you.

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Windows OS is not supported, and to run OpenProject on OSX requires setting up a development environment. Linux may be the preferred OS for developers, but Windows is hands down more mainstream, which makes the fact that it isn't supported problematic.

OrangeScrum

OrangeScrum is a task and project management tool, available as a free and open source downloadable desktop app called "OrangeScrum Community," or for purchase as cloud-based or self-hosted software. It is written in CakePHP and is compatible with Windows, OSX, and Linux operating systems.

Free, standard features include task management using lists or a Kanban board, resource utilization, and task and resource reports and analytics. Users can purchase premium features as add-ons to the free plan, or they can upgrade to a paid plan.

Premium features include time tracking, recurring tasks, Gantt charts, project templates, client management, and user role management. Training and onboarding support is available for an additional fee.

OrangeScrum Community users have access to a global forum as well as online documentation to help troubleshoot issues. There's also an installation guide and email, Skype, and phone support. Capterra reviewers give the product an average 4/5 stars for customer service.

Users may find information surrounding OrangeScrum's plans a little confusing, as the free and paid versions go by the same name. In a Google search for "OrangeScrum", the top results are for organgescrum.com and orangescrum.org with no clear indication that they are the same product.

ProjectLibre

ProjectLibre is a popular open source project management tool with over three million downloads. It offers Gantt chart functionalities that help you create tasks and simultaneously

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visualize the critical path on a single dashboard and visualize task dependencies and spreadsheet reports for calculating project costs and understanding resource availability.

The tool is compatible with Microsoft Project, allowing to migrate Gantt charts and files. ProjectLibre's user interface isn't inviting for those unfamiliar with Microsoft Project and similar tools.

ProjectLibre is compatible with OpenOffice, LibreOffice, and Microsoft Project 2003, 2007, and 2010, but it has not been updated to accommodate fully with Microsoft Project 2013 or 2016.

ProjeQtOr

ProjeQtOr is a solid, open source project management tool originally released in 2009 by French developer Pascal Bernard. Over the years, dozens of contributors have put significant work into the project, expanding it into a deep project management system with a dizzying number of features, including portfolio management, bug tracking, risk management, and budget management.

ProjeQtOr is completely free. The developer makes money off the project by charging for hosting the system, premium support (basic support is available via community forum), professional training, and developing custom features. Users can also request features for free in the forum. "Sponsoring" a feature request just expedites the process. The system is regularly updated with new patches coming out several times per month and a new major update to add features and address issues roughly every other month. The community forum is also very active. Bernard, who goes by "babynus" on the forum, responded to ten topics on the day that the implementation team reviewed it.

ProjeQtOr has a lot going on which can be overwhelming for new users. The website itself says: "ProjeQtOr can frighten you at first sight: The number of menu icons available after installing the application is impressive, and you may dread complexity.

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B2.2.3 Collaborative and social networking platforms

In today's world, social networks are more than just chatting platforms; they are now a source of knowledge and awareness. Open source social network development platforms come with pre inbuilt tools those are flexible and helps to easily customize and build on top of it.

Elgg

The Elgg is an open source social network software which is free to download. It is built on a framework that allows creating any kind of social environment. Whether starting a social network for university, a college, or for an organization to build communities, a development team can use Elgg. It is a 2008 award-winning open source social networking engine. Elgg uses the Apache, PHP, MySQL, and Linux environments and has a good community to solve the arising issues with a repository of 1000+ open source plugins.

Elgg features:

- Well-documented core application user interface (API) for developers to easily start and learn.
- Composer to make the installation of Elgg easy and simple; the composer further allows easy maintenance of Elgg core and related plugins.
- Flexible system of hooks to allow extension and modifications of application with help of plugins and custom themes.
- Cacheable system for good performance, user authentication, and built -in security system such as anti-CSRF validation, strict XSS filters, and HMAC signatures.
- Client-side API.
- Content access policies.
- File storage.
- Notifications service.
- RPC web services.

Dolphin social networking

Dolphin Pro is an open-source software for creating custom social networks and web communities. It is written in PHP and for database uses the MYSQL. This social networking website software platform is fully modular and offers multiple modules such as Ads, Payments, Photos, Polls, Profile Customizer, Profiler, Chat, Profiler, Desktop, Facebook Connect, Forums, Videos, Memberships, Messenger, Page Access Control, World Map, Events, Custom RSS, Chat, SMTP Mailer, Sounds and more… It also features social profiles, timelines, likes, shares, voting, friends, Chat+ (WebRTC multiuser audio/video chat) and comments.

Opensource social network

OSSN is another very good open source social network software with a bit Facebook®-like interface and features such messaging, friend request panel, and few other elements. It allows creating a full-featured social media network platform that allows groups, photos, files, messages, and more. OSSN is multilanguage social network software. It is available in two versions basic and premium. Furthermore, users can download it as an installer for the Linux operating system or virtual image.

The Open source social network features third party integrations, tools themes, games, audio video call, authentication (Google reCAPTCHA), and more.

HumHub

HumHub is a free and open source social network software kit and framework with a user-friendly interface just like Facebook®. It is lightweight and features multiple tools to make communication and collaboration easy. HumHub offers the ability for customization towards building and creating a customized social network, social intranet, or huge social enterprise application based on the specific needs of the target group.

HumHub is a flexible system and offers a modular design that can be extended using third party tools to connect existing software or any other even written the development team. HumHub offers a self-hosted solution which gives full control over the created social network, meaning that that the development team can manage their own server, data, and rules. Community and enterprise edition options are available.

Oxwall

Oxwall is a free social network software cum content management system. It is based on PHP and uses the MYSQL database to deploy the social network environment development. It is available in three editions: free, starter solution ($249), and advanced solution ($2999). In the free edition, the development team has access to the Oxwall software, the developer's forum, third-party plugins, and the documentation. The Oxwall CMS is compatible with all types of websites and it is also scalable.

BuddyPress

BuddyPress is a product of the well-known content management system WordPress. It helps to create social media networking websites with WordPress. One of its advantages is that it is simple to use. In addition, many BuddyPress design themes are available online that help the development team to easily customize the look and feel of a social network website. BuddyPress is based on PHP and can be customized easily by an experienced developer. BuddyPress is a completely free and open source social network development platform.

The BuddyPress social content management system features custom profile fields, personal profiles, email notifications with smart read/unread, support for the creation of micro-communities, plugins, extensions support, private messaging, friendship connections, a platform for discussions, and much more.

B2.2 Development tools and resources

Considering the possible development from scratch of the ALIEN platform, different tools would be required.

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B2.2.1 Programming languages

Behind all web development tools there is a programming language. A programming language is a formal constructed language designed to communicate with a computer and create programs that control the behaviour of an application. Following is a summary of popular web programming languages:

PHP

A popular general-purpose scripting language that is especially suited to web development.

NodeJS

It is an event-driven I/O server-side JavaScript environment based on V8.

Javascript

It is a programming language of HTML and the web.

HTML5

It is a mark-up language, the latest version of HTML and XHTML.

Python

It is a programming language that lets you work quickly and integrate systems more effectively.

Ruby

It is a dynamic, open source programming language with a focus on simplicity and productivity.

Scala

A pure-bred object-oriented language allowing a gradual, easy migration to a more functional style.

CSS3

Latest version of cascading style sheets used in front-end development of sites and applications.

SQL

It stands for structured query language used with relational databases.

Golang

It is an open source programming language that makes it easy to build simple, reliable, and efficient software.

Rust

A systems programming language that runs blazingly fast, prevents segmentation faults, and guarantees thread safety.

Elixir

A dynamic, functional language designed for building scalable and maintainable applications.

TypeScript

It is an open source programming language that is a superset of JavaScript which compiles to plain JavaScript.

B2.2.2 JavaScript libraries

Javascript is one of the most popular programming languages on the web. A Javascript library is a library of pre-written Javascript which allows easier access throughout the development of a website or application. Following is a list of popular Javascript libraries:

jQuery

It is a fast, small, and feature-rich JavaScript library.

BackBoneJS

It allows developers to give a JS app some backbone with models, views, collections, and events.

D3.js

It is a JavaScript library for manipulating documents based on data.

React

Facebook®s Javascript library developed for building user interfaces.

jQuery UI

It is a curated set of user interface interactions, effects, widgets, and themes.

jQuery Mobile

HTML5-based user interface system designed to make responsive web sites.

Underscore.js

It is a functional programming helpers without extending any built-in objects.

Moment.js

It allows the parsing, validating, manipulating, and displaying of dates in JavaScript.

Lodash

It is a modern utility library delivering modularity, performance, and extras.

Vue.js

It is an open source JavaScript framework used for building user interfaces.

B2.2.3 Front-end frameworks

Front-end frameworks usually consist of a package that is made up of other files and folders, such as HTML, CSS, JavasScript, etc. Many standalone frameworks exist. A solid framework can be an essential tool for front-end developers. Following is a list of popular front-end frameworks.

Bootstrap

It is an HTML, CSS, and JS framework for developing responsive, mobile first projects on the web.

Foundation

A family of responsive front-end frameworks that make it easy to design beautiful responsive websites, apps and emails that look amazing on any device.

Semantic UI

It is a development framework that helps create beautiful, responsive layouts using human-friendly HTML.

Uikit

It is a lightweight and modular front-end framework for developing fast and powerful web interfaces.

B2.2.4 Web application frameworks

A web application framework is a software framework designed for aiding and alleviating some of the challenges involved in the development of web applications and services. Following is a list of popular application frameworks:

Ruby

Ruby on Rails is a web-application framework that includes everything needed for creating database-backed web applications, with the MVC pattern.

AngularJS

It is a framework that allows developers to extend HTML vocabulary for web application. AngularJS is a framework, even though it is lightweight and sometimes referred to as a library.

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Ember.js

It is a framework for creating ambitious web applications.

Express

It is a fast and minimalist web framework for Node.js.

Meteor

It is a full-stack JavaScript app platform that assembles all the pieces needed for building modern web and mobile apps with a single JavaScript codebase.

Django

It is a high-level Python web framework that encourages rapid development and clean, pragmatic design.

ASP.net

It is a free, fully supported web application framework that helps developers to create standards-based web solutions.

Laravel

It is a free, open-source PHP web application framework for building web applications on MVC pattern.

Zend Framework 2

It is an open source framework for developing web applications and services using PHP.

Phalcon

It is a full-stack PHP framework delivered as a C-extension.

Symfony

It is a set of reusable PHP components and a web application framework.

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CakePHP

It is a popular PHP framework that makes building web applications simpler, faster, with less code.

Flask

It is a micro framework for Python based on Werkzeug and Jinja 2.

CodeIgniter

It is a powerful and lightweight PHP framework built for developers who need a simple and elegant toolkit to create full-featured web applications.

B2.2.5 Task runners and package managers

Tasks runners are used for automating workflow. For example, a developer can create a task and automate the minification of JavaScript. Then build and combine tasks to speed up development time. Package managers keep track of all the packages used and ensure that they are up to date and on the specific version needed. Following is a list of popular task runners and package managers.

Grunt

It is a JavaScript task runner for automation.

Gulp

It is a task runner that keeps things simple and makes complex tasks manageable, while automating and enhancing workflow.

Npm

It is a pack manager for JavaScript.

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Bower

It is a web package manager that manages components that contain HTML, CSS, JavaScript, fonts, or even image files.

Webpack

It is a module bundler for modern JavaScript applications.

B2.2.6 Databases

A database is a collection of information that is stored so that it can be retrieved, managed and updated. Popular databases for web development include:

MySQL

It is one of the world's most popular open source databases.

MariaDB

A database created by the original developers of MySQL. MariaDB is also becoming very popular as an open source database server.

MongoDB

It is a next-generation database that lets you create applications never before possible.

Redis

It is an open source, in-memory data structure store, used as a database, cache, and message broker.

PostgreSQL

It is a powerful, open source object-relational database system.

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B2.2.7 API tools

Web developers typically use APIs on a daily basis. APIs are essential in today's web development environment, however, can sometimes be difficult to work with in terms of monitoring, creating, or combining. Thankfully, there are a variety of tools available to make working with APIs much more efficient. Following is a list of popular related applications:

Runscope

It is an API performance testing, monitoring, and debugging solution.

Zapier

It is a tool for connecting the APIs of various apps and services in order to automate workflows and enable automation.

Postman

It is a complete API development environment that includes functions for designing, testing, monitoring, and publishing.

SoapUI

It is an advanced REST and SOAP testing tool with the ability to perform functional testing, security testing, performance testing, etc.

B2.2.8 Collaboration tools

Every great development team needs a way to stay in touch, collaborate, and be productive. Nowadays, development teams often work remotely. The team at KeyCDN is actually spread across many different continents. Tools like the ones described below can help employees streamline their development workflow:

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Slack

It is a messaging app for teams that is on a mission to make working life simpler, more pleasant, and more productive.

Trello

It is a flexible and visual way to organize anything with anyone.

Glip

It is a real-time messaging application that offers integrated task management, video conferencing, shared calendars, and more.

Asana

It is a team collaboration tool for teams to track their work and results.

Jira

It is a package built for every member of a software team; it helps plan, track, and release great software or web applications.

B2.2.9 Website speed test tools

The speed of a website can be a critical factor to its success. Faster loading websites can benefit from higher SEO rankings, higher conversion rates, lower bounce rates, and a better overall user experience and engagement. It is important to take advantage of the many free tools available for testing website speed, such as:

Website Speed Test

It is a page speed test developed by KeyCDN that includes a waterfall breakdown and the website preview.

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Google PageSpeed Insights

It analyzes the content of a web page and generates suggestions to make that page faster.

Google Chrome DevTools

It is a set of web authoring and debugging tools built into Google Chrome.

Dotcom-Tools Speed Test

It is a tool that allows testing the speed of a website in real browsers from 25 locations around the world.

WebPageTest

It is a tool that allows running a free website speed test from multiple locations around the globe using real browsers, such as Internet Explorer or Chrome, at real consumer connection speeds.

Pingdom

It is a tool that allows testing the load time of that page, analyzing it, and finding bottlenecks.

GTmetrix

It is a tool that provides insight on how well a site loads and provides actionable recommendations on how to optimize it.

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B3. PEDAGOGICAL MODEL

The foundation for the ALIEN pedagogical model of use of the platform has to take into account three different aspects: institutional, pedagogical, and technological.

On top of the understanding of the needs for each of these tangents lies the problem-based learning approach, which is considered to be a well-proven pedagogical and a well working learning approach used in many countries, including some of the countries in which ALIEN has partners.

The ALIEN methodological approach is centred on principles and steps of problem-based learning and its integration with the ALIEN platform. Before describing the pedagogical methodology, it is important to address what teacher actions and benefits from the deployment of this approach.

B3.1 A review of problem-based and active learning

Problem-based learning is an educational approach through which learners build knowldge by problems (Kilroy, 2004). In many cases, problems are open ended, meaning they do not have only one correct answer, and they are inspired by real-life. Problem-based learning aims to help students connect with educational material. It builds knowledge in a manner that simulates future professional roles.

Problem-based learning is deployed in all educational levels, including school, education, and professional education.

Problem-based learning has its roots in medical education. In the 1960s, it was observed that courses in the first 3 years of educational curricula at McMaster University, Hamilton were not related to clinical medicine, in orther words to the deployment of medicine in everyday real-life scenarios involving patients (McMaster University). A new educational curriculum was designed

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

in which students could focus on the practical application of medical knowledge. Nowadays, 80% of medical schools in the United States apply problem-based learning.

Problem-based learning is deployed beyond the medical sector. It is used in law education, in entrepreneurship education, and social sciences through the study of real-life cases. It is further used in engineering and STEM education for building studnet capacity to synthesize solutions to complex challenges by integrating knowledge from the entire spectrum of educational curricula.

The advantages of problem-based learning are many:

- It promotes creativity and critical thinking (Abt, 1987).
- It promotes exploration, which builds capacity for independent learning.
- It promotes the ability to evaluate information stemming from different sources.
- It builds communication and collaboration skills.
- It fosters discussion and justification of varying solutions to a problem (Awang, Ramley, 2008).
- It supports the transfer of new knowledge from the academic environment to the real world through challenges inspired by real life.

Problem-based learning does not follow traditional educational practices, in which the educator transfers information to a passive group of students. Even classroom setups in traditional educational environments demonstrate this one-way relationship between educators and students, who are “opposite” each other. This does not imply that traditional classroom learning does not have its merits. It is based on behavioral models based on which information is transfered from short-term to long-term memory, is categorized, and is effectively retrieved through repetition. For this reason, traditional learning models focus on the execution of a series of exercises on each topic until concepts are mastered.

Figure 1. Traditional classroom setup, in which educators and students are opposite each other, demonstrating a one-way knowledge transfer model.

Problem-based learning is part of the wider active learning approach. In active learning students build knowledge by doing. Active learning involves all educational activities in which students build knowledge my means other than seeing and listening. Active learning aims to engage students in learning in a more direct and explorative way. In active learning students may:

- Role play.
- Explore.
- Collaborate.
- Visit sites of interest.
- And, finally, solve problems.

Active learning encourages students to engage in analysis, synthesis, and evaluation. Through these activities students develop knowledge, skills, and attitudes.

Active learning is based on the fact that students retain knowledge better when it is build by doing. The following figure demonstrates that students retain 5% of the content of lectures, 10% of what they read, 20% of what they hear, 30% of what they see through demonstrations, 50% of what they discuss in groups, 75% of what they practice by doing, and 90% of what they teach others (The Learning Pyramid).

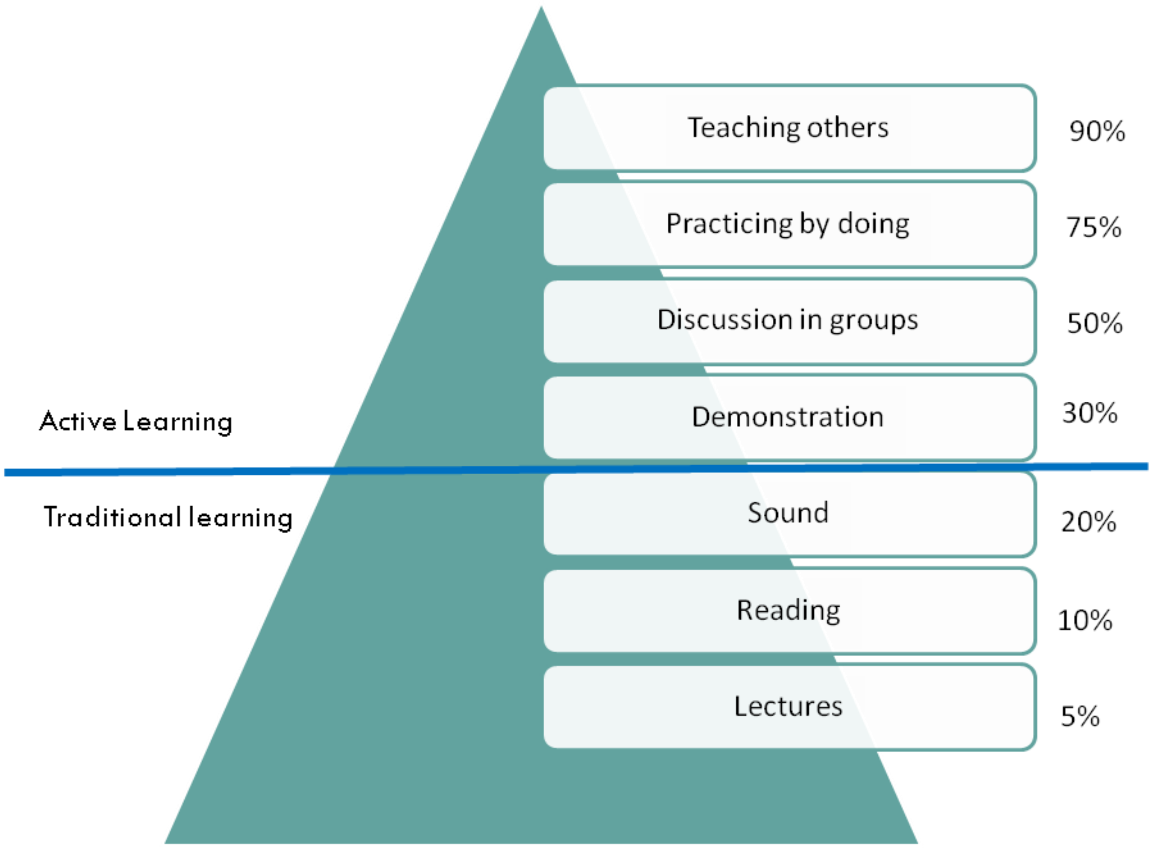

Figure 2. Retention levels of knowledge based on learning methods.

While traditional learning focuses mostly on lectures, reading, and hearing active learning uses as learning tools the methods demonstrated in the upper levels of the pyramid, thus contributing to more effective knowledge retention.

Active learning builds higher order thinking skills. In Bloom's taxonomy (Bloom), demonstrated in the following figure, higher order thinking skills refer to the upper levels of the skills pyramid.

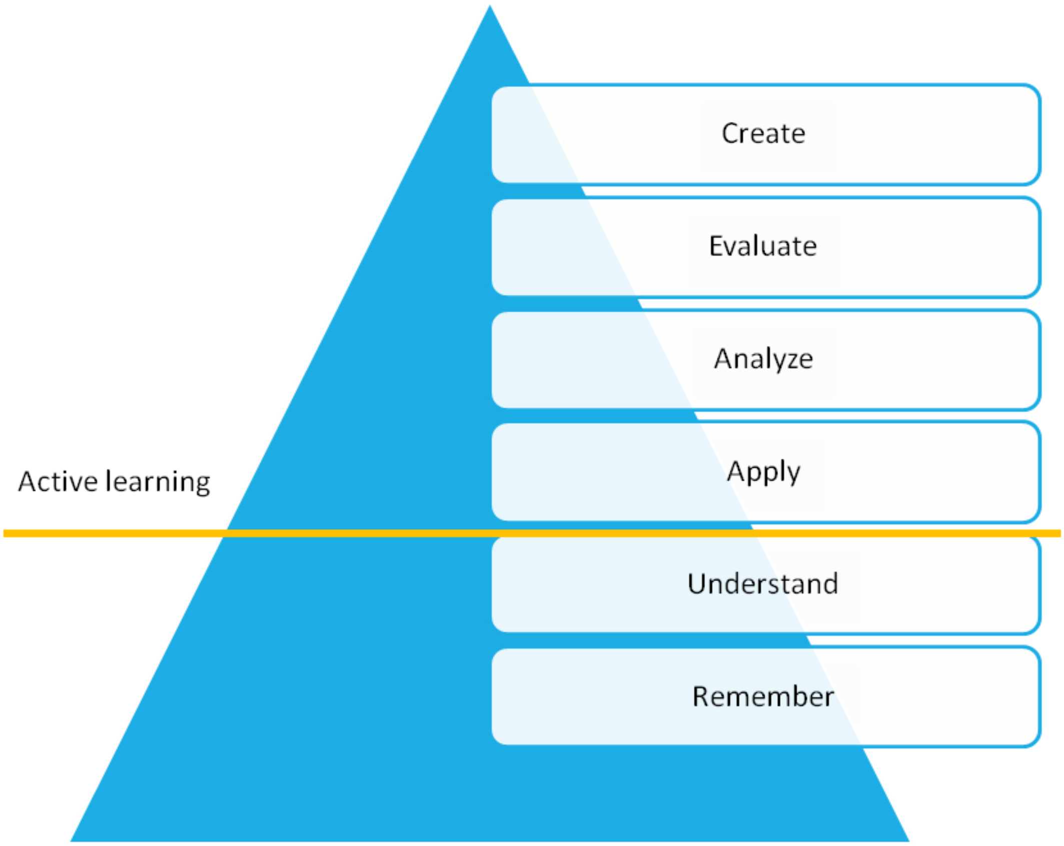

Figure 3. Bloom's taxonomy.

According to Bloom's taxonomy, the first step in building knowledge is remembering, which is followed by understanding, being able to apply new knowledge, being able to analyze information, being able to evaluate information, and creating new knowledge from old.

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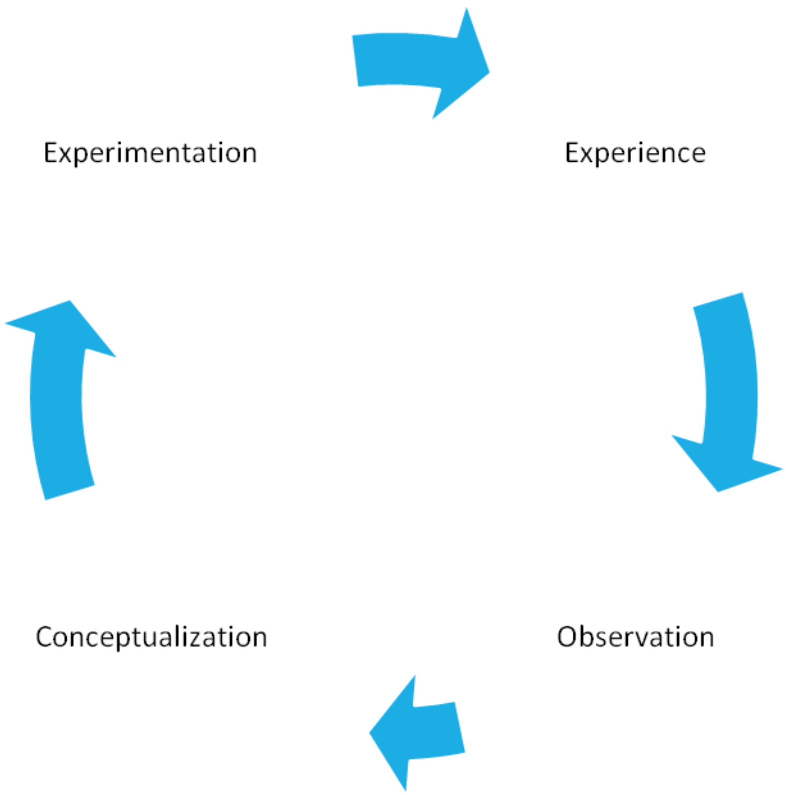

Figure 4. Kolb's experiential learning model.

Traditional learning focuses mostly on the lower two steps of the pyramid, namely remembering and understanding information. Active learning focuses on the higher levels of the pyramid, which involve being able to deploy new knowledge in real-life contexts.

Finally, experiential learning introduced by David Kolb is based on the principle an experience sets students into their road to knowledge. Following a triggering event, students research and observe, categorize new knowledge, experiment, and explore. Through this process students evolve, having developed new knowledge and possibly attitudes.

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B3.2 The basis of active learning: constructivism

Active and problem-based learning have their roots in constructivism, a theory introduced by Seymour Papert (Papert, 1980). Constructivism advocates that knowledge is synthesized, rather than transferred.

Constructivism is based on the theory of constructionism of Jean Piaget. Piaget, who was a phychologist and a teacher to Papert, is the creator of the IQ test. He observed children given a specific problem introduced wrong solutions repeatedly. However, when given the same problem a few years later, they systematically introduced correct solutions. This lead Piaget to conclude that congitive development in humans takes place in stages. He identified the following stages in human development:

- 0 - 2 years of age, sensor motor stage. In this stage children focus on coordination between their mind and senses.
- 2 - 7 years of age, magical thinking. In this stage children understand how the world works around them, however they do not attempt to explain why it functions in a specific way. They simply accept that the world “magically” works in a specific way.
- 7 - 11 years of age, logical thinking. In this stage children develop the capacity for logical thinking. For this reason, it is meaningful to expose them to problems that involve logic.
- 11 - 16 years of age, abstract thinking. In this stage, children develop capacity for grasping abstract concepts.

Piaget further advocated that at when a child moves from one development stage to another, she completely replaces her view of the world with a new one.

Putting the concept of constructivism into play, Papert developed the concept of “microworlds”. Microworlds are simplified representations of the real world in which a learner is encouraged to solve a problem. Well designed microworlds include enough information for learners to solve the problem at hand but omit “noise”, or information that subtracts from their focus on

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problem-solving. Microworlds consist of objects and relationships between them. Rules change the relationships between objects.

The first microworld was the turtle, which Papert designed for building knowledge on Eukleidian geometry among school learners. The world was designed for encouraging students to draw geometrical shapes. The world invovled a turtle, which constituted a cursor, and simple commands that controlled the movement of the turtle. The commands were front (move ahead), back (move back), turn right, turn left, pen up, and pen down.

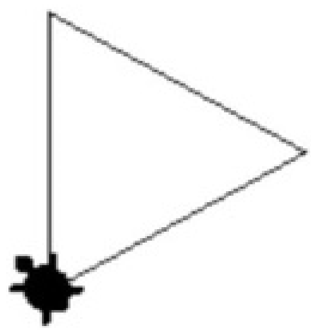

Figure 5. The turtle microworld.

Microworlds can be considered as the theoretical predecessors of serious games and simulations. Similar to microworlds, digital learning worlds are simplified versions of the physical world that include an environment in which students can explore and rules to follow towards reaching well defined goals.

B3.3 Digital games and simulations for problem-based learning

B3.3.1 Serious games and simulations

Serious games are games that are developed for a purpose other than entertainment (Abt, 1987). Serious games are used in diverse sectors. Some of the more popular are:

- Education.
- Professional training and development.

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- Crisis management.
- Health.

In educational contexts, serious games have an explicit learning purpose that is carefully thought out and is linked to educational objectives. The advantages of serious games in learning are many (Abt, 1987):

- Games introduce users to a puzzle. Everyone likes a puzzle! Games may be used for motivating learners to engage in educational processes.
- Games have clear objectives. When carefully designed, game objectives can be linked to educational ones, contributing to educational achievement.
- Through visualization, games contribute to the understanding of abstract concepts.
- Players undertake realistic roles, design strategies, and make decisions. This helps develop critical and analytical thinking as well as problem-solving skills.
- Games provide real-time feedback. This helps learners understand the consequences of their choices by helping them establish links between cause and effect. This process contributes to the scaffolding of knowledge.
- Games may also be used for students evaluation in a safe environment in which mistakes do have real-life consequences.
- They may also be deployed in authentic evaluation, namely evaluation of knowledge through processes that simulate how it will be used in real life contexts.

Two types of games may be identified:

- Games that are developed for entertainment purposes and are used in educational contexts.
- Serious games that are developed from the beginning for education.

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The former may require educators to adapt learning to the focus and functionality of the game. The latter, namely serious games, are themselves adapted to education thus not requiring teachers to modify their class content based on game limits in terms of content and features.

On the other hand, the concept of "gamification" refers to the deployment of games elements in non-game settings, such as learning. Gaming elements include:

- Clear goals and missions.
- A sense of affiliation.
- Rewards.
- Undertaking of roles.
- Social recognition.
- Access to additional information.
- Collaboration.
- Competition among individuals or groups.
- Communication of achievement, e.g. using leader boards.

Such elements are commonly used in popular emerging learning platforms and MOOCs for promoting the long term student engagement of the learning process.

The deployment of games in learning is not a new idea; it is as old as the concept of digital games. The digital games industry business cycle is over $87b yearly, while the learning games market has a business cycle of $2 to $3b per year. A very well known example of the deployment of gamification for business training is that of Delloite, a consulting company that introduced gamification in its employee training platform with the objective of promoting the higher engagement of staff members in training activities. In addition to the more traditional educational content that included text, images, and video the platform introduced gamification elements such as leader boards and rewards. Some of the rewards were attributed to participants when they did not expect it, introducing a surprise element that increased

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motivation. Delloite further noticed that individuals that entered the platform with little experience would have difficulties to achieve enough success in order to be listed in leader boards. This would result in the discouragement of the participation of less experienced professionals. For this reason, the leader board function was modified so that everyone's points were reduced to zero at the end of each week. This allowed all participants to enter the learning activities from the same starting point, providing opportunities for less experienced users to be recognized. Studies demonstrated that there was a link between the participation of employees in learning through the gamified platform with promotions, demonstrating the effectiveness of gamification. Furthermore, it was shown that even highly ranked individuals participated, another evidence for the success of the methodology.

B3.3.2 A review of problem-based learning games

Following is a description of examples of digital tools in the form of games and simulations that may be deployed in problem-based learning contexts. The proposed ALIEN problem-based learning platform will be populated with descriptions of eductional activities that are based on similar tools.

The **eCity** game (eCity, 2015) aims at exposing secondary education students problem-based learning activities through complex challenges to which students introduce solutions by combining knowledge from diverse curricula subjects. The game is in the form of a city on which students are called to introduce interventions for addressing modern challenges. The game has 8 scenarios:

- Designing an energy network for the city.
- Designing an internet service provider network.
- Introducing protection from earthquakes.
- Introducing flood protection.
- Designing a renewable energy network.

- Designing a mobile communications network.
- Introducing solutions fro alleviating pollution.
- Designing a public transport network.

Students work within specific parameters, which include a limited budget. Students compete in the form of a game. The winner is typically the student that achieves the highest number of inhabitants in his city as a result of positive interventions.

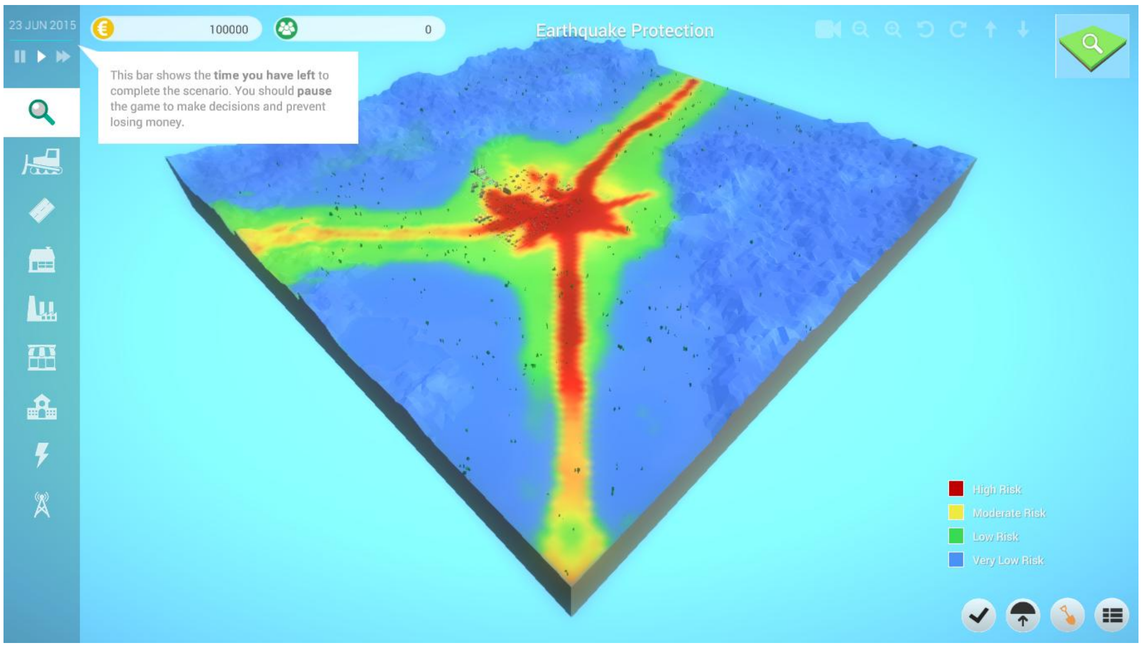

Figure 6. Designing earthquake protection in the eCity problem-based learning game.

The **LEAP** games (LEAP, 2016) target engineering students and aim to introduce broadly the principles of agile and lean design. Two games are available:

The SCRUM game exposes engineering students to agile design principles. Agile design originates from the software engineering sector. It is applied towards designing solutions when the user requirements are not well understood in advance or when they evolve.

Figure 7. Exploring agile principles in the SCRUM LEAP game.

SCRUM is a practical method for the application of agile design. In SCRUM the development team identifies user requirements in the form of "user stories". User stories are broken down to tasks, which the team prioritizes in collaboration with the product owner, an individual that has a good understanding of the software objectives. The team works in sprints, or development cycles, delivering the software functionality in increments. The whole process is coordinated by the SCRUM master, an individual that calls a daily meeting for all involved in the design process in order to ensure that everyone is aware of project implementation status. The SCRUM game exposes students to the related agile processes. It demonstrates how these processes are can positively contribute to design beyond software engineering in all engineering principles. Students are asked to design a university campus and a garden with specific characteristics in 2 separate learning activities. Students undertake typical SCRUM roles, such as the product owner, the SCRUM master, or a team member. The goal is to reach the objectives of the customer as close as possible.

The 5S game aims to expose students to lean industry design.

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Figure 8. Exploring the 5S principle in the 5S LEAP game.

Lean design emerged from the automobile industry. It aims to contain production costs by removing any activities from the production process that are not necessary. 5S stands for sort, set in order, shine, standardize, and sustain.

The related game demonstrates how this principle has applicability in broad engineering principles beyond the automotive sector. Students are asked to perform tasks in a pharmacy, a scrapyard, and a digital office space. The game demonstrates that if the working space is not well managed the time required to perform the given tasks is high. By adopting the 5S principles students may achieve their goals more efficiently.

The **PHET** application suite (PHET) encourages students to experiment with math and science through a set of simulations that allow digital exploration.

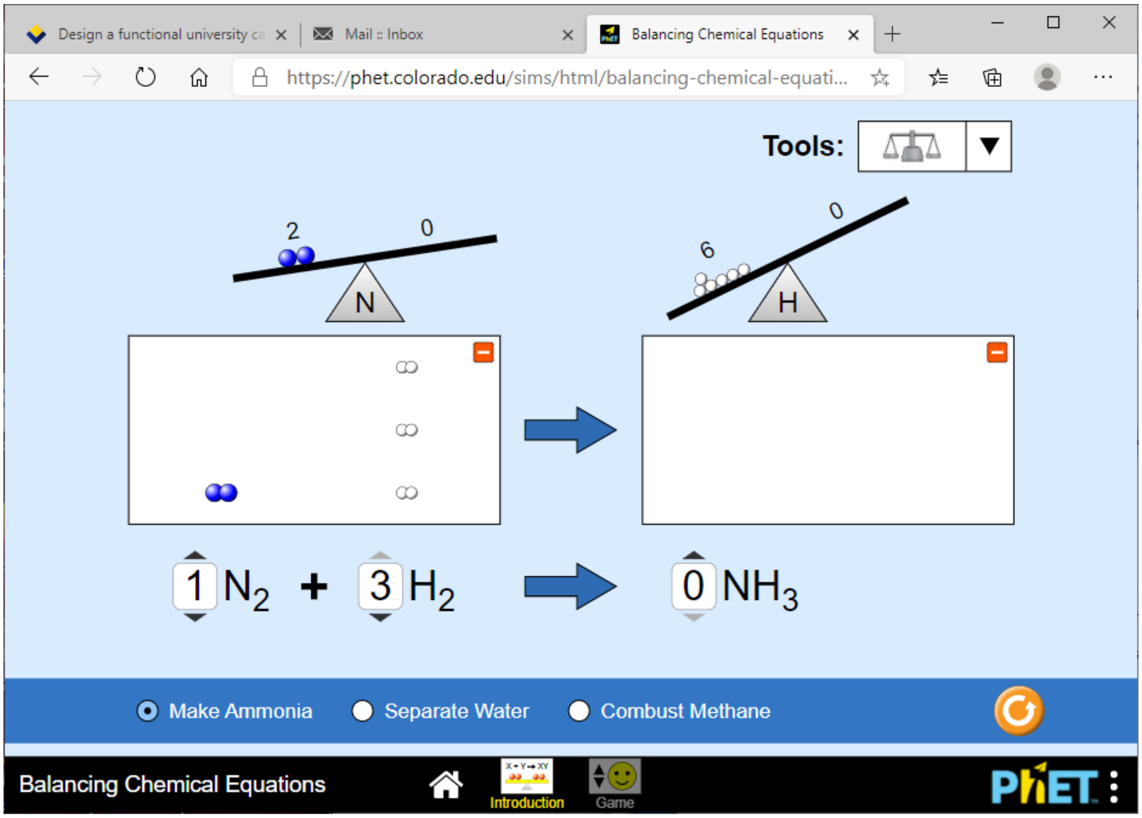

Figure 9. Exploring physics in the PHET application suite (retrieved from https://phet.colorado.edu/sims/html/balancing-chemical-equations/latest/balancing-chemical-equations_en.html).

The simulations engage students in inquiry in an intuitive manner that follows game principles. Students may deploy digital exercises on physics, chemistry, math, biology, or earth science.

The **OnLab** simulator is an educational 3D virtual environment developed by the Hellenic Open University (OnLabs). It aims to introduce students through digital exploration to the fundamental use of a microscope. The activity allows students to observe and familiarize themselves with various aspects of an educational photonic microscope's functions, before they actually use it in a lab context for observing specimens. The simulator goes a step further demonstrating the use of a functional biology lab. The simulator is the result of applied research that simulates the actual physical lab of the Hellenic Open University. The objective of the application is to introduce a digital simulator through which students can be exposed to the manipulation of laboratory instruments in a safe and cost effective way.

Figure 10. OnLabs simulator of a biology lab (retrieved from https://sites.google.com/site/onlabseap/).

B3.4 Problem-based learning and ET2020 objectives

Problem-based learning is in line with Education and Training 2020 (ET2020) objectives. These include:

- Linking education to real-life. This in problem-based learning is achieved by exposing students to educational scenarios inspired by the real world.
- Linking skills with industry and societal needs. This is achieved through educational scenarios that are inspired by industry practices and societal challenges.
- Fighting unemployment. This is achieved by developing the skills and knowledge that industry needs today.
- Building both basic and transversal skills. As discussed above, problem-based learning helps build critical and analytical thinking, collaboration capacity, entrepreneurial mindsets, and other transversal competencies.

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- Linking education to emerging learning design, such as problem-based learning.
- Linking education to digital technologies and open educational content. In problem-based learning this is pursued through the deployment of digital applications, games, and simulations that promote exploration and inquiry.

Problem-based learning is particularly relevant in higher education for addressing the challenges that the sector faces today, and specifically:

- Building knowledge for addressing skills shortages. This is achieved in problem-based learning by developing highly skilled young adults that help industry pursue emerging opportunities through human capital.
- Promoting sustainable employment through skills and competences that address industry needs.
- Encouraging active citizens. This is achieved by building the problem-solvers of tomorrow that possess the knowledge and competences for tackling the challenges of the 21st century.

B3.5 Applying problem-based learning

The basic steps of problem based learning involve:

- Understanding the starting point of learning, i.e. what students know.
- Identifying what additional knowledge students need to develop.
- Designing activities through which desirable knowledge will be built.

There are many ways in which problem-based learning is applied in practice. Some common steps include:

1. Researching the field under consideration first independently, and subseqeutly in groups under educator guidance.
2. State the known variables of the given problem.

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3. Introduce hypotheses.
4. Brainstorm.
5. Evaluation information.
6. Synthesize solutions through collaboration and knowledge integration.

Problem-based learning is often deployed in small groups. The formation of groups benefits students by allowing them to learn from their peers. Teams may be the same throughout an academic semester or change for each educational activity.

Each team member has a role. Team roles include (Belbin):

- Researcher, who finds ideas.
- Team player, who completes tasks for the team.
- Co-ordinator, who monitors team objectives.
- Evaluator, who evaluates diverse ideas.
- Specialist, with specialized knowledge on specific, related topics.
- Implementer, who identifies a workable strategy and follows it to completion.
- Finisher, who polishes the final result.

Ideally, teams must be formed in a manner that ensures rich skill sets.

B3.6 The role of the educator

Problem-based learning is a student centered approach, in which the responsibility of learning is transferred to learners who are called to identify their educatonal goals and to engage in activities that contribute to achieving them. Despite this transfer of responsibility, the educator has a significant role in problem-based learning. The role is not to transfer knowledge but, rather, to be a mentor and a facilitator to students helping them reach their learning objectives. In problem-based learning, educators engage in the following:

- Guide.

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- Support.
- Encourage.
- Build students' self-confidence.
- Broaden students' understanding of the subject at hand.
- Co-ordinate learning activities.

B3.7 Active learning recommendations

The ALIEN active learning approach aims to support educators in their teaching and in securing that individual students are motivated, engaged, and achieve progress towards their learning goals. The approach ensures that teachers can monitor, track, and adapt activities to individual student needs and, as a result, secure a higher learning curve for a class.

Due to differences in motivation and expectations related to active learning, it is recommended to review and pilot the ALIEN active learning framework with a group of educators that are "technological missionaries", namely they are have an interest in active learning and are motivated to deploy technology in educational contexts. The "technological missionaries" could pilot the ALIEN active learning approach, promote it to broader groups of educators, and provide free workshops on how to best deploy problem-based and active learning. The names and pictures of the teachers involved in the use and promotion of the ALIEN active learning methodology could be promoted through the ALIEN project portal.

Teacher training and support in the use of the ALIEN active learning approach and on the platform itself is needed. This can be implemented through a combination of face-to-face teaching, on-line workshops, and illustrative examples that deploy games or simulations demonstrating how digital tools can enrich engagement and interactivity in the classroom.

For the broad adoption of the ALIEN active learning design, teachers must understand the possibilities and the advantages of this approach. The best way to achieve this is to encourage

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educators to pilot the ALIEN solution in their classes and to ensure that they are in a position to define well structured problems and assignments for students to implement.

Furthermore, to ensure the long-term deployment of active and problem-based learning it is essential that the ALIEN learning intervention is used in close association with formal higher education curricula. For this reason, it is important to offer functionality through which educators can create assignments and problems and to track student efforts towards synthesizing a solution. Taking this a step further, it would be beneficial to encourage educators to collaborate with external companies or organizations for generating problems that are realistic and inspired by real world industry needs.

On the other hand, fostering student motivation to engage in learning can be pursued through “productive failure”. This approach challenges students to persistently develop representations and solutions to a new problem. While students may initially fail to produce canonical representations and will not be able to use concepts or theories in the initial stages of learning, they will try to reason based on their best knowledge. Educators can challenge students to introduce several different ways to solve a specific problem and to synthesize a final solution based on this pool of ideas.

Before introducing problem-based learning approaches in the classroom, educators must identify the learning outcomes, the skills, and the basic knowledge that students will acquire through the suggested activities. If possible, the identified learning goals must be aligned with the educational objectives and practical elements of formal curricula. Problem-based learning emphasizes working with real-world problems which motivates students more than working on textbook exercises.

It is further recommended that educators group students in teams of 3-6 individuals based on the teachers’ understanding of collective team knowledge. It is suggested that the newly formed groups initially work on one or two selected ALIEN platform problems in order to build communication avenues and trust between team members.

B3.8 ALIEN problem-based learning steps

The ALIEN methodological approach involves the following steps, which are designed on well accepted problem-based learning[1] recommendations of the Engineering Design Process:

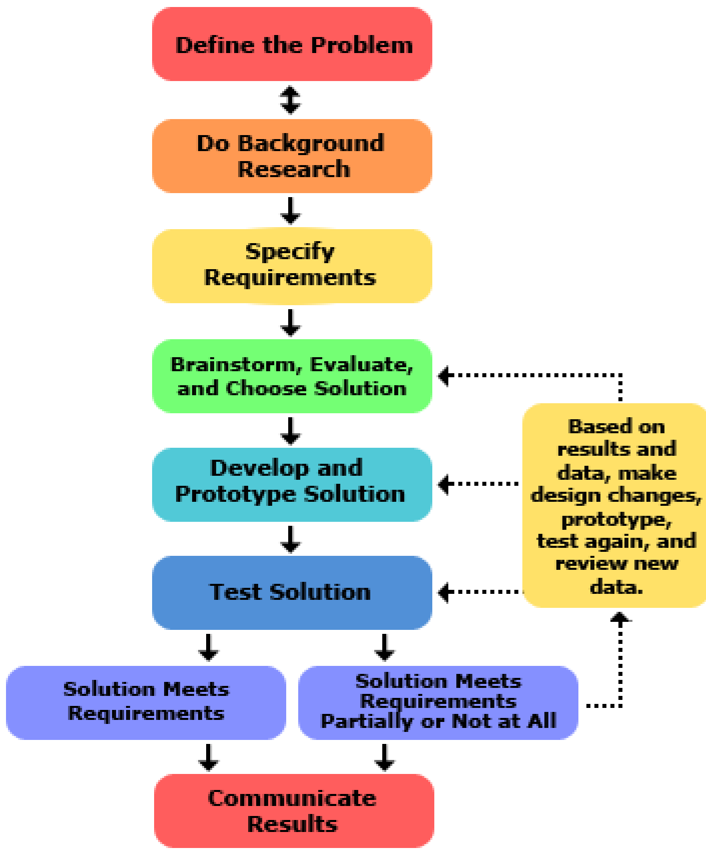

Figure 11. Problem-based learning steps.

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1 University of Iowa, Problem-Based Learning Steps, https://teach.its.uiowa.edu/sites/teach.its.uiowa.edu/files/docs/docs/Steps of PBL ed.pdf

STEP 0: The teacher selects and formulates the topic. She then formulates the learning goals and expected achievements. If possible, the teacher a range of learning goals and progression stages to accept that individual students do not learn equally fast or have the same possibilities for learning.

In this stage, the teacher plans how and what the students must learn and explain the learning goals to students. The learning goals may be related to the curriculum of a particular subject, or they may be related to special competences that students must develop, knowledge, or techniques of general or specialized character of a particular subject or theme. The learning goals and achievements are the foundation on which problems and themes are developed. The teacher informs the student on the tasks at hand and explains the working methodology. If the teacher wants the students to define the problem statement related to the theme of their task, the students are directed to step 1. If the teacher wants to make sure that, for example, all students work on the same specific problem, she can define the problem and direct students to begin their work with step 2.

STEP 1: Students identify the problem. Students work in groups to define the problem that they will analyse and try to synthesize a solution to. This means formulating questions and ideas and looking into books or other material they have at hand with the objective of understanding what the problem statement is, i.e. what is the problem that they will work with.

This step can be shortened. If the teacher chooses to start the activity by precisely defining the problem for students, then student activity may begin in step 2. The teacher must be aware that there is a chance that different student groups will work with different problem statements related to the topic. Furthermore, the teacher may engage in a discussion with students on the problem statement and the way in which it can be answered or solved. Through this discussion the teacher may direct students to introduce changes in the problem statement.

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STEP 2: Students explore the problem statement and topic. In this step students ask themselves: “what do we know?”, “what do we need to know?”, “How can we find out what we need to know?”. Through these queries, students identify available resources and tasks they need to undertake for solving the problem.

In this step students identify what they need to know for solving the problem. They engage in project planning activities and task allocation. This can be achieved through the ALIEN platform. Through games or simulations related to the problem and topic, students can get a better understanding of what they need to know and how to approach a potential solution. The teacher supports this process by engaging students in a discussion on knowledge that they need to develop, which leads to a need-to-know list. The teacher further discusses with students methods through which they plan to build the necessary knowledge and encourages them to effectively allocate tasks to team members. Through the-need-to-know-list, the teacher has a clear indication of the starting point for the student activities as a basis for understanding and measuring the progress later.

STEP 3: Students investigate the problem. Students collect data to answer the questions the set in previous steps. They can consult experts, read books, read or watch other relevant material that the teacher can help them identify. Students may also engage in empirical work, surveys, or interviews for collecting the information for answering the questions in focus.

The implementation of this step is longer. The ALIEN platform can be used; as a prerequisite, teachers need to upload onto the platform videos or point to relevant games or simulations before the activity starts. Students will use this material for exploring the thematic area under consideration. It is advisable for students to maintain a logbook of the tools they use and what they learn from each resource that they investigate. This logbook can also be uploaded onto the ALIEN platform. The teacher must have access to this logbook.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

STEP 4: Students identify possible solutions. Students describe different solutions and actions to the questions they identified in step 2. Furthermore, they introduce an answer to the overall problem statement they defined in step 1. Students should try to explain and justify their solution. They should be able to discuss potential problems in their solution and alternative approaches. Solutions can be introduced in various ways: as a game, as a video, as a report, as a poster, with diagrams, with calculations, or with relevant laboratory work as basis. The ALIEN platform can be used to upload the possible solutions allowing students to compare and share information on another groups' work.

The teacher must support students in this process by discussing the pros and cons of the suggested solutions. This discussion will ensure that student findings are associated with the learning goals of the exercise. At the same time, the discussion will allow the teacher to observe student progress through the face-to-face communication and the review of their solutions.

STEP 5: Present findings. Students present their findings to their peers and to the teacher. This can be achieved through oral presentations, through videos, or other method agreed by and with the teacher.

At this stage it will be useful for students to fill-out a self-reflection form that includes questions aiming to establish how well they understand the project they are working on as well as their experience working with their team. The teacher may prepare and share the self-reflection among students. Through student responses and data gathered in previous steps the teacher can develop an informed opinion on how students perceive themselves and their overall progress. The self-reflection represents a student view of the learning process and can provide insight on how students may improve their learning achievement in future projects.

Throughout this process the teacher is present and can overlook the work either in class or online on the platform at any time. Students can work and cooperate face-to-face or online. The teacher can measure the student progress by comparing pre- and after reflections. Students can deploy a variety of skills, techniques, and knowledge throughout the problem-solving process. The teacher may design the activity in a manner that emphasizes particular elements or skills through appropriate problem formulation and through feedback generated by student work.

The teacher assumes the role of a facilitator that supports to students by pointing them to the right direction, however without directly presenting the solution to a given problem. Depending on variations among groups in terms of skills and quality of team collaboration, the teacher may provide more clear directions to some teams in comparison to others to ensure that all groups achieve results.

The ALIEN platform supports different parts of the active learning process. It further supports the development of collaboration skills. The teacher can use the platform actively to structure exercises, to train students through games, videos, or simulations and to follow group collaboration.

The ALIEN online platform aims to provide a virtual model of conventional real-world problem-based learning practices through on-line collaboration. The platform functionality aims at deeper levels of learning, critical thinking, shared understanding, long-term retention of knowledge, social and communication skills development, group cohesion, and teamwork skills enhancement.

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B4. PROBLEM-BASED LEARNING ORIENTED PLATFORMS

Following is a review of popular problem-based learning platforms.

Project Pals

Project Pals (Project Pals) is a powerful tool that helps educators and students organize project work. Through Project Pals educators design a template to guide students through a specific project on which they can collaborate or work together to explore, learn, brainstorm, and create. Project Pals improves student learning and enhances educator teaching in one platform. The Project Pals platform is equipped with powerful knowledge creation and visualization tools enabling students to investigate, create, and problem-solve in an interactive workspace updated in real-time.

Project Pals provides a single platform for researching, creating, presenting, assessing, and sharing knowledge. The platform enhances everyday student-centered learning activities and long-term collaborative projects. The Project Pals methodology focuses on the three most powerful contributors that, according to research, improve student understanding:

- External problem representation.
- Computational thinking.
- Design thinking.

The methodology helps structure students' approach to problem solving across subjects and provides an effective framework guide for project-based learning.

The following services are available to educators:

- Creating an original project or choosing a template from an existing catalogue of common core-aligned projects; alternatively, co-authoring and co-managing projects with other teachers on interdisciplinary inquiries. Once a project is created, educators can form student teams and assign tasks.

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- Monitoring of student progress in the workspace updated in real time, commenting on student work, chatting with teams, and evaluating proficiency using a built-in rubric tool. Educators have access to project data for insight into individual and team contributions.
- Publishing of student projects and portfolios for building a learning hub and sharing work with peers and parents. Students can present findings to an audience by designing a deck or digital poster board.

The following services are available to students:

- Creating original project assets or importing assets, including media files and Google® docs. Students can also drag-and-drop assets within their workspace visually arranging content in meaningful ways. They can further tag assets to classify and organize information.

HEADRUSH

Headrush (Headrush) is a learning management platform built specifically for learner-centered schools activities and project-based programs. Headrush allows students to start learning from different levels. Students learn best by doing and through effective feedback loops that lead to better learning. The following are characteristic features of the service:

- Co-designing of project-based learning activities by teachers and students. The software allows for flexible management of project work so that teacher-centered, student-entered, or co-designed projects are easy to digitally develop and track. Headrush supports asynchronous student achievement tracking, which allows students to manage their own learning. As students co-manage and co-track their own progress with their project advisors they develop a genuine understanding of their own skill development and overall learning progress towards educational goals. By design, this allows a more natural transition from a teacher-centered to a student-centered classroom. It further enables each learning community to find the best balance between enabling deeper learning and fulfilling personal educational needs.

- Digitally managing project projects with four easy steps. This service is available not only to educators but also to students, who can manage their own problems. The steps that participants follow are:
  - Proposing a project.
  - Managing and tracking project work.
  - Completing and assessing project work.
  - Warehousing or renovating.

With over 30 years of industry practice and knowledge built in, HEADBRUSH project planning forms are comprehensive and allow for effortless, collaborative management via movable task boards and visual to-do checklists. HEADRUSH supports the uploading, sharing, and revising of project evidence and resources. After assessment and completion of personalized learning targets, students can warehouse their work for storage, renovate projects, or review their process portfolio to look back on their progress.

In HEADRUSH, an educator assumes the role of advisor, mentor, facilitator, and coach in the project-based world. HEADRUSH helps facilitate ongoing feedback loops between advisors and students. Advisors can digitally view their students' project progress and leave personalized comments for review. These feedback loops allow for constructive reflection on project progress in all steps of learning including project proposal, evidence uploading, or assessment.

As guidance is an integral part of common workplace practice, HEADBRUSH facilitates peer review allowing other students to provide useful feedback alongside advisors. HEADRUSH offers remote project-based coaching for educators by educators. While teachers provide regular feedback to students, HEADBRUSH coaches are available to provide helpful feedback to the teachers themselves. Furthermore, students can send a direct message to educational coaches for an additional feedback loop on their project work as well.

This human-centered approach allows schools to personalize learning while remaining true to their individual missions or guidelines provided by educational authorities. This customizable approach allows schools to remain accountable when quantifying student progress and makes the tracking of both personal and collaborative projects user-friendly and timely.

Workbench

Workbench is a free project-based learning platform where. It allows students to complete tasks in class or individually using everything from basic art supplies and recyclable materials to innovative technologies such as Sphero EDU, Parrot, Jamboard, and more. Workbench provides predesigned lessons for teachers to use directly or to copy and modify for a variety of grade levels and educational goals.

Through Workbench educators can create projects from scratch or choose from one of many lessons that come complete with standards, videos, questions, and images. Educators may choose the “create” option under “lessons” through which Workbench walks them through the steps of titling, adding standards, adding resources, and listing steps. Subsequently, teachers can assign lessons to a class or to individual students. Students mark their progress in their Workbooks as they complete activity steps, which may include watching videos, viewing images, answering questions, creating, and uploading content. Teachers can monitor student progress in real time allowing for formative assessment and re-teaching of concepts if needed.

Workbench is an innovative one-stop service for teachers to find and share lessons and projects that support both core and STEAM curricula. Teachers can flip their classroom by assigning videos and independent learning tasks that are followed by student collaboration in class in the context of performing experiments or creating media. Teachers can individually assign projects by area of interest or level of complexity adding in support as needed via videos, guiding questions, and progress monitoring. They can build higher-order thinking skills by asking open-ended questions, tracking student progress, and viewing responses in real time.

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ProjectFoundry

ProjectFoundry is a tool that helps manage and guide asynchronous learning. The tool has been available for over a decade. Teachers and students, each in their own locations, are on track sharing learning experiences and completing work. Students journal their learning by logging the time they allocate to learning activities and their growth, meeting their individual learning needs, and sharing evidence of their learning through their portfolio. ProjectFoundry allows the seamless exchange of notifications on work to do and work completed. The software presents in real-time progress on completing standards and growing for the benefit of students, educators, and parents.

Forge

Forge is a web-based project-based learning software tool. It is suitable for use in a single classroom or curriculum. It supports 1 teacher and up to 100 students. Forge is designed to minimize challenges faced by educators; it helps keep students on track toward achieving their learning goals. Forge provides:

- Asynchronous learning for teachers and students.
- Embedded videos easily teach students and teachers how to get to work.
- Shared learning experiences created by teachers and students.
- Evaluating work for demonstrating progress on personal learning plans.
- Student journal capturing that provide insights on student reflections, learning, skills, and mindsets.
- Student time logging, which introduces a window in work time, growth, and needs.
- Student evidence sharing in their portfolio.
- Seamless exchange of notifications on work to do and work done from classroom or home and back.

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- Real-time progress visualization on standards, 21st-century skills, and growing proficiency.
- Keeping everyone in the know through access for teachers, students, and parents.
- Reviewing progress through powerful FoundrySONAR® actionable real-time analytics for educators and learners that support the generation of reports for sharing with the school community.
- Real-time insight into what students are accomplishing, how well they are learning, and what they need to be successful when teachers, administrators, and students need to be at home.
- Creating projects, independent reading, internships, and all kinds of learning experiences that are guided and tracked, whether students are at home or in school.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

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B5. SPECIFICATION AND DESIGN

Agile learning methodologies will be used for the development of the platform and tools. In agile processes the design phase is revisited over and over in cycles during the implementation of a product or service to ensure that outcomes meet the needs of the target users through the integration of user input throughout the design and implementation process. In educational contexts, agile practices can be applied by encouraging learners to revisit their initial solutions to a given problem once more feedback on how their solution addresses user needs is generated through evaluation or other means. In other words, learners are encouraged to apply agile practices in the context of their educational projects.

B5.1 Agile terminology

Agile terminology includes:

- User stories, in other words scenarios of use of a particular software product or service. The user stories are the basis for identifying the implementation tasks of the project.
- Product backlog, which includes all the tasks to be implemented for completing the project.
- Shippable version, which corresponds to the intermediate version of the final result which, however, includes functionality that allow it to be used as a complete product.
- Sprint, which corresponds to an implementation cycle that results into a shippable version of the product.
- Sprint backlog, which is a list of the tasks to be implemented in a particular iteration of the programming process.
- The product owner, an individual that is either the customer or a representative, who provides the user stories, decides on the tasks that will be implemented in each sprint, and accepts the final result, i.e. approves its functionality.

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B5.2 User stories: scenarios of use

The agile product backlog is a prioritized features list, containing short descriptions of all functionality desired in the platform. Typically, the scrum team and the product owner write down everything they can think of for agile backlog prioritization. This agile product backlog is almost always more than enough for a first sprint. The scrum product backlog can grow and change as more is learned about the product.

The predominant way to express features on the agile product backlog is in the form of user stories, which are short, simple descriptions of the desired functionality told from perspective of the user.

In this case, three different user roles are identified:

- Students.
- Educators.
- University managers.

The user stories for ALIEN, for each of the three roles, were designed by consortium members following their teaching experience.

Technical work and knowledge acquisition activities also belong on the agile backlog. An example of knowledge acquisition could be a backlog item about researching various JavaScript libraries and making a selection. For ALIEN, the technical work entries will be decided by the development team.

The prioritization of the agile product backlog will be decided by the development team in a later stage. As such, the following list of user stories is not prioritized.

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B5.2.1 General requirements

- The platform should support the community and the features should be used by everybody, should be user-friendly with a great emphasis on the spirit of community and collaboration.
- The platform should allow users to access content related to the domains chosen. That said, can`t be too generic.
- The target group of the community should be clear: teachers or students (or both) and what type of engineers, for example from all engineering fields or just from a specific one.
- The platform should allow work as a meeting point that provides solutions to the community.
- The platform should include different strategies of active learning with different activities and adapt the community with that in mind and possible offer an option for the user to select the desired one.
- The platform should reflect the different stages of problem-based learning and help manage the learning process.
- The platform should include team work support and extra functionality, including communication systems and sharing of information, debates, discussion groups....
- The platform should include evaluation by applying digital systems. The evaluation may be composed of the perception of the students to evaluate the learning experience and contribute to the understanding of how they see the experience, providing a more active evaluation and including peer review.

Additionally, the platform should permit:

- Organization of teams to report problems.

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- Support for students in producing evaluation content and problem creation for sharing purposes.
- Support a list of types of problem-based learning and find software that could help students.
- Problems related to software development.
- Allow the application of the same strategy with members from different areas and promote reflection, including the premise of "learning by failure".
- Support multidisciplinary approaches and focus on problem solving.
- Explore the strategy of collective storytelling.
- Provide a translation system in the backend and a platform for translation into English. More languages could potentiate more users.

In terms of implementation difficulties, it is advisable to be aware that:

- The platform can´t be too difficult to use, it should be user-friendly.
- There may be a need for teacher training. If teachers have received training in a specific area or have a background from a specific Engineering field, they might be able to use the platform without support, but if they don't it may be hard for them and training should be provided.
- The platform should facilitate the easy transition into problem-based learning for teachers by apply some similarities of other existent systems.
- The platform should address the issues of different time zones when students are engaged from different parts of the world.

B5.2.2 Student user stories

As a student using the ALIEN platform, I want to:

1. Get feedback on assignments to I can learn.

2. Compare myself with others so I can see if I am best.
3. Be able to upload material such as video, photos, and text files to present results of the group work.
4. Learn how to work in groups to improve my group work skills.
5. Be able to contact my group members and share the material produced with them so we do not have to do individual assignments.
6. Learn by use of games because it makes me more motivated.
7. See videos of things I do not understand because it helps my perception of what I have to do.
8. Be able to print, either on paper or electronically, what we have done to bring to my home to work more on it or to show my parents.
9. Have direct contact to the teacher for support when necessary to prevent waiting time. This is useful also for demonstrating to others in the class see that we have a problem.
10. Want to be able to see another group's work, when finalized, so I can learn from that as well.
11. Learn through a combination between the platform and physical presence and use of my hands so I also learn how to become better at physical things for which I am training for.
12. Be able to see simulations of how I perform when meeting customers that I train to meet through my vocational education to be better at doing that.
13. See pictures or similar of the problem we have to work on because I have a better perception of pictures than text.
14. Use my creativity to build assignments for other groups in class because I could learn from that.
15. Be able to save what we have done so we don't waste everything when allocated time is over or the computer is out of electricity without us realizing that.
16. Be able to retrieve saved material so we do not miss anything.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

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17. Be able to search for different assignments or games that can fit to the challenge we are working together on in my group to support the challenging parts of problem-based learning, such as problem formulation, team work that is not going well, getting in groups with persons I do not normally talk to, and more.
18. See how well I, or me and my group, do on the assignment so I can understand what the teacher thinks of the way we work.
19. Be able to distribute parts of the work to other persons in the group so we individually can make annotations, upload photos and videos, and perform other actions to make the group work more effectively.
20. Be able to communicate with other groups because we are aware that they may know something we don't.
21. Use emojis or similar when communicating with other groups because I am used to similar functions on mobile phones when communicating with my friends outside university.
22. Be able to link to websites which have information on the work we focus on in the group to make sharing and documentation easy.
23. Be able to use the cursor when selecting elements (click and drop) on the platform since that I am used to that.
24. Have the possibility to increase the front sizes so all of us in the group can read the text.
25. Work on real problems that someone owns since that makes me more motivated.
26. When learning physics, I want to use physical lab simulators. Examples include simulators on atomic physics through which I can experiment with atom models and manipulate collisions of different atoms in simulated atom accelerators; fission-bombs, fusion-bombs, and simulated nuclear reactors; physical simulators through which I can experiment with the effect of the special relativity theory and the general relativity theory; and others.
27. When learning chemistry I want to use chemistry lab simulators, through which I can mix different liquids to see the chemical formula reaction schemes and physical effects, such as color or explosions, and look at the molecule models' new compositions.

28. When learning physics I want to explore simulated magnetics experiments to experiment with current, coils, forces, velocity, flux, and geometrical dimensions by controlling parameters and measuring the resulting effects, e.g. in a Tesla car.
29. When learning biology, I want to explore simulated bio chemical experiments, for example on simulated animals, to see how medicine affects their behavior and well-being. Another example is simulated DNA experiments that allow speeding up in a virtual environment the timely physical processes.
30. When learning health science, I want to explore simulated human surgery operations by means of real tools and 3D glasses in an augmented setup in a simulated process to perform, for example, heart operations where my performance is monitored and scored.
31. Each time we solve a problem we may get points which we can use to purchase other assets in the environment.
32. Be able to keep track of what I have completed in an activity and what still remains for me to do. I often find it hard to remember my progress because I have autism and that means I struggle with complex concepts. Maybe it would be helpful to have an easy to use indicator.
33. Know how much time I have left for completing an exercise.
34. Be able at the end of a learning session to review what I have done and see how I got to the end. It may be useful for me to add comments to each stage I complete. I think that might help me learn how to solve problems.
35. Be able to think of potential solutions to a problem over a period of time, for example a few days, draw solution sketches using text, images, videos, or other, and then upload all the bits and pieces, the evidences if you will, to the platform for describing my ideas.
36. Upon completing an activity, get awarded points for the most effective solution paths I designed towards solving a problem.
37. Have things on paper. It would be neat to have a collage of my work at the end of an activity.
38. Work together with my best friends.

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39. The platform should allow several team members to type something in the same document at the same time, in a manner similar to Google Forms®. Or, if we prefer, to work on different activities.
40. Be able platform as I am partially sighted so I need big text.
41. Control what the teacher can see at any moment. I don't want her/him to see my early drafts. For this reason I prefer to work in a local file on my computer and upload the final result to the platform once my work is completed.
42. The platform should be really easy to use without the needs of extended instructions.
43. The platform should support spell checking.
44. The platform should allow me to problem solve with my friends from home, by being able to use the functionality from a distance. If this is not possible, it would still be nice to be able to use mobile applications such as Whats App® to share my work with my team members.
45. The platform should be easy to use. I also want it to be easy to minimise so I can use other applications in between my work tasks. Me and my friends are working on one project so it would be good if we could all see what each other is doing even on our own laptops or even on a shared laptop – but actually – I might like to hide some of what I'm doing from the others because Theresa can't be trusted sometimes and she might just copy off me and then the teacher might think I copied off her.
46. The platform should allow me to see how the other groups are doing, that way I might be able to persuade Boris (he's the lazy one) to do some more work.
47. Be able to use search engines, such as Google®. It would be good if we could drop links into the platform and maybe images from Google® or even Youtube® videos.
48. The platform should allow kids with special needs to have extra hints and tips. Maybe we could prepare and send them some hints and get extra points for our team. In fact it would be neat if we could be awarded points by the teacher (brownie points) for keeping our effort moving.

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49. Use my phone to take photographs of items that I can use to describe my ideas and inspiration. I need to be able to upload these pictures on the platform in an easy way. In fact, the only reason I might use the platform is to get teacher points; I think the platform must do something "magical" with everything we have done.
50. I want to be able, when we're done, to package the magic and send it back to all of us in the group.

B5.2.3 Teacher user stories

As a teacher using the ALIEN platform I want to:

1. Review problem-based learning plans so that I can decide if I would like to use it or not with my students.
2. Know the requirements of a problem-based learning plan so that I can decide if I can use it in my university.
3. Be able to assign students to a problem-based learning plan so that I can introduce them in new projects and activities.
4. Review the contributions made by students to a problem-based learning activity so that I can track what they have achieved and be aware of any problems they may have encountered.
5. Edit a problem-based learning plan so that I can include new information or make changes to adapt it.
6. Give indications to students for supporting them in their efforts through services such as chat.
7. Ask students questions and queries so that I can check their development.
8. Remove and censor inappropriate student contributions so that I can control the working spaces.
9. Propose a work plan to students so that I can guide them during project development.

10. Survey students in order to know what their interests are and what difficulties they face.
11. Be able to share student products among different teams so that they can perform peer assessment or deliver presentations.
12. Survey my students on their interests so that I can perform group formation and problem-based learning assignment.
13. Ask individual team members questions so that I can assess their engagement in team work.
14. Create and edit problem-based learning plans so that I can develop my own projects.
15. Search for partners interested in some problem-based learning plan so that I can collaborate with other universities.
16. Report issues to the administrator so that I can be supported in case of administrative problems.
17. Pose questions to an expert so that I can be supported in case of difficulties while developing problem-based learning activities.
18. Schedule a problem-based learning plan so that I can manage time appropriately.
19. Make sure the platform can help sharing student homework with classmates and can facilitate student communication with the teacher even from home.
20. Make the sure that the platform can help in keeping class work more active allowing students to directly participate in the lesson she is following through the platform. This can naturally happen if the class is structured appropriately. For example, every student may have her own iPad® while every classroom may have a smart TV for displaying information that makes the class more interactive.
21. Make sure that the platform can help in developing work groups. Thanks to this platform the teacher will overview student work in order to guide them during class work, allowing the group to be more ordered and productive.
22. Make sure that the platform can help in involving the students with apprentice problems or other problems through the drawing of personalized lessons.

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23. Assign homework and evaluate student submissions online so that precious class time is not wasted in related activities.
24. Create groups and assign problems so that students practice on new knowledge built in the classroom.
25. Make sure that the platform will provide a safe discussion area so that students interact with each other, with me, and with students from other universities abroad, with the added benefit of also improving their language skills.
26. Make sure that the platform will make students more interested in class work as a result of them being familiar with online tools.
27. Make sure that the platform will support the discovery of new teacher resources.

5.2.4 Manager user stories

As a manager using the problem-based learning platform I want to:

1. Know what teachers are doing in their classrooms so that I have information that allows me to better manage the process.
2. Know what students are doing in their classrooms.
3. Know which methodologies teachers are using in their classrooms so that I can evaluate their application.
4. Know which tools students are using in their classroom-computers so that I can evaluate the convenience of them.
5. Know which tools teachers are using in their classroom-computers so that I can evaluate their ease of use and effectiveness.
6. For each learning methodology, know the ration learning/methodology so that I can analyse its utility.
7. Know why the teachers have chosen the corresponding methodologies for their courses.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

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8. Know the best tools for implementing problem-based learning so I can be better informed to select a more effective collection of learning tools.
9. Know the best problem-based learning methodology, or the methodology that is more appropriate for delivering the courses in my university so that I can be better informed for selecting a more effective collection of learning tools for each course.
10. Know which tools students are using for building knowledge when they are not physically in the classroom so that I can evaluate their effectiveness and ease of use.
11. Know the participation of students and teachers in problem-based learning methodology so that I can evaluate better its deployment.
12. Know the repositories in which problem-based learning activities are stored as well as the links between these activities and courses so that I can make informed recommendations to teachers in relation to activity selection for addressing specific learning objectives.
13. Know the repositories in which problem-based lesson plans are stored as well as the links between these activities and courses so that I can make informed recommendations to teachers in relation to activity selection for addressing specific learning objectives.
14. Know the repositories in which problem-based best practices are stored as well as the links between these activities and courses so that I can make informed recommendations to teachers in relation to activity selection for addressing specific learning objectives.
15. Know the repositories in which problems and projects are stored as well as the links between these activities and courses so that I can make informed recommendations to teachers in relation to activity selection for addressing specific learning objectives.
16. Control user access.
17. Get statistics of the number of requests for retrieval of content.
18. Get statistics of the number of users that access the system.
19. Get statistics of the evolution of requests over a specific period of time.
20. Be informed on malicious intent against the system.
21. Be informed on inappropriate content.

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22. Search for profiles based on keyword searches on specific fields, such as class attended, location, name of student, so I can find others I might want to connect with.
23. Send an email to any platform member via a form so that we can connect.
24. Read practicing and training activities and approve or reject them so that only applicants who qualify can become certificated.
25. Edit any site member profile so that I can correct problems.
26. Update existing activities so that they reflect accurate information.
27. Approve information submitted for publication before it becomes openly accessible through the platform so that I am confident for the quality of information being listed.
28. Receive an email whenever new information is submitted so that I am aware of the submission and I can process it, namely approve it or reject it..
29. Edit and delete information ads so I can correct small problems or make sure each ad complies with platform guidelines.
30. Make sure that information/activities published on the platform disappear 30 days after being posted.
31. Run any report form that a student or teacher can run so that I can see overall information for any activities on the site.
32. Have a free product so that I don't compromise my budget.
33. Have a product that adapts to my existing infrastructure so that I don't need to invest and hence don't compromise my budget.
34. Have an easy to use product so that I don't overburden my teachers' working time and hence don't compromise my budget.
35. Have a very safe product so that I don't have any security issue with the general public, especially the parents.
36. Get an innovative product so that I can I can market the university’s innovative practices to educational authorities.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

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37. Get a product that adapts exactly to the state official curriculum so that I can easily justify its deployment to educational authorities.
38. Get a product that can open venues of collaboration with other educational institutions that can last beyond the project's time frame.
39. See how teachers interact with students so I can evaluate teacher performance.
40. Have open communication with teachers and students in order to receive their feedback and expectations on university practices.
41. Save time and place by making teachers use online tools everywhere.

B5.3 ALIEN platform design

Based on the above pool of agile design “stories”, following is a high level design for the ALIEN virtual learning environment for the direct stakeholders of the project, namely learners and educators.

B5.3.1 General functional requirements for all users

The following functionality is available for all users of the virtual learning environment:

Title	Creating a user profile.
Description	A user should be able to create a profile that includes information such as name, affiliation, and a photo. It may also include optional information such as a cover image.
Justification	Identifying a user in the platform.

Title	Managing a user profile.
Description	A user should be able to modify and update the information in all the

	fields of his profile.
Justification	Updating profile information is necessary as a user evolves professionally and personally, changing roles and affiliations.

Title	Updating user account settings.
Description	A user should be able to manage the settings of his account in relation to his interaction with other users. This may include, for example, when a user receives email notifications from the system: when someone mentions his name, when someone responds to a user post, when another member sends the user a new message through the platform, when another member sends a friendship request, when a member accepts a friendship request, when a member invites the user to join a group, when group information is updated, when the user is promoted to group administrator, when a member requests to join a group that the user has created, and more.
Justification	Allowing users to control their communication with other users in the virtual learning environment and to personalize their experience.

Title	Reviewing user activity.
Description	A user should be able to review all his activity in the platform, including posts of problems, posts to forums, engagement in groups, experience gained, and more.
Justification	Enabling a user to review his activity ensures that he has an overview

	of all his actions in the virtual learning environment.

Title	Reviewing notifications.
Description	A user should be notified when someone engages with him in the platform. He should also be able to review all his notification in a single access area.
Justification	Reviewing notifications allows users to more effectively stay connected with other members of the community.

Title	Sending a message.
Description	A user should be able to compose and send a message to other members of the community.
Justification	Allowing users to send messages through the platform facilitates the easier communication of members.

Title	Reviewing messages.
Description	A user should be able to review all his messages, including the ones he has received, the ones he has composed, and the ones he has sent to other members of the community.
Justification	Organizing messages and managing them allows users to keep track of their communication with other members of the community.

Title	Making friends.
Description	A user should be able to invite someone to be his friend. In addition, a user should be able to see when a friend was last active in the virtual learning environment. Furthermore, a user should be able to manage friendship requests sent to him by others, and accept or deny them.
Justification	Allowing users to have friends emulates popular functionality in social platforms, promotes the social dimension of learning, and enriches user experiences.

Title	Creating a group.
Description	A user should be able to create a group.
Justification	Creating groups allows users to follow special interest and to personalize their communication with others in the virtual learning environment.

Title	Joining a group.
Description	A user should be able join groups created by others.
Justification	Similarly to above, joining groups allows users to follow special interest and to personalize their communication with others in the virtual learning environment.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

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Title	Posting on forums.
Description	A user should be able to create a forum. Furthermore a user should be able to create a new post on a forum and to respond to the posts of others. A user should be able to review his activity in forums, to follow the conversations he is engaged in, and to maintain a list of favourite forum topics.
Justification	Posting on forums is a good way of asynchronous communication. It allows users interested on similar topics to communicate in a shared space. It further allows users in different time zones to collaborate more effectively.

Title	Managing forums.
Description	A user should be able to manage his forums. He should be able to review a list of all his forums and to review activity of other members on the forums.
Justification	Posting on forums is a good way of asynchronous communication. It allows users interested on similar topics to communicate in a shared space. It further allows users in different time zones to collaborate more effectively.

Title	See a list of all groups available in the virtual learning environment.
Description	A user should be able to see all groups in the virtual learning environment in order to choose whether to join them.

Justification	Reviewing and joining groups allows users to follow conversations on specialized topics and promote the social aspect of learning.

B5.3.2 Functional requirements for educators

As users of the ALIEN virtual learning environment, educators can use the general functionality described in the above section. In addition, educators should be able to:

Title	Creating a learning activity.
Description	An educator should be able to create a structured problem-based learning activity. The activity may be used by himself or by others. For this reason, the activity needs to provide information that allows others to repeat it in their classroom. Descriptive fields may include the activity tile, learning objectives, educational context, instructions to be provided to students, resources to be provided to students, a suggested solution and indicators of reaching it, instructions for other educators, additional resources for educators, alternative implementations, and more.
Justification	Structuring a learning activity maximizes its usability allowing others to benefit from it. Educators can benefit from functionality that enables content reuse.

Title	Editing a learning activity.
Description	An educator should be able to edit a problem that he has already created.

Justification	Editing problems allows educators to keep the information on the learning activities they create up to date with student needs.

Title	Reviewing owned activities.
Description	An educator should be able review a list of all the activities that he has published through the platform.
Justification	Reviewing owned activities allows an educator to more effectively manage them by having access to them through a single area in the virtual learning environment.

Title	Sharing content.
Description	An educator should be able share his educational content with others. This may be supported through functionality that allows educators to create a new problem from an existing one. Educators may start with a pre-filled form that include the descriptive information for an existing problem and be allowed to alter them for adapting the learning activity to their own needs.
Justification	Sharing and reuse of content maximizes the impact of the virtual learning environment by allowing peers to benefit from each other’s instructional experiences and creativity expressed in the problems they publish.

Title	Reviewing all activities in the virtual learning environment.
Description	An educator should be able review all activities published in the virtual learning environment.
Justification	Reviewing all activities allows educators to gain inspiration of the good practices deployed by others in problem-based learning. They may reuse content as is, modify it to address their needs, or gain insight on creating their own new activities.

Title	Creating a “room” for student collaboration on a specific activity.
Description	An educator should be able to create a space in which students registered in a class or working on a common activity may enter and follow instructor defined structured activities. The space should allow educators flexibility on how to structure the activities in order to be adaptable to diverse learning needs. The space should also allow educators to upload instructions created externally and described in a file. Each room should have a unique identifier that the educator may give to students for entering the room lobby. In addition, educators should be able to view the way the room appears to students in order to make corrections and adjustments before making the related activity available to them.
Justification	Creating a virtual classroom allows educators to design long-term activities, to assign step-wise tasks, and to monitor student progress.

Title	Edit a room.
Description	An educator should be able edit the information provided in a room for making adjustments and corrections.
Justification	Editing a room allows an educator to keep the information published up to date taking into account evolving learning processes.

Title	Managing own rooms.
Description	An educator should be able to review all the rooms that he has created and edit the descriptions of the related activities, resources, and tasks.
Justification	Managing rooms allows educators to adjust activities to the needs of individual learner groups. In addition, it allows educators to reuse their past work in order to structure new activities for students.

Title	Getting rewards for engaging in the community.
Description	An educator should receive rewards for his engagement in the community. Different rewards may be available for different type of activities. For example, an educator may earn rewards for creating problems, for collaborating, and for building experience.
Justification	Rewards add a gamification element in the virtual learning environment that acts as a motivator for individuals to continue their engagement in the learning activities in the long term.

B5.3.3 Functional requirements for learners

As users of the ALIEN virtual learning environment, learners have access to the general functionality described above. In addition, the following features may be available for learners:

Title	Accessing educational content.
Description	A learner should be able to access problems and content created by educators.
Justification	Access to content through the virtual community allows learners to virtually engage in problem-based learning either individually or as part of a group.

Title	Entering a learning room.
Description	A learner should be able enter a learning room created by an educator using a specific code.
Justification	Entering a learning room allows learners to communicate with educators, to take part in step-wise educational activities, and to engage with other learners enriching educational experiences.

Title	Receiving rewards for engaging in the community.
Description	Similarly to educators, a learner should receive rewards for his engagement in the community. Different rewards may be available for different type of activities. For example, an educator may earn rewards for creating problems, for collaborating, and for building experience.

Justification	Rewards add a gamification element in the virtual learning environment that acts as a motivator for individuals to continue their engagement in the learning activities in the long term.

Title	Creating a problem.
Description	Similarly to educators, a learner should be able to create a problem in the community, enriching the virtual learning environment repository.
Justification	Designing a problem is a creative activity that promotes learner critical and analytical thinking. Creating a problem may be part of broader problem-based learning practices benefitting students.

Title	Editing a problem.
Description	Similarly to educators, a learner should be able to edit a problem that he has created.
Justification	Updating a problem allows a student to keep problem descriptions up to date with evolving interests.

Title	Managing own problems.
Description	A learner should be able to review a list of all the problems that he has created and to manage them.
Justification	Managing problems that he has created allows a student to monitor

	and review all content that he has contributed to the virtual learning environment and to make adjustments as he sees fit.

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

B6. ALIEN PLATFORM EVALUATION STRATEGY

Evaluation, as a way of systematically assessing merit, worth, or significance, is commonly used in various contexts to make decisions for improving, validating, or certifying tools, methods, or processes. Evaluation should have a constructive nature and contribute to design, development, and implementation of tools or processes.

The ALIEN platform is a pedagogical tool. Its evaluation should be conducted by groups that represent direct stakeholders, namely teachers and students. Evaluation planning involves the design of processes and tools for data collection in relation to the platform usability and learning dimension. Data collection that will lead to the assessment of the accomplishment of ALIEN's high level objectives on building problem-solving skills in engineering education will be implemented through on-going internal and external validation that will start early and will engage external groups of users throughout the implementation period. The continuous nature of the evaluation will ensure that the input of stakeholder representatives will be taken into account during the design and implementation process of the proposed tools and methodologies.

The evaluation will be "formative", that is, meant to inform product design. In other words, user input will be integrated into ALIEN project outcomes, including both methodologies and digital services, for ensuring that the final result addresses user needs. It will also be "summative", meaning that at the end of the project implementation period the quality of the pedagogical results will be documented into a report that will be publicly available to interested parties.

The evaluation will take place at three levels:

1. Internally, engaging project partners.

2. Externally, engaging external groups of users that are representative of stakeholders, and specifically learners and teachers.
3. Through external experts who will provide a professional opinion on the completion, quality, and effectiveness of the platform.

Evaluation will deploy qualitative and quantitative approaches, the results of which will be integrated for generating richer feedback. Quantitative models are based on statistical information. Qualitative models are deployed when information cannot be documented through a simple yes or no answer or through numerical values on a scale. Qualitative feedback is typically documented in the form of text. It may be used for documenting user experiences, attitudes, and perceptions.

Each partner will engage external groups of users, both learners and teachers, in learning activities built upon the ALIEN Platform..

Although not compulsory, the implementation in each country should start with a training workshop for teachers presenting the problem-based learning methodology and the ALIEN Platform. Tentatively, a teacher training workshop may engage approximately 20 educators who would be trained on the ALIEN content and tools in order to become comfortable with their integration into teaching practices. After the initial training, educators may be allowed some time, for example a week, for testing and becoming familiar with the ALIEN content on their own.

The format and duration of local/national level implementation will be decided by each partner taking into account the availability of the target group and the local conditions.

During the implementation sessions, teachers will:

- Use observational assessment methods and document the reaction of learners and their progress in building coding skills.
- Document their findings in short texts.

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At the end of the implementation activities, students may fill-in a follow-up questionnaire documenting their perceptions and views. Teachers may collect the students' verbal qualitative opinions and comments through a group interview and transcribe their opinions. The collection of opinions is intended to provide a free platform for participant to express their views, leading to richer feedback. Teachers may ask students to provide insight on the overall organization of the implementation, their perception on the acquired knowledge, and their perception on the relevance and effectiveness of the ALIEN platform. Students may also report on any learning difficulties or problems they faced during the use of the ALIEN platform as well as how they overcame these problems.

Teachers may also report their own views related to:

- Their perception on the accomplishment of learning objectives by the students.
- Their perception on the relevance and effectiveness of the ALIEN platform for problem-based learning implementation.
- Their perception on the usability and acceptance of the ALIEN platform.

Validation through external experts will be also pursued aiming to further improve the ALIEN platform and ensure that it meets the needs of learners and teachers. The consortium will:

- Identify 2 external experts. Experts can be researchers or university professors related to teacher training, education, computer science, etc.
- Provide them with the project proposal and the O1 reports. Give them access to the contents available.
- Ask participants to follow the implementation with the ALIEN platform.
- In the end, collect their qualitative opinions and comments verbally through a structured interview and transcribe their opinions. Some aspects on which external experts may provide their opinion are:
    - The overall organization of the implementation.

- Their perception on the accomplishment of learning objectives by the students.
- Their perception on the relevance and effectiveness of the ALIEN platform.
- Their perception on the usability and acceptance of the ALIEN platform.

B6.1 Indicators for evaluating the learning dimension

For evaluating the learning dimension, open questions will be deployed that allow participants to provide input in a qualitative manner. They will address aspects such as:

- The accomplishment of learning objectives by students when using the ALIEN platform.
- The perception of users, namely learners and teachers, on the relevance of problem-based learning towards building engineering industry skills.
- The perception of users on the relevance and effectiveness of the deployment of games and simulations as digital tools that promote exploration in the context of problem-based learning.
- The perception of end users on the relevance and effectiveness of ALIEN platform towards developing problem-solving skills for engineering education.
- The acceptance of the proposed ALIEN platform by teachers and students.
- The perception of usability of the ALIEN platform.

B6.2 Indicators for evaluating usability

A standard System Usability Survey (SUS) will be used for evaluating the usability of the platform in a quantitative manner[2].

2 Adapted System Usability Scale (SUS): https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would like to use this platform frequently.					
I found the platform complex.					
The platform was easy to use.					
I need the support of a technical person to be able to use this platform.					
The various functions in this platform were well integrated.					
There was too much inconsistency in this platform.					
Most people would learn to use this platform very quickly.					
The platform was very cumbersome to use.					
I felt very confident using the platform.					
I needed to learn a lot of things before I could get going with this platform.					

586297-EPP-1-2017-1-EL-EPPKA2-CBHE-JP

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B7. SUMMARY OF SPECIFICATIONS DESIGN

This document provided an analysis of the technical specifications for the implementation of the ALIEN digital learning platform for supporting problem-based learning activities. The design of the ALIEN platform is based on agile processes, in which specifications are documented as user stories broken down in tasks. This document provides a rich analysis of suggested functionality, which is the result of brainstorming activities among project partners. This work resulted in the identification of functionality integrated into the ALIEN digital learning platform. The document furthermore analysis the pedagogical model of the project by providing overviews of problem-based learning design, active learning, and related experiential learning models and discussing their roots in pedagogical theories. Finally, the document introduces a strategy for evaluating the relevance, acceptance, and effectiveness of the ALIEN digital learning platform through qualitative and quantitative models generating feedback to be integrated into the ALIEN software services for ensuring that the final result addresses the learning needs of engineering students.

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APPENDIX I. CONTENT DESCRIPTION STRUCTURE IN ALIEN

GENERAL DESCRIPTION OF THE LEARNING ACTIVITY	
Title of activity	Title that will appear in the ALIEN platform.
Author	Name of author.
Duration	Selection from pre-defined list: less than an hour, 2 to 4 hours, over 4 hours.
Goals	The overall educational goals of the learning activity.
Learning objectives	Specific learning objectives.
Field	Engineering field of application.
Simulations used	Links to digital games or simulations used in the learning activity.
INSTRUCTIONS FOR STUDENTS	
Problem statement	Problem statement, or title, to be given to students.
Instructions	Step by step instructions for students to follow for implementing the learning activity.
Solution	The correct solution, or a potential correct solution. Indicators that students may use to know that they have reached the correct solution.
Resources	Links to educational resources that students may use while exploring the learning activity.

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	Links to simulations or games that students may use. Titles of books or articles. Other related resources. And more.
INSTRUCTIONS FOR EDUCATORS	
Teacher guidance	Instructions aimed at educators that wish to deploy their activity in their classrooms: How to introduce the activity to students. What support to provide. Potential difficulties that students may face and resolutions. Questions for facilitating collaboration in the classroom. And more.
Resources	Additional resources, to the ones listed above for students, which educators may use for coordinating the implementation of the learning activity.
Alternative activities	Suggestions for alternative implementations of the learning activity.
Early finishers	What additional activities may early finishers engage with while they still have time available after completing the original learning activity?

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