Active Learning in Engineering

European Projects to Foster the Uptake of New Teaching Methodologies

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***Abstract*— Traditional (passive) teaching methodologies do not develop competences and skills that are required in the professional life of Engineers like the ability to work collaboratively, to lead teams, to solve problems, to take decisions, to be creative, etc. As such, Engineering Education needs to adopt new teaching methodologies that foster the development of those competences. This is a worldwide concern as there is already a shortage of experienced professionals. Several initiatives are already taking place to tackle this issue and this article presents a set of projects that were designed to foster the uptake of active learning methodologies, that is, learning processes that require the active involvement of the students. The first results of these projects have been quite promising generating increased motivation in the students.**

Keywords—engineering, active learning, problem-based learning, design thinking

I. INTRODUCTION

Traditional learning methodologies based on passive transmission of information do not allow students to develop a set of competences that are required in their professional life [1]. This is particularly relevant in Engineering as there are specific competences that an Engineer must possess: he/she must be able to analyze problems, to conduct and narrow research, to analyze constraints, to generate solutions for the problems and, above all, to take decisions.

"Technical know-how, as well as other competencies, such as communication skills, leadership skills, and interpersonal skills are needed for engineers to perform well in the industry" [2].

Engineers must weigh different design choices on their merits and choose the solution that best matches the requirements [3, 4] with the highest efficiency.

Therefore, Engineering Higher Education Institutions are required to modernize their pedagogical methodologies, moving into active learning processes whereby students engage in activities that promote higher order learning skills like analysis, synthesis, and evaluation.

Project and Problem-based learning, Experiential learning, Agile learning, Design Thinking and Inquiry-Based Learning are examples of active and learner-centered methodologies that can be used for that purpose. The identified benefits for engineering and technology students are considerable improvements in critical, lateral and creative thinking, problem solving strategies, intrinsic motivation, group collaboration, communication skills, entrepreneurship and integration with the society [3].

Supporting active learning through ICT tools (virtual community's platforms, personalized learning platforms, games, simulations, virtual and augmented reality systems, etc.) creates Virtual Learning Environments (VLE) where the "digital native" student feel comfortable and is motivated to learn [5]. These tools, advanced Open Educational Resources, highly interactive and immersive, can be used effectively to scaffold learning for higher education engineering and technology students as they develop the required set of competences. They can also more easily reflect the dynamic nature of the world and the quick evolution of systems that prompt changes in the required professional skills. These emerging technologies need to be taken in consideration by policymakers, researchers, developers, and educators [6].

This article presents a set of European projects that, by introducing new, technology-supported, active pedagogical methodologies, contribute to improve the quality of higher education. These projects also respond to the need of modernization of higher education by improving the quality of education and teaching with new learning and teaching tools and pedagogical methodologies. They also emphasize the need to have a collective answer to this issue and not a nationally-oriented approach which is inevitably going to fail, as it already happened in the past.

II. PROJECTS TO FOSTER ACTIVE LEARNING

The projects presented next were developed in the scope of European programmes related to education and training. They are a mix of applied research and development in the pedagogical realm but also in terms of innovation in the use of new technologies for cognitive development.

A. *eCity - Virtual City Environment for Engineering Problem Based Learning (Lifelong Learning Programme, KA3 2014-2016)*

The eCity project rationale was to design and develop a game platform, based on a city-development simulation engine to stimulate the integration and continuous exploitation of Problem Based Learning [7]. The eCity project was led by the Instituto Superior de Engenharia do Porto, in Portugal, and involved partners coming from Portugal, Spain, Italy, Greece and Turkey.

The game was used by students from secondary and vocational schools and higher education engineering schools. It included a set of scenarios corresponding to real engineering problems in the context of a city and players had to solve those problems under constraints also previously defined. For instance, The player was asked to build power plants (eventually solar farms and wind farms) to produce enough energy for the city; to distribute the produced energy; to protect the environment; to choose the right places to build and the right type of construction to ensure safe buildings; to ensure signal coverage for mobile phones; to plan transportation between cities and so on [8].

The game was evaluated by students and the majority (65%) found the game fun or very fun to play because it included real life problems. Students also said that it represented an entertaining approach to study these subjects and they scored high the ability to control the results of their actions and the immediate feedback on their choices. Students found the game like an activity to do during their free time that could be beneficial for their learning process. There was also a positive feedback from the teachers that recognized the potential of eCity as a tool to be used in the classroom.

B. *LEAP – Lean and Agile Practices linking Engineering Higher Education to Industry (Erasmus+ KA2 Strategic Partnership 2016-2018)*

The LEAP project aimed at building experience and knowledge among higher education students on emerging lean and agile industry practices empowering them to effectively transition into the professional world [9]. Lean practices encourage students to design solutions that meet needs while minimizing the deployment of resources. Agile practices expose students to industry cycles in which design is integrated throughout production processes, as opposed to only in the early stages of production, ensuring that the final product effectively addresses consumer needs.

The LEAP project was coordinated by the University of Thessaly, in Greece, and counted with partners from Portugal, Spain, Greece, UK and Estonia.

The project further aimed at promoting the development of high quality digital content for higher education linked to both academic and industry needs.

LEAP pursued these objectives through the design and development of serious games that encourage learners to adopt industry roles, to think critically for addressing community and societal needs through agile engineering solutions, to practice on the application of industrial process management in the context of their higher education curricula, and to take into account environmental responsibility issues in service design and implementation. Recognizing the importance of supporting educators on integrating the proposed innovative learning methods and tools into their teaching practices LEAP also developed good practice guidelines and instructor support content.

C. *DESIGN IT - Design thinking in higher education for promoting human-centered innovation in business and society (Erasmus+ KA2 Strategic Partnership 2017-2019)*

The DesignIT project aims at introducing innovative design thinking interventions into entrepreneurial higher education towards preparing students to enter evolving economies by being adaptive, resilient, innovative, and creative and by possessing the practical entrepreneurial skills that will allow them to put ideas into action in business as well as social well-being contexts.

The project targets the educational needs of students by introducing design thinking skill building activities that can be integrated into wide subjects and help learners understand the core design thinking concepts as well as explore its practical applications in diverse contexts.

The project will further promote collaborative and explorative learning approaches and will exploit the advantages of gamification, namely the deployment of game elements in learning contexts, towards promoting student engagement, motivation, evaluation, and step-by-step scaffolding of knowledge. DesignIT further targets the needs of educators by introducing instructor support content for integrating design thinking into learning by challenging students to generate new ideas and bring them into life.

Specific learning scenarios inspired by real-world case-studies will be designed around clear educational objectives, namely the promotion of soft skills such as creativity, group-work, and customer understanding along with practical capabilities such as designing a working and viable basic business offering. The scenarios will be integrated into the proposed gamified learning environment, will challenge students to generate ideas and solutions through team work, will cultivate a design thinking culture and encouraging out-of-the-box thinking, and will promote social responsibility in entrepreneurship.

The DesignIT gamified learning environment will be designed for deployment as a complementary educational tool in wider blended learning activities classroom during which learners will have the opportunity to learn from each other and from the teacher through peer idea evaluation as well as the evaluation of the viability of the proposed business solution.

D. *ALIEN – Active Learning in Engineering (Erasmus+ Capacity Building Project 2017-2020)*

The ALIEN's project aim is to improve the quality of higher education by providing more motivating, stimulating and effective learning contexts that prepare students for their professional life. Therefore, the objective of the project is to design, implement and validate an Active Learning context based on PBL (Project/Problem) methodologies addressing real-life issues related to science, technology, engineering and math (STEM) concepts. The methodology will be supported by a VLE integrating a set of digital tools that will allow students to experiment, collaborate and communicate in an extended and multinational learning community that will also include other stakeholders like teachers and researchers.

ALIEN includes a large number of partners from Europe and Asis, namely from Portugal, UK, Greece, Estonia, Bulgaria, Malaysia, Vietnam, Nepal, Pakistan and Cambodia.

ALIEN's expected impact includes also the institutional strategical adoption of Active Learning as the primary pedagogical approach.

As concrete results, the project will produce:

- A strategic plan to be adopted/adapted by each institution on the use of Active Learning and Problem/Project Based Learning;

- A validated pedagogical methodology that promotes Active Learning through the use of ICT tools. For instance, by requiring that engineering students themselves develop new challenges and problems. This way they will be directly applying the concepts learned in higher education;

- A PBL laboratory in each University that has the equipment and human resources required to implement the institutional strategy on Active Learning; The lab is expected to work as a place where teachers can create and test their own problems, where they can connect to the virtual community of teachers and researchers and where practical sessions with students can take place;

- An online collaborative platform that supports the production, storage, share and reuse of problems and challenges to be used in PBL and that allows a multinational community of researchers, teachers and practitioners to discuss around the implementation of active learning. The platform will also organize the process of setting up a PBL process by guiding the teachers through all the stages of the methodology.

- A set of 45 serious games and simulations and corresponding pedagogical guidelines, available on the platform that demonstrate, how to use PBL. To the possible extent, these problems will be configurable and customizable, for instance to reflect real situations;

- A set of training actions motivating and preparing teachers for the implementation of PBL;

As a complement the project will produce several elements (reports, posters, flyers, web site, conference articles, newsletters, etc.) that will disseminate information about Active Learning and Problem/Project based Learning.

III. CONCLUSIONS

Higher Education Institutions are required to modernize their pedagogical methodologies, moving into active learning processes whereby students engage in activities that promote higher order learning skills like analysis, synthesis, and evaluation. This is particularly relevant in the case of Engineering considering the scope of competences that are required in the professional world.

In this article we have presented four European projects that are concerned with this issue. Two of them have already been concluded and contributed with a set of results that were positively assessed by students. The other two, although still-ongoing, have also provided very relevant positive feedback in relation to the products already developed.

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