Active Problem-based Learning for Engineering Higher Education

Hariklia Tsalapatas[1], Carlos Vaz de Carvalho[2], Olivier Heidmann[1] and Elias Houstis[1]
[1]*Institute University of Thessaly, Argonafton & Filellinon, 38221 Volos, Greece*
[2]*Porto Polytechnic, Rua Dr. Doberto Frias 712, 4200465 Porto, Portugal*

Keywords: Active Learning, Problem-based Learning, Digital Laboratories, Simulations, Learning Games, Engineering Higher Education, Modernization, Labour Market.

Abstract: The engineering sector today faces a shortage of technical personnel as a result of fast evolving technologies in innovation related sectors expected to drive economic growth. Engineering higher education is in need of modernization in order to link student skills to labour market needs. Skills necessary for supporting economic growth include both a sound theoretical background as well as transversal competencies such as problem-solving capacity, creativity, and analytical thinking. This work presents a problem-based learning framework that aims to more effectively develop students for transitioning into the world of work. This is pursued through active educational approaches supported by digital learning services that promote collaboration, innovative mindsets, autonomous, and self-relying work. The proposed platform facilitates learning experiences that integrate simulations and serious games linked to real world challenges in the context of wider, blended learning practices. The framework is being developed by a network of European and South Asian universities with the objective of integrating needs from diverse cultural, economic, and educational environments resulting into an educational platform with international relevance.

1 INTRODUCTION

One of the key challenges for growth in the engineering sector is the lack of availability of skilled personnel able to support emerging opportunities. According to the New Skills Agenda for Europe (European Commission, 2016) high level skills are necessary for the personal and professional growth of an individual and the realization of aspirations and dreams. Furthermore, skills constitute a key driver for job creation and determine competitiveness in a global economy whose growth is driven by innovation. In engineering, the skills demanded by the job market include a sound theoretical backbone as well as transversal competencies such as critical and analytical thinking, problem solving, entrepreneurial capacity, ability to collaborate as well as work independently, ability to work in a cross-cultural environment, digital competencies for work, and more.

As technology evolves in a fast pace, educational providers may struggle to keep curricula up to date and in line with industry needs. This is a natural consequence of the rigid nature of formal education which results in long processes for updating educational offerings. This high lights the need for modernizing higher education towards building the skills remanded by the job market. According to the Investing in Europe's Youth communication (European Commission, 2017), the investment in skills can contribute to the fighting of unemployment, innovation, competitiveness, and social fairness. According to the Agenda for the Modernization of Higher Education roadmap (European Commission, 2017), higher education institutions are in need of aligning the skills they build to society, to drive innovation, and to link their academic programs to the needs of people, companies, and public services in their regions for benefitting their surrounding areas.

The modernization of higher education programs for linking them to emerging business and societal challenges and opportunities requires, among others, updating educational approaches to ensure that skills developed can be transferred into the world of work, enriching learning experiences through digital technology, increasing student motivation by linking education to the real world, and linking educational activities to innovation and

Tsalapatas, H., Vaz de Carvalho, C., Heidmann, O. and Houstis, E.
Active Problem-based Learning for Engineering Higher Education.
DOI: 10.5220/0007720403470351
In *Proceedings of the 11th International Conference on Computer Supported Education (CSEDU 2019)*, pages 347-351
ISBN: 978-989-758-367-4

research. This work presents a framework for updating higher education practices in engineering through problem-based learning approaches that help build problem solving capacity and analytical thinking. The proposed educational framework is further enriched through simulations and learning games inspired by real world challenges that facilitate the transfer of newly developed knowledge to the world of work facilitating a smoother transition of students from academia to the industry. The framework is being designed and developed in the context of project ALIEN: Active Learning in Engineering Education (Project ALIEN, 2017), which brings together universities from Portugal, Greece, Estonia, Bulgaria, Malaysia, Vietnam, Cambodia, Pakistan, and Nepal with the objective of designing educational interventions that contribute to the modernization of higher education initiatives in South Asia.

2 ENGINEERING HIGHER EDUCATION CHALLENGES IN SOUTH ASIA

South Asia is an emerging economy with high growth prospects. According to the OECD Economic Outlook for South East Asia, China, and India 2019 (OECD, 2018), growth in the region is estimated to an average of 6.1% for the period 2019-2023 despite domestic and external challenges. In relation to education similarities and differences exist. In the countries of interest in this work, namely Malaysia, Vietnam, Cambodia, Pakistan, and Nepal, challenges include the effectiveness of higher education, the fighting of unemployment, the competitiveness of graduates, and building skills for work. More specifically, according to the OECD Structural Policy Country Notes (OECD, 2013), Cambodia's growth is threatened by inefficiencies in the country's higher education system and challenges in both demand and supply for higher education. Malaysia and Vietnam, although facing different challenges in the labour market, are in need of aligning skills to the requirements of their economies (OECD, 2013). In Nepal, being the poorest country in South Asia, a key goal is making basic education accessible to all (Danida, 2004). Pakistan is faced with fragmentation of technical and vocational education and training, skills mismatches, and skill recognition challenges that limit the portability of its workforce (OECD, 2012).

Initiatives do exist for enriching higher education practices in line with societal needs in the countries in focus. The Malaysian Ministry of Education launched in 2007 the Malaysian National Higher Education Strategic Plan beyond 2020 (NHESP/PSPTN). According to the Malaysia Education Blueprint (Ministry of Education Malaysia, 2015), future educational goals include increased access, research growth, and improvement of institutional global rankings. The Cambodian Ministry of Education, Youth, and Sport has launched the Cambodian Higher Education Vision 2030 aiming at identifying long term direction for higher education development. The Government of Pakistan introduced the Pakistan Vision 2025 initiative which aims to develop a knowledge economy by increasing enrolment to higher education from the current 1.5m to 5m (Government of Pakistan, 2016).

3 PROBLEM-BASED LEARNING IN ENGINEERING EDUCATION

Problem-based learning is a methodological educational approach through which learners build skills by solving a specific problem (Barrows, 1986) (Savery and Duffy, 1995). While problem-based learning was first initiated in medical education (Barrows, 1996), where students would learn by addressing specific medical cases, it is now widely deployed in secondary as well as higher education. In problem-based learning students are challenged to combine skills from diverse thematic areas to solve wider problems. The advantages of problem-based learning are many. In addition to building core knowledge, the method promotes the development of critical and analytical thinking skills, inquiry, collaboration, and entrepreneurial mindsets. In problem-based learning students are called to identify the problem at hand and its parameters, analyse potential approaches for addressing it, break the problem down to smaller tasks, and synthesize an overall solution by combining those to smaller, more contained tasks. In problem-based learning the instructor acts as a facilitator that guides students through the discovery and learning process (Boud and Feletti, 1997).

In engineering education problem-based learning challenges students to apply knowledge from diverse subjects and thematic areas to solve problems often inspired by the real world. This approach builds

student capacity to apply newly developed knowledge in a manner that simulates acting in a professional environment, promoting the transferability of knowledge to the world of work.

Digital technology allows the enrichment of problem-based learning through the deployment of tools and services that may be applied in wider blended-learning scenarios. Simulations, learning games, collaboration environments, and more can enhance learning experiences at all stages of the problem-based learning process, from problem presentation, to analysis, collaboration, and solution synthesis. An example of a related environment is the eCity learning application (eCity, 2013) which exposes secondary education students to engineering skills by challenging them to tackle non-trivial problems inspired by real life the solution to which requires an engineering perspective and the combination of STEM knowledge taking also into account economics parameters.

4 A PROBLEM-BASED LEARNING FRAMEWORK BUILDING ENGINEERING SKILLS

This work focuses on the design and development of a learning intervention that exploits problem-based learning for building engineering skills for work. The intervention targets engineering education and is designed to address educational objectives and challenges in South Asian countries taking into account European experiences. More specifically, the proposed problem-based learning framework aims to address the need for modernizing higher education offerings by:

- Promoting links between educational offerings and industry skills requirements.
- Building core engineering knowledge.
- Exploiting digital technology for enriching learning experiences and for addressing educational objectives.
- Fostering the development of transversal skills including analytical thinking, entrepreneurial thinking, collaboration in an international environment, and capacity for independent work.

The learning intervention is implemented vertically to address the needs of the educational process in several levels. It includes the development of infrastructure and facilities, the design and implementation of supporting digital learning services, and instructor capacity building towards ensuring that proposed methodologies and tools are integrated into day to day activities of participating organizations and beyond.

At the infrastructure level, work focuses on the development of problem-based learning labs at 12 South Asian universities in Malaysia, Vietnam, Cambodia, Pakistan, and Nepal taking into account individual organizational needs. These laboratories aim to enhance the capacity of universities to integrate problem-based learning into existing educational practices. The aim of the laboratories is:

- To digitally enable problem-based educational activities.
- To effectively support the deployment of digital tools, such as serious games, simulations, and AR/VR tools in learning.
- To provide a pool of workstations that students can use in problem-based learning contexts.
- To provide a pool of workstations that students and staff can use for developing problem-based learning digital applications.
- To increase interactivity in the classroom through better connectivity to the internet and access to interactive equipment such as smart TVs and more.

At the digital services level, work focuses on the design and implementation of a digital platform that facilitates problem-based learning. The platform is aimed to be deployed as a complementary learning service within broader problem-based learning activities. It is further aimed to be flexible in order to be relevant in the context of diverse institutional strategies related to problem-based and active learning in broad educational, cultural, and economic environments. The educational objectives of the proposed digital platform are:

- To promote problem-based learning through on-line services which facilitate the deployment of related activities in digitally enabled classrooms.
- To provide access to rich educational content for problem-based learning engineering contexts.
- To increase classroom collaboration.
- To increase student interaction across universities promoting international collaboration.

The proposed digital learning platform is complemented with digital applications that challenge students to deploy problem-based learning approaches for solving engineering problems. The content is in the form of digital learning games, simulations, and other applications that expose students to educational scenarios that require broad theoretical and field knowledge while promoting critical thinking. The design of the problems is being pursued with the collaboration of teams from South Asian and European universities to ensure broad coverage of diverse educational needs linked to institutional objectives of participants and industry needs in their respective countries.

At the instructor capacity building level, work focuses on enabling educators and educational institutions to effectively integrate digitally-enabled problem-based learning activities to already well-designed educational practices for better preparing students to enter the workforce. Given that instructors play a significant role in facilitating problem-based learning (Boud and Feletti, 1997), their preparation for deploying the methodology in the classroom is important for reaching educational goals. Work in this area involves:

- The development of good practice guidelines for instructors on the most effective deployment of the proposed problem-based learning intervention.
- The development of manuals on the deployment of the digital services as well as specific digital content in the form of learning games and simulations.
- The potential customization of digital learning content for better addressing institutional and class requirements.
- Suggestions on extra-curricula activities related to problem-based learning.
- The organization and delivery of training sessions in South Asian countries on the deployment of problem-based learning in engineering.
- The organization of transnational peer collaboration activities for collective skill building and exchange of good practices and experiences.

The above work aims to lead to a holistic, end-to-end approach that promotes problem-based learning in a user centred manner that best addresses the interests of students, instructors, educational institutions, and society.

5 CONCLUSIONS

This work presented the design of a vertical learning intervention for fostering problem-based learning in engineering higher education in Europe and South Asia. The proposed learning intervention is currently under development. Instructor training and evaluation activities will begin in early 2019 in South Asia through learning experiments that engage students and educators in 12 universities. Feedback from these activities will be integrated into the design and technical implementation of proposed methodologies and digital learning tools for ensuring that the final outcome best addresses student needs.

ACKNOWLEDGEMENTS

This work is funded with the support of the Capacity Building for Higher Education Erasmus+ Program of the European Commission. Project ALIEN: Active Learning for Engineering Education, with ID 586297/2017, is implemented from 2017 to 2020.

REFERENCES

Barrows, H. S., 1986. A Taxonomy of Problem-based Learning Methods. Medical education, 20(6), 481-486.

Barrows, H. S., 1996. Problem-based Learning in Medicine and Beyond: A Brief Overview. New directions for teaching and learning, 1996(68), 3-12.

Boud, D., Feletti, G., 1997. The challenge of problem-based learning. Psychology Press.

Danida, 2004. Joint Government – Donnor of Basic and Primary Education Programme II, retrieved from http://www.oecd.org/countries/nepal/35049393.pdf on January 30, 2018.

European Commission, 2016. A New Skills Agenda for Europe, retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016DC0381&from=EN on January 30, 2018.

European Commission, 2017. Investing in Europe's Youth, retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=COM:2016:940:FIN&from=FR on January 30, 2018.

Government of Pakistan, 2016. Pakistan 2025: One Nation-One Vision, page 34.

Ministry of Education Malaysia, 2015. Malaysia Education Blueprint 2015-2025 – Higher Education, retrieved from https://www.um.edu.my/docs/default-source/about-um_document/media-centre/um-magazine/4-executive-summary-pppm-2015-2025.pdf?sfvrsn=4 on January 30, 2018.

OECD, 2012. Skills Development Pathways in Asia, retrieved from

http://www.oecd.org/cfe/leed/Skills%20Development%20Pathways%20in%20Asia_FINAL%20VERSION.pdf on January 30, 2018.

OECD, 2018. Economic Outlook for South East Asia, China, and India 201, retrireved from https://read.oecd-ilibrary.org/development/economic-outlook-for-southeast-asia-china-and-india-2019/summary/english_f8d45e2b-en#page1 on January 30, 2018.

OECD, 2013. Structural Policy Country Notes, Cambodia, retrieved from https://www.oecd.org/dev/asia-pacific/Cambodia.pdf on January 30, 2018.

OECD. 2013. Structural Policy Country Notes, Malaysia, retrieved from https://www.oecd.org/site/seao/Malaysia.pdf on January 30, 2018.

OECD, 2013. Structural Policy Country Notes, Vietnam, retrieved from https://www.oecd.org/site/seao/Viet%20Nam.pdf on January 30, 2018.

Project ALIEN, 2017. Active Learning in Engineering Education retrieved from http://projectalien.eu on January 30, 2018.

Project eCity, 2013. A Virtual City Evironment for Engineering Problem-based Learning, retrieved from http://ecity-project.eu on January 2, 2019.

Savery, J. R., Duffy, T. M., 1995. Problem based learning: An instructional model and its constructivist framework. Educational technology, 35(5), 31-38.