ENHANCING CONCEIVE-DESIGN COMPETENCIES IN PART-TIME ENGINEERING EDUCATION: ESPRIT'S APPROACH TO CDIO

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ABSTRACT

This communication examines the adaptation of the CDIO framework for evening engineering courses at ESPRIT, tailored to senior technicians holding a Bachelor of Engineering degree. These professionals enroll in the program to pursue the National Diploma in Engineering over an extended four-year period, compared to the three-year day courses. The evening students bring substantial experience in the 'Implement' and 'Operate' components of CDIO but often need further development in 'Conceive' and 'Design - a point for improvement highlighted by several human resources managers in the engineering industry. Integrating 180 ECTS (European Credit Transfer and Accumulation System) into this longer duration, the curriculum is customized to enhance these skills. The primary goal is to cultivate graduates who are technically knowledgeable and skilled in innovation, problem-solving, and the practical application of engineering principles. The evening courses aim to align with the same educational objectives and standards as the day courses, despite different student profiles and timelines. The paper outlines the strategic implementation of these courses, emphasizing how the tailored approach effectively bridges the gap in Conceive and Design skills, thereby equipping students with the comprehensive CDIO skill set expected of a graduate engineer.

KEYWORDS

Skill Gap Analysis, Conceive-Design Skills, Curriculum Customization, Part-Time Engineering Program, Standards: 1, 2, 5, 7, 8, 11.

INTRODUCTION

The imperative of enhancing employability in engineering education at universities depends on aligning curricula with evolving industry needs. Rapid technological advancements necessitate engineers who are adept with current knowledge and skills to address industry challenges (Gope & Gope, 2022). Universities must adapt their curricula to prepare graduates for immediate integration into the workforce and societal contribution. This adaptation involves embedding necessary skills into engineering programs and offering experiential learning for practical experience (Rouvrais, Remaud, & Saveuse, 2020). The goal is a curriculum that meets enterprise demands and equips students for successful industry careers (Manna, Joyce & Nortcliffe, 2023).

The traditional focus on technical skills is insufficient; employers now seek graduates with a blend of technical, interpersonal skills, and practical experience. This shift necessitates curricular changes to encompass communication, teamwork, problem-solving, and design thinking, coupled with enhanced industry collaboration to ensure relevance of skills and knowledge (Stiwne & Jungert, 2010). Addressing this challenge will yield highly employable graduates capable of significant organizational contributions (Stiwne & Jungert, 2010).

For professional engineering students, it's essential to keep pace with the rapidly changing skills needs of industry. The field's constant flux with new technologies and challenges underlines the need for ongoing skill updates. Their learning path should build on existing knowledge while engaging in advanced activities for career progression (Manna, Joyce & Nortcliffe, 2023).

The CDIO framework, focusing on conceive, design, implement, and operate, is central to engineering education. For part-time students, emphasizing the 'conceive' and 'design' aspects is vital, leveraging their technical foundation and the use of generative AI tools to speed up technical production. Generative AI facilitates tasks like code review, allowing focus on high-level design and conception.

Problem-based learning (PBL) and design projects are effective in enhancing 'conceive' skills. PBL confronts students with real-world problems, developing creativity, idea evaluation, and effective communication (Gope & Gope, 2022). Design projects and reviews further refine these skills, encouraging critical thinking, alternative evaluation, and stakeholder communication (Zou, Liu, Yhang & Han, 2017).

This approach intersects with objectives to boost employability, apply PBL, personalize learning, and develop CDIO skills. It aims at a student-centered model, focusing on skill and career development and heightened engagement with the learning process. Our methodology is structured in three sections: building on professional students' existing knowledge, presenting our aligned working method, and highlighting the benefits of these methods for competence and motivation. The conclusion will summarize undertaken actions and the anticipated outcomes.

WHY AND HOW BUILDING ON THE EXISTING KNOWLEDGE OF PROFESSIONAL STUDENTS

When designing learning path for professional engineering students, it is crucial to build on their existing knowledge, to meet their specific needs and career goals and to ensure their engagement with the learning process (Duckett, 2010). This process requires a thorough understanding of the knowledge and skills that professional students already possess, which can be achieved through a needs assessment that includes surveys, interviews, or focus groups. Once this information is gathered, course content can be aligned with industry needs and job roles, ensuring that professional students are learning the skills that are most relevant to their careers (Arsad & Idrus, 2019). Incorporating emerging technologies and trends into course content is also important, as this can help professional students to stay up to date with the latest developments in their field. Case studies, research projects, and guest lectures from industry experts constitute effective ways to incorporate emerging technologies into course content. Providing opportunities for hands-on learning is also essential for professional engineering students, as they typically have extensive experience in the industry.

Flexible learning options are also essential for professional engineering student's classes. Online courses, hybrid courses, and self-paced learning modules can all be effective ways to provide flexible learning options that accommodate the needs of professional students.

Providing opportunities for peer-to-peer learning can help to create a collaborative learning community that supports the professional development of engineering students. Group projects, discussion forums, and networking events are effective ways to facilitate peer-to-peer learning and build a sense of community among professional students. Universities can use peer-to-peer teaching to allow students to share their expertise with their peers. This can help students to reinforce their own knowledge and skills, identifying emergent skills, while also providing support to their peers (Jambari, Razali, Seth@Noh, Ahyan, Pairan, Ahmad & Osman, 2019).

The flexibility of the process and personalizing learning experience allow students to focus on developing advanced skills, such as critical thinking, problem-solving, and collaboration. Additionally, innovative teaching methods can provide students with a more engaging and interactive learning experience, helping to keep them motivated and engaged throughout the course (Solari, Vizquerra & Engel, 2019).

DESCRIPTION OF THE LEARNING MODEL AND IMPLEMENTATION

For professional students, the engineering curriculum lasts four years, with a global number of ECTS expected to be achieved by students equal to 180. The breakdown is 40 credits for each of the first three years of studies, 30 credits for the fourth year and the last 30 credits attributed the end of studies project. Each of the first three years includes a capstone project designed to professionalize and apply courses contents.

To implement the "build on their existing knowledge" approach, we focused on restructuring the capstone project, where students are traditionally invited to develop technological solutions, aligned to the technical and scientific contents insured during courses. Projects specifications including technical and scientific requirements are traditionally provided by the academic tutors with limited insight on developing the 21 century skills, namely: critical thinking, creative thinking, communicating, and collaborating.

The main constraint encountered by the tutors lies in the heterogeneity of the professional profiles, with different levels of mastery of the technical components. This results in asynchronization between members of the same team in terms of progress, mastery and quality of the final deliverable. A decreasing motivation of some team's members with advanced mastery of technical concepts, due to the weakness of the challenge compared with the professional activities and achievements.

Aligned to the 'build on their existing knowledge' principle, the objective of this work is providing an implementation of the capstone project ensuring better alignment with the professional learners needs in terms of complementary training within an inclusive environment enhancing collaboration and communication. We added to the learning path a module entitled 'professional project', lasting 10 hours, with work realized by teams of 6 members focusing on developing details of the capstone project and tasks repartition. Acceptance of the project is conditioned by its degree of innovation and relevance in terms of solving a real problem and conceiving and designing a solution. Proposed projects are assessed by senior industry

professionals, to measure the degree of alignment with business requirements in terms of conception and design.

According to the CDIO framework, the learning process is completed by inviting students to develop or build the final product or service, aligned with the conceive and design operations results adopted and approved during the professional project module. In addition to technical skills, this second part focuses developing real word managerial skills, namely: project management, tasks allocations, workgroups, timelines, supported by the advanced expertise of professional students.

Finals realizations are assessed following a competency grid inspired from the CDIO syllabus 3.0. For the following the major section of the assessment grid:

- Fundamentals knowledge and reasoning
- Personal and professional skills and attributes
- Interpersonal skills: collaboration, teamwork and communication
- Conceiving, designing implementing and operating systems in enterprise Societal and environmental context-The innovation process.

Criterions under sections are parametrized with reference the type of deliverable of the project with scores reflecting originality of the final product, and excellence of the managing process.

ADVANTAGES OF THE PROPOSED REFORME

Professional Project

By integrating the course "Professional Project" in the curricula, we build a learning experience where professional students can effectively define a personalized learning model. Through this reform, we are trying to emphasise the following components:

Personalized learning: By allowing students to define their own project objectives, universities can provide a more personalized learning experience that is tailored to each student's individual needs and career goals. Personalized learning enhances conceiving and design skills by stimulating autonomy, goal-setting, adaptability and meta-reflective thinking, creating strong foundations for generating original ideas and producing well-aligned designs.

Adaptative and collaborative learning: By allowing students to work on a project that is relevant to their personal and professional goals. By allowing students to work on their professional project in a collaborative environment, universities can facilitate peer-to-peer learning and provide students with opportunities to learn from each other. This learning envirenment help students to develop their conceive and design skills by allowing them to share ideas, provide feedback, and learn from their peers.

Real-world experience: By requiring students to work on a real-world project, universities can provide students with valuable experience. The resulting learning environment help students to build their professional portfolio and prepare for their future career. Conception and design skills are particularly addressed, given expectations of the introduced course in terms of proposed project and solution originality.

Reflection and peer reviewing: Universities enhance conceptualization and design abilities in students by facilitating reflective practices and encouraging peer assessment. These approaches enable learners to recognize weaknesses and devise methods for improving targeted areas, ultimately refining their skill sets. This iterative process strengthens their problem-solving capabilities and promotes continuous growth throughout their academic journey.

Mentoring or Teaching Assistantships: Professional students can gain valuable experience and solidify their understanding of the material by serving as mentors or teaching assistants for lower-level courses. Mentoring or teaching assistantships substantially improve conceiving and design skills by offering direct observations, promoting cross-disciplinary dialogue and addressing challenges creatively.

Assessment of the professional project by senior professionals

Benefits of integrating seniors in the assessment of the “professional project” are as follows:

Expert feedback: Senior professionals in the discipline have extensive experience and expertise in the field, which can provide valuable feedback to students on their professional project. The feedback helps students to identify areas for improvement, refine their skills, and develop their knowledge and understanding of the discipline.

Real-world perspective: Senior professionals in the discipline can provide a real-world perspective on the professional project, helping students to understand how their work can be applied in a practical context. The feedback helps students to develop their skills and knowledge in a way that is relevant to their future careers.

Networking opportunities: the intervention of senior professional provides students with opportunities to network and build relationships with industry leaders. This can help students to build their professional network and increase their chances of finding employment or internship opportunities in the future.

Credibility and recognition: the feedback of senior professionals in the discipline provide students with credibility and recognition for their work.

Quality assurance: the feedback of senior professional ensures that the project meets high standards of quality and relevance. The assessment model helps students to develop their skills and knowledge in a way aligned with industry expectations and best practices.

Competency-based assessments:

Here are some advantages of competency-based assessments:

They are authentic and meaningful: Competency-based assessments measure learners' ability to apply their knowledge and skills to real-world problems.

They are learner-centred: Competency-based assessments focus on the learner's individual needs and strengths. This allows learners to demonstrate their skills and knowledge in a way that is most appropriate for them.

They are flexible: Competency-based assessments can be adapted to meet the needs of different learners and learning environments.

They can be used for formative and summative assessment: Competency-based assessments can be used to provide feedback to learners on their progress, as well as to make summative judgments about their achievement.

CDIO COMPLIANCE

The adoption of the CDIO framework in ESPRIT's evening engineering courses addressed the skill gap in design and implementation. This approach demonstrates a strategic application of the CDIO standards, meeting specific educational needs and enhancing the skill set of graduates. In the sequel, we describe the implementation of CDIO Standards in the evening courses, focusing on bridging the skill gap in Conceive and Design.

Alignment with CDIO Standards:

Adherence to Standard 1 (The Context): The program's focus on developing 'Conceive' and 'Design' skills in students, who already possess experience in 'Implement' and 'Operate', aligns with Standard 1. This standard emphasizes the importance of covering all aspects of the product and system lifecycle - Conceive, Design, Implement, Operate - within the context of engineering education (CDIO Standards, 2023).

Conformity with Standard 2 (Learning Outcomes): The curriculum's focus on enhancing innovation, problem-solving, and practical application of engineering principles aligns with Standard 2. This standard calls for specific, detailed learning outcomes for personal and interpersonal skills, and product process system and service building skills, in line with program goals.

Consistency with Standard 5 (Design-Implement Experiences): The strategic implementation of the curriculum, with an emphasis on enhancing 'Conceive' and 'Design' skills, is consistent with Standard 5. This standard advocates for the inclusion of multiple design-implement experiences in the curriculum. By customizing the curriculum to focus on areas where students need further development, the program ensures that students engage in a balanced range of activities, covering all stages of the engineering process.

Alignment with Standard 7 (Integrated Learning Experiences): The evening courses are designed to provide integrated learning experiences, aligning with Standard 7. This standard emphasizes the importance of pedagogical approaches that enhance the learning of disciplinary knowledge along with personal and interpersonal skills. By bridging the gap in 'Conceive' and 'Design' skills, the program provides an integrated learning experience that combines theoretical knowledge with practical skill development.

Adherence to Standard 8 (Active Learning): PBL is the main approach to course delivery at ESPRIT School of engineering, particularly in the conception and design components in the context of the evening courses. This strategic pedagogical adoption adheres to Standard 8, which focuses on active and experiential learning methods. The evening courses are structured to engage students in active problem-solving and design tasks, reflecting the standard's emphasis on active engagement in the learning process.

Adherence to standard 11 (Learning assessment): The evaluation methods employed in the PBL evening courses, align with CDIO Standard 11, which emphasizes the assessment of student learning in various skills along with disciplinary knowledge. In this approach:

- Report Preparation: Students prepare detailed reports on their projects, which improve their ability to document and articulate technical content, a key component of disciplinary knowledge.
- Peer Review: The peer review process engages students in critical analysis and feedback, enhancing their interpersonal skills and ability to evaluate engineering work critically, in line with the CDIO's emphasis on collaborative learning and self-improvement.
- Presentations and Defence: Presenting and defending their projects before a jury cultivates students' communication skills and their ability to articulate and justify their design choices, aligning with CDIO's focus on effective communication in professional settings.

The evening engineering courses at ESPRIT demonstrate a comprehensive and thoughtful alignment with the CDIO framework, particularly in addressing the unique needs of senior technicians. The program's focus on enhancing 'Conceive' and 'Design' skills, while leveraging students' existing strengths in 'Implement' and 'Operate', ensures that graduates are equipped with the complete set of skills and competencies expected of an engineering professional as outlined in the CDIO Standards.

CONCLUSION

This work presents the implementation of a training model for professional students in ESPRIT's evening engineering course, aimed at enhancing conceive and design skills within the CDIO framework. The model addresses the career development needs of professionals with diverse expertise and profiles. It caters to two groups of bachelor's degree holders: those seeking career change or progression in a new field and experts aiming for career advancement. The approach includes a "professional project" module for ideation, design, and conception, followed by an "integration project" module. Projects developed in groups are assessed by industry experts to ensure they meet industry standards. This method responds to the challenge of maintaining engagement among experienced professionals by leveraging their expertise to elevate project quality and align skills with labor market demands. It emphasizes lifelong learning and career advancement. The implement and operate components of the CDIO approach are addressed through the project module, promoting self-training to meet industry needs. The model was implemented in the second-year class of the computer engineering cycle this academic year, with results to be discussed in a future article.

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