# CDIO IMPLEMENTATION FOR ESPRIT UNIVERSITY STUDENTS DURING INTEGRATION WEEK

**Sinda Bel Haj Daoud, Hiba Maalaoui**

Commun core department, Esprit

## ABSTRACT

Since 2012 Esprit (Private Engineering and Technology School) focuses on training directly operational engineers through an innovative pedagogical approach in particular project/problem-based learning (PBL). Esprit first-year students are often willing to embrace challenges, but these may not always align with what teachers have in mind given that they were, throughout the entire curriculum, as passive receivers. To better support first-year students and foster knowledge acquisition, performance, engagement, collaboration and the overall positive learning experience, Esprit organizes a yearly integration week named PBL0 from all specialties IT, electro-mechanical, civil engineering. It is also intended to facilitate students' transition to university life by combining fun collaborative activities and assisting them in settling into their new surroundings. In this context, the integration week has been designed to incorporate sustainability aspects in a project aligned with CDIO standards 3, 5 and 8 as guidelines and has been formulated to include active learning in its many forms, such as project/problem-based learning, case studies, small group discussions and oral presentations. This research paper will expose the designed scenario of the integration week and the various actions that students should take to gain the required knowledge. It starts with brainstorming to promote student recognition, followed by a design phase, which focuses on translating conceptual ideas into a concrete plan. This includes creating prototypes and selecting appropriate technologies. The third stage involves implementation, focusing on developing the desired output. The project concludes with an evaluation, where the best projects are chosen based on a criteria grid.

In this work, we will go over each stage of the project in detail and provide results discussion in light of how the integration week was perceived by the students.

## KEYWORDS

Project-based learning, first-year engineering, sustainability, CDIO standards 3, 5, 8.

## INTRODUCTION

First-year students must be shaped at an early stage to fit their profile by the time they graduate. Thus, it is essential to concentrate on learning goals related to attitudes, teamwork, leadership, and communication abilities. However, it's not easy to learn these skills, especially in the context of engineering training.

Welcome days at universities is an event organized specifically for new students at the beginning of the academic year. This event aims to introduce incoming students to the university environment, its resources, and the campus community.

It typically includes a series of activities and sessions designed to assist new students acclimate to their new academic environment and to be familiar with the pedagogical concept adopted by their university.

In this context and for 12 years Esprit (Private Higher School of Engineering and Technology) organizes an integration week for first-year students across all specialties computer science electromechanics and civil engineering, known as PBL0 “Problem Based Learning 0”, this week serves as an introduction to the active learning approach adopted by our university.
PBL 0 is a teaching unit that forms part of the study plan, with a coefficient equivalent to 1 ECTS (the European Credit Transfer and Accumulation System adopted by Esprit). (European Commission,2015).

For the integration week of 23-24 academic year, Esprit received 1840 students, who were divided into 300 multidisciplinary teams by committee members before the beginning of the event, working on a specific topic and supervised by 75 tutors from various specialities. At the end of this period, three teams will be selected as winners.

Various constraints confront these challenges, including: the large number of students, the variety of specialities among students and teachers, and the status of being first-year learners.

In order to deal with these limitations, it is necessary to respond to the following inquiries:

- What would be the recommended approach to better support first-year students and prepare them for active learning?
- Which subject best suits the diverse skill sets of both instructors and students?

Esprit is promoting advanced engineering education in Tunisia and has gained international recognition through its membership of the CDIO initiative founded by MIT (Massachusetts Institute of Technology).

A particular focus on engineering education is to enable engineers to develop new techniques and technologies in an era of technology, information, and inventive economies. A complex approach for developing specialists who can manage a system, product, service, or process through its whole lifecycle is outlined in the CDIO International Standards. Conceiving, designing, implementing, and operating engineering activities are a context in which the framework places a strong emphasis on engineering basics. The term CDIO is an acronym for all four phases. (Crawley et al., 2007).

The CDIO initiative is based on four phases namely:

- Conceive phase: Defining customer needs; considering technology, enterprise strategy, and regulations; developing concepts, techniques and business plans.

- Design phase: Creating the design; plans, drawings, and algorithms that describe what will be implemented.
- Implement phase: Transforming the design into the product, including manufacturing, coding, testing and validation.
- Operating phase: Using the implemented product to deliver the intended value, including maintaining, evolving and retiring the system.

Since 2013, Esprit provides a pilot program integrating CDIO concepts into project-based learning to manage the integration week through conceive, design, implement and operate phases.

In order to ensure that the highest standards of education are maintained, the CDIO Initiative has defined twelve standards that every program established under the CDIO syllabus must meet. (Malmqvist et al.,2019)

In this study we focus on Standard 5 “Design-Implement Experiences”, standard 8 “Active Learning”, (Brodeur & Crawley, 2009) and the current version of the Syllabus 3.0 “the new optional CDIO Standard for Sustainable Development” (Malmqvist et al.,2022) to illustrate the way in which instructors provide students with the skills of active learning, problem-analysis and problem solving, teamwork and communication. (Malmqvist et al.,2020)

In this case study, we will describe our strategy and show how students can progress from problem identification to the development of solution using CDIO approach.

This paper starts by giving an overview of the methodology implemented followed by a detailed explanation of how each phase of CDIO is applied in our case. It concludes with an analysis of results, considering the students' perceptions of the integration week.

## RELATED WORK AND BACKGROUND

All of us are the result of traditional pedagogy. We acquired knowledge through attending lectures and completing traditional written assessments. Student and instructor training is necessary for changing education reform to innovative pedagogy focused on real-world issues that relate to the working world. (Caroline Verzat,2009)

We draw inspiration from the fruitful experiences of our Belgian colleagues at Louvain-la-Neuve, who have been using active learning strategies with their students. (D. Ducarme and B. Raucent,2011)

Since 2012, Esprit has organized the “PBL0” week at the start of the academic year, dedicated to raising awareness of active learning among first-year students. Given that each year a different topic is set to be carried out, students are grouped into teams to solve the problem.(Kaouther.L et al.,2016)

Due to the Covid-19 pandemic, we had to move towards creating online content. This included creating lecture videos and developing different skills using online Learning Management Systems (LMS) for communicating with students, presenting the schedule for the week as well as the content of each slot, moderating discussion forums and holding assessments.

## METHODOLOGY IMPLEMENTATION

To ensure that all students complete their projects on schedule, it is necessary for the project to be refined into concrete steps and the CDIO approach is selected.

As shown in Figure 1 the designed scenario of the integration week "PBL0", spread over 4 days, follows four steps as they progressed from problem identification to solution development.

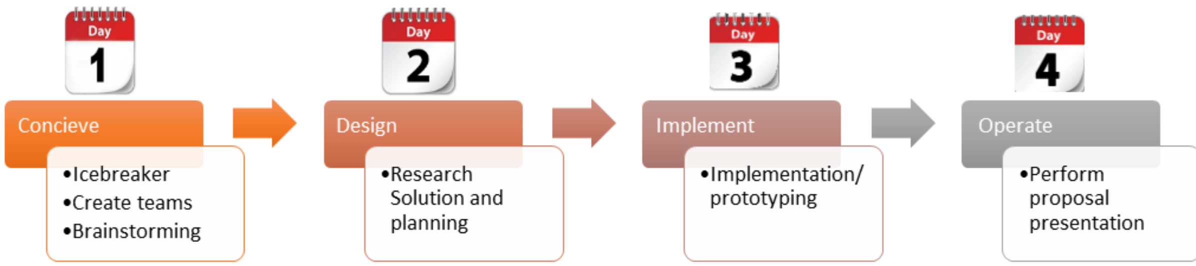


Figure 1. PBL0 Using CDIO.

### *Conceive*

The conceive phase takes place on the first day of the integration week. After the welcome ceremony given by the Esprit directors, students and tutors join their respective classrooms, according to an order previously communicated by the PBL0 organising committee.

The integration week starts with an icebreaker activity with the aim of facilitating interaction and communication between participants, building a positive classroom atmosphere and creating a positive learning experience.

As groupwork is a vital aspect of project-based learning, fostering students' confidence in handling meaningful challenges, students are divided into multidisciplinary groups, with 6 to 8 members per team.

The goal of multidisciplinary Project-Based Learning (PBL) is to foster collaboration and integration of knowledge from various disciplines. By working in multidisciplinary teams, students bring diverse perspectives, skills, and expertise to solve complex, real-world problems. (Buck Institute of Education, 2015).

Students were engaged to undertake a real-life project that aligns with the student's different specialities and focuses on Sustainable Development Goals (SDGs) 3 "Health and Well-being" and 4 "Quality Education". (The United Nations,2023)

The project, titled "University Life Project," aims to create a 3D model of university life to shape a well-rounded and open-minded student who receives a quality education and becomes a responsible citizen.

At the end of the first tutored session, the instructor presents and explains the challenge for the week, the progress of the first phase and the assignments that must be achieved during the asynchronous part of the conceive phase, which are already configured in the course space.

In this phase, teams need to understand the current context of the problem and generate project ideas. For that, we suggest making internal research to identify the existing solutions. To ensure the success of this phase, we have offered students a range of activities including quizzes, videos, and a discussion forum within the course space.

Once the first day is over, all the teams are invited to submit a theoretical study on the course space.

In Table 1 is the conceive phase undertaken during the first day of integration week.

Table 1. Conceive Phase

| Student's activity | Instructor activity | Product | Resources | Learned skills |
|---|---|---|---|---|
| Research on project ideas<br>Combining ideas<br>Generate project idea | Explain the problem.<br>Guide students in their research | Theoretical study | Quiz, videos and questions related to the subject | Critical thinking<br>Communication<br>Teamwork |

***Design***

The design phase focuses on translating conceptual ideas into a concrete plan.

Once the idea generation has taken place, the students are led to research possible alternatives in order to evaluate, compare and choose the best one.

Before proceeding with the design of the models, the tutors must make sure that the suggested solution satisfies the requirements of the topic in question before moving further with the model's creation and providing the required tools.

Following this step, students move on to the theoretical study of the selected solution based on planned activities that includes general design guidelines.

In order to select appropriate tools and build the solution prototype, students split up their work such that each person is in charge of a single assignment.

To assist students, throughout the entire development process, instructors are available for consultation.

When design flexibility and group work are combined, a decentralised learning environment is produced where groups may receive feedback and direction related to their theoretical knowledge design.

Based on instructor feedback, students can iterate on their assumptions and their design decisions before starting to create their scale models.

In Table 2 is the design step undertaken during the second day of the integration week.

Table 2. Design Phase

| Student's activity | Instructor activity | Product | Resources | Learned skills |
|---|---|---|---|---|
| Identifying necessary tools Generate design plan | Discuss and validate the theoretical study. | Provide a technical study | Software tools | Technical skills Communication Teamwork Project management |

***Implement***

The implement phase consists of creating final products. After finalising the product concept, each team is required to build a 3D model in line with the conceptual study already completed. Given that they work on a sustainable project they use recyclable materials such as plastic bottles, cans, cardboard, etc. to create the solution model.
As shown in Figure 2, it's quite simply extraordinary for students and tutors to see such innovative and creative projects.


Figure 2. Students' Prototypes

In Table 3 is the implement step undertaken during the third day of the integration week.

Table 3. Implement Phase

| Student's activity | Instructor activity | Product | Resources | Learned skills |
|---|---|---|---|---|
| Implementation of ideas | Supervise the process | 3D solution model | recyclable materials Software tools | Creative & technical skills Teamwork |

***Operate***

The operate phase takes place at the end of the week, this is the most rewarding stage as all the projects are already working and ready for viewing and assessment.
At this level, teams need to present their project to their coach, their colleagues, guests and the directors of Esprit. For that, they need to prepare a pitch and a presentation that explains the idea and highlights the efforts made by the entire team. As PBL 0 is a module in the first-year programme, it must be graded. During the "operate" phase, each team must present its

solution. The tutor validates their work by completing a criterion grid assessing both the scientific content and the oral presentation. For the scientific content, four assessment criteria were proposed: the importance of the problem and its impact, the choice of the suggested solution, and the product's quality. As for the oral presentation, the teams will be assessed on the quality of their oral presentation and their argumentation.

The integration week concludes with a ceremony where three best projects are chosen based on a criteria grid considering the project's creativity and originality.

In Table 4 is the operate step undertaken during the last day of the integration week.

Table 4. Operate Phase

| Student's activity | Instructor activity | Product | Resources | Learned skills |
|---|---|---|---|---|
| Perform proposal presentation | Project evaluation<br>Selection of the best projects | 3D solution's model<br>Presentation support | A scale model. | Critical& thinking skills.<br>Communication<br>Technical skills<br>Teamwork |

## RESULTS AND ANALYSIS

In this section, we demonstrate the significance of using the CDIO approach to introduce the project-based learning to first-year engineering students through their final marks and a survey. The breakdown of students' final marks is shown in Figure 3.

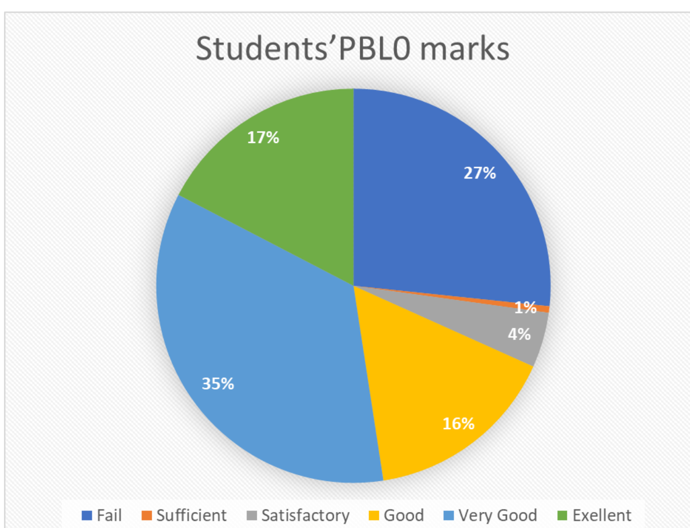


Figure 3. Students' PBL 0 Marks

We note that 74% of students successfully completed PBL0, with 68% achieving good to excellent grades. Indeed, most of the students who did not validate PBL0 were absent during the integration week.

The survey was performed at the end of the first semester of the current academic year 23-24. It used a series of questions qualified by the 3-point Likert scale.

In this section, results from 432 responses received are presented and followed by discussion, pointing out the strengths and weaknesses of using CDIO in a project-based learning during the integration week. Our attention focuses on the dimensions related to:

1. Students' PBL0 perceptions,
2. Achieving project's goals through CDIO approach,
3. Preparing students for active learning through CDIO approach,
4. Students' learned skills.

The dimension 1 "Students' PBL0 perceptions" intends to evaluate the perceptions of students related to the integration week in general and the results of the survey are presented in Figure 4, showing that among 432 students, 93% were satisfied, while 7% were not.

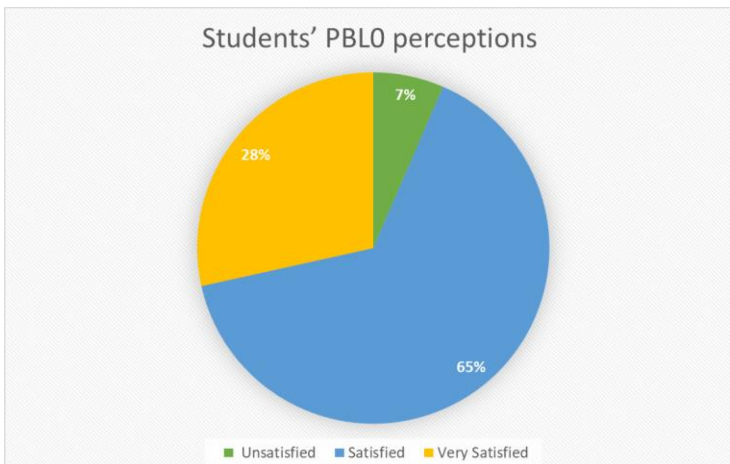


Figure 4. Students' PBL0 Perceptions

The dimension 2 analysed is related to "Achieving project's goals through CDIO approach". Figure 5 shows that 92% of students attest that the four phases of the CDIO allowed them to accomplish their project's goals, while 7% weren't satisfied with the previously outlined process.

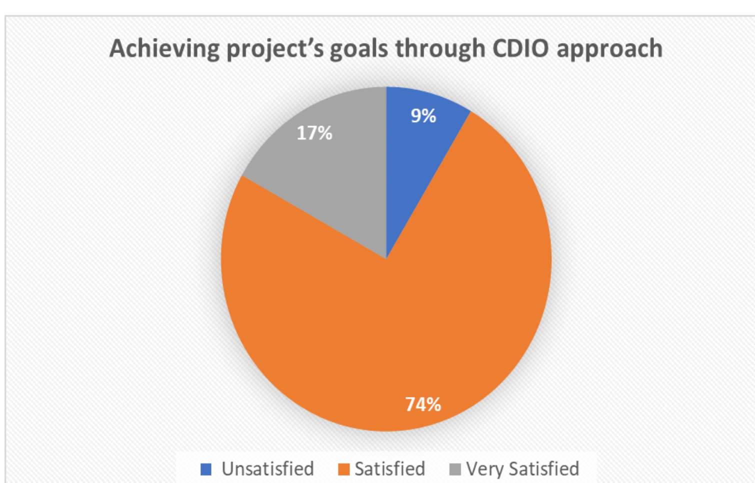


Figure 5. Achieving Project's Goals Through CDIO Approach

Another analysed dimension pertains to "Preparing students for active learning through CDIO approach". Figure 6 shows that 85% of students thought that using the CDIO four phases in the integration week, enabled them to familiarise themselves with the project-based approach applied in the first semester, while 15% believe that it did not.

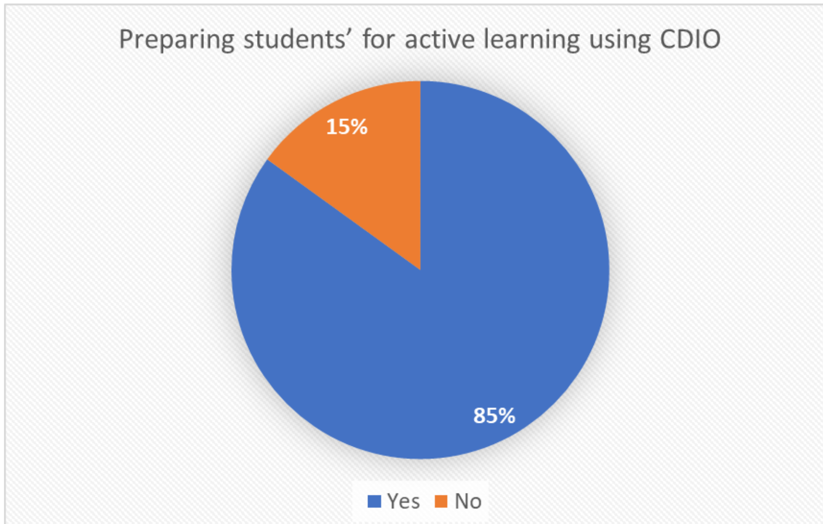


Figure 6. Preparing Students For Active Learning Through CDIO Approach

As seen in Figure 7 which analyses the last dimension "Students' learned skills".

Students highlights that the PBL0 contributes strongly to the development of skills that are important for pursuing the curriculum of engineering students, such as team-working, communication, project management and thinking & critical skills.

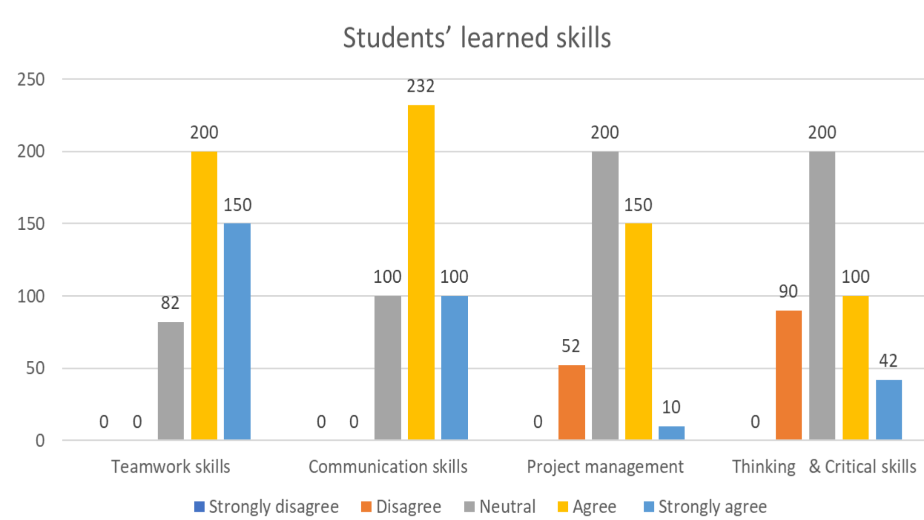


Figure 7. Students' Learned Skills

Considering the above, it is clear that the majority of students had a positive overall experience and believed that the integration week using the CDIO process had improved their grasp of the PBL approach. However, a minority of students seem to be dissatisfied with the integration week. This attitude can eventually be explained by the fact that four days are not enough to learn about the active approach. Another potential issue that may be contributing to the discontent among students is the disparity in their backgrounds especially as it was their first steps to tackle new academic challenges unlike to what they had previously encountered. Furthermore, teamwork could also be seen as an obstacle for some students who are used to working on their own.

## RECOMMENDATIONS

Overall, and according to feedback from teachers during the retrospective meetings held at the end of the integration week, the model works well. It is both an opportunity for students to learn in an engaging way and to gain knowledge through experience.

To offer a more effective experience, it could be required to implement specific adjustments to the process:

### *Synthesis*

Before closing the event, it is essential to summarise the knowledge acquired by the students on active learning during the integration week via a question-and-answer session, highlighting the role of adapting the CDIO approach in the process.

### *Information points in non-tutored sessions*

Students appreciate having areas where they can ask questions outside the classroom.
In future iterations we intend to set up information points attended by tutors to provide students with better guidance and meet their needs in non-tutored sessions.

## CONCLUSION

This paper highlights how the CDIO approach was successfully conducted the integration week intended for first-year engineering students under the guidance of instructors that are specialists in different areas.

Both teachers and students may find it challenging to switch from traditional teaching and learning methods to an active learning atmosphere. To guarantee this transition throughout the integration week, the CDIO strategy has been applied to the above case.

According to the concept of Standard 3, 5 and 8, we found that embedding CDIO into the integration week produced positive results as revealed by students' performance in creating innovative projects, improving self-learning, problem-solving, communication skills, team-working, and knowledge acquisition.


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## BIOGRAPHICAL INFORMATION

***Sinda Bel Haj Daoud*** is a computer science teacher at ESPRIT school of engineering since 2015.

***Hiba Maalaoui*** is a computer science teacher at ESPRIT school of engineering since 2017.

### *Corresponding author*


Sinda Bel Haj Daoud
ESPRIT Private School of Engineering
Dept. of common core:
Algorithms and programming teaching unit
1, 2 rue André Ampère -
2083 - Pôle Technologique - El Ghazala
sinda.belhajdaoud@esprit.tn