

SIX MONTHS OF ENGINEERING WITH CDIO APPROACH

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ABSTRACT

This paper reflects on a series of engineering events and competitions organized over six months at our university, aligned with the CDIO (Conceive, Design, Implement, Operate) approach. These activities aimed to engage students in engineering challenges that bridge theoretical knowledge with practical application. The events included workshops and design competitions, fostering problem-solving, teamwork, and critical thinking while igniting student interest in engineering. Innovative methods were employed to attract students, ensuring the activities were engaging and relevant. The events guided participants through all CDIO stages, creating a dynamic learning environment. Students were encouraged to take ownership of their projects, gaining exposure to real-world engineering applications. To evaluate the effectiveness of these initiatives, a participant survey was conducted. Feedback was collected on engagement levels, skill development, and the impact of the CDIO framework on their understanding of engineering principles. The survey revealed that students found the events highly engaging and beneficial. The hands-on approach and focus on real-world problems provided deeper insights into engineering concepts compared to traditional classroom learning. Collaborative elements fostered teamwork and communication, essential for engineering success. Participants noted that the CDIO framework helped them develop a structured approach to problem-solving, valuable in both academic and practical settings. The findings underscore the potential of the CDIO framework to enhance engineering education by offering comprehensive, hands-on experiences. These activities resonate with students' interests and career aspirations, improving learning outcomes and fostering a stronger connection to the engineering profession. The success of these events demonstrates the value of the CDIO approach in creating meaningful, engaging, and effective engineering education experiences, paving the way for future initiatives that align with student needs and industry demands.

KEYWORDS

Introduction to Engineering, CDIO skills development, professional skills, CDIO Standards: 1, 3, 4, 6

INTRODUCTION TO SIX MONTHS OF ENGINEERING

Engineering education must evolve to meet the growing demands of modern industries. The integration of theoretical knowledge with practical applications is critical for preparing students for real-world challenges. The CDIO framework provides a structured and innovative approach to achieving this goal, emphasizing problem-solving, teamwork, and critical thinking. This paper discusses a six-month initiative at Oguz han Engineering and Technology University of Turkmenistan (ETUT), where a series of engineering events and competitions were organized under the CDIO framework. These activities aimed to bridge the gap between academic learning and practical application, fostering student engagement and professional development.

The program was designed to address key aspects of engineering education, including hands-on learning, professional skills development, and exposure to real-world challenges. Through workshops and design competitions, students were encouraged to explore engineering concepts creatively and collaboratively. This initiative highlights the importance of experiential learning and aligns with global trends in engineering education, where practical skills are increasingly valued alongside theoretical knowledge.

Objective of the Research

The primary objective of this research was to evaluate the effectiveness of the CDIO framework in enhancing engineering education at ETUT. This initiative aimed to address the limitations of traditional engineering curricula, which often emphasize theoretical knowledge while offering limited opportunities for practical application. By organizing a series of workshops and competitions over six months, the study sought to bridge this gap, providing students with hands-on experiences that align with real-world engineering challenges.

One key objective was to assess how well the CDIO framework engages students in active learning. Engineering education is most effective when students are not merely passive recipients of information but are actively involved in the learning process. This research aimed to determine whether the CDIO approach could foster such engagement by encouraging students to take ownership of their projects and actively participate in problem-solving activities. Another critical objective was to evaluate the impact of the CDIO framework on skill development. Modern engineering demands a combination of technical expertise and professional skills, such as teamwork, communication, and critical thinking. The initiative was designed to cultivate these competencies by requiring students to work collaboratively, articulate their ideas effectively, and think critically about complex engineering problems. The research sought to measure improvements in these areas and understand how the CDIO framework contributes to their development.

Additionally, the research aimed to explore the relevance of the CDIO framework in preparing students for industry demands. Engineering graduates often face challenges when transitioning from academic environments to professional settings due to a lack of practical experience. By simulating real-world scenarios, the CDIO approach provides students with an opportunity to apply theoretical knowledge in practical contexts. This study sought to determine whether such experiences enhance students' readiness for professional engineering roles and their ability to adapt to industry expectations.

The research also aimed to gather insights into student perceptions of the CDIO framework. Understanding how students view this approach is crucial for evaluating its effectiveness and identifying areas for improvement. By collecting feedback through surveys and interviews, the study sought to uncover students' perspectives on the learning process, the challenges they faced, and the benefits they derived from participating in CDIO-based activities.

MATERIALS AND METHODS

The six-month initiative at ETUT was meticulously planned and executed to maximize student engagement and learning outcomes. The program consisted of multiple interconnected activities designed to guide students through the CDIO stages, providing them with a comprehensive understanding of engineering practices. The methodology for this initiative is detailed below.

The first step involved designing events that would effectively cover all stages of the CDIO framework. A multidisciplinary team of faculty members and engineering professionals collaborated to create a series of workshops and competitions that were both challenging and engaging. The goal was to design activities that not only stimulated intellectual curiosity but also encouraged students to apply theoretical knowledge in practical settings. Emphasis was placed on real-world problems to ensure the relevance of the activities to future engineering careers.

To attract a diverse group of participants, innovative outreach strategies were employed. Announcements were made through various channels, including social media, university bulletin boards, and classroom visits. The promotional efforts highlighted the unique learning opportunities provided by the initiative, such as hands-on experience, teamwork, and the chance to tackle real-world engineering challenges. These efforts were successful in drawing a wide range of students, from freshmen to seniors, and from various engineering disciplines.

CDIO stages

In the design competitions, students were tasked with addressing specific engineering problems that required innovative solutions. The competitions were structured to guide participants through the CDIO stages. In the "Conceive" phase, students were required to identify a problem and propose a feasible solution. This phase emphasized critical thinking and creativity, as students brainstormed ideas and assessed their viability.

The "Design" phase involved detailed planning and the creation of technical drawings or blueprints. Students worked in teams to develop comprehensive project plans, incorporating feedback from mentors and peers. Collaboration was a key aspect of this phase, as it mirrored real-world engineering practices where teamwork is essential for success.

In the "Implement" phase, students brought their designs to life by constructing prototypes or models. Resourcefulness was often required, as students had to work within the constraints of available materials and tools. This phase provided hands-on experience and allowed students to see their ideas take tangible form.

Finally, in the "Operate" phase, students tested their prototypes in simulated or real-world conditions. This phase emphasized iterative improvement, as students analyzed the performance of their solutions and made necessary adjustments. The ability to refine and optimize their designs was a critical learning outcome of this phase.

Throughout the initiative, mentors played a crucial role in guiding students and providing constructive feedback. Faculty members, industry professionals, and senior students acted as mentors, sharing their expertise and offering insights into best practices. Their involvement ensured that the activities were both educational and aligned with industry standards.

To evaluate the effectiveness of the initiative, a comprehensive survey was conducted among participants. The survey included both quantitative and qualitative questions, covering aspects

such as engagement levels, skill development, and the perceived impact of the CDIO framework on their understanding of engineering principles. The feedback collected through this survey was instrumental in assessing the success of the initiative and identifying areas for improvement.

In addition to the survey, observational data was collected during the workshops and competitions. Faculty members monitored student participation and collaboration, noting instances of innovation, teamwork, and problem-solving. This data provided valuable insights into the effectiveness of the CDIO framework in fostering a dynamic and engaging learning environment.

Comparison of effect of Six months challenge

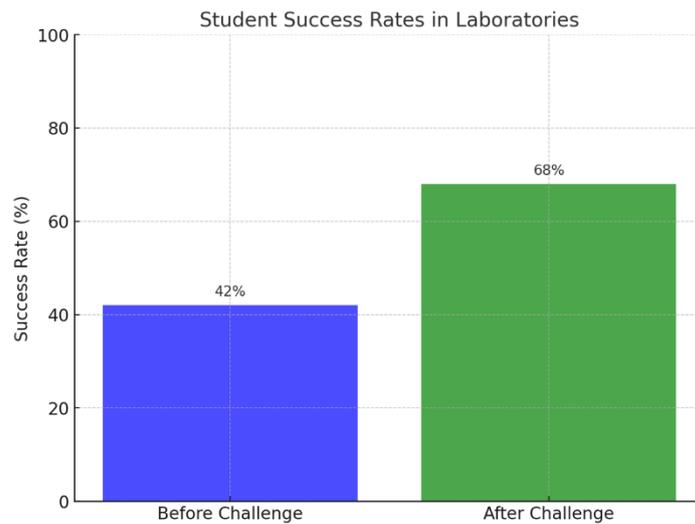


Figure 1. Student performance analysis dashboard

The Figure 1 illustrates the impact of the six-month engineering challenge on student success rates at ETUT. The data compares student performance in laboratory-based assessments before and after the challenge.

Prior to the challenge, the success rate was 42%, representing 1890 out of 4500 students achieving satisfactory results. This baseline reflects the traditional approach to engineering education, which emphasized theoretical instruction with limited practical engagement.



Figure 2. Percentage overview of results of six months challenge

After the challenge, the success rate significantly increased to 68%, equating to 3060 students demonstrating improved performance. This improvement highlights the effectiveness of the challenge in enhancing student learning outcomes through hands-on activities, competitions, and interdisciplinary projects.

The Figure 2 visually represents this progress, with two bars indicating the percentage of successful students before and after the challenge. The first bar, labeled "Before Challenge," is shorter, signifying the lower success rate, while the second bar, labeled "After Challenge," is taller, reflecting the substantial improvement.

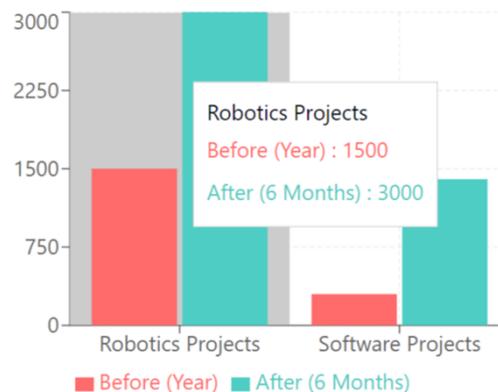
This comparison underscores the value of experiential learning and the CDIO framework in fostering academic and practical excellence in engineering education. The diagram serves as a compelling visual summary of the initiative's success in bridging the gap between theoretical knowledge and real-world application.

Impact of the Challenge on Project Output: Robotics and Software Development

The six-month engineering challenge not only improved student success rates but also significantly influenced the quantity and scope of student projects, particularly in the fields of robotics and software development. The diagram illustrates a dramatic increase in the number of projects completed in these domains, highlighting the transformative impact of the challenge on students' productivity and engagement with engineering disciplines.

Robotics Projects

Before the challenge, the annual output of robotics projects was approximately 1500. This number reflects the baseline productivity of students under traditional educational methods, where projects were often limited by a lack of motivation, resources, or opportunities for hands-



on experimentation. Robotics, being a complex and interdisciplinary field, requires a blend of theoretical knowledge and practical skills. The relatively modest output prior to the challenge indicated that students were not fully engaged or adequately supported in pursuing such projects.

Figure 3. Comparison of quantity of robotic projects (before – after)

In Figure 3 after the implementation of the challenge, the number of robotics projects surged to approximately 3000 within just six months. This doubling of output in half the usual time demonstrates the effectiveness of the challenge in fostering student interest and capability in robotics. The activities organized during the challenge, including workshops, competitions,

and mentorship programs, provided students with the tools, guidance, and motivation to explore robotics in greater depth. The CDIO framework played a crucial role in this success by encouraging students to conceive innovative ideas, design functional prototypes, implement their designs, and test their solutions in real-world scenarios.

The diagram visually represents this growth, with two bars labeled "Before Challenge" and "After Challenge" for robotics projects. The first bar, representing the annual output of 1500 projects, is significantly shorter than the second bar, which illustrates the remarkable achievement of 3000 projects in just six months. This stark contrast underscores the profound impact of the challenge on student productivity and engagement in robotics.

Software Development Projects

The field of software development also experienced a substantial increase in project output as a result of the challenge. Prior to the challenge, the annual number of software development projects was approximately 300.

This relatively low figure highlighted a need for greater emphasis on programming and software engineering in the curriculum. Many students lacked the confidence or resources to undertake software projects, resulting in limited output.

Following the challenge, the number of software projects skyrocketed to 1400 within six months. This nearly fivefold increase in output over a significantly shorter timeframe demonstrates the challenge's success in inspiring students to explore software development. The inclusion of specialized workshops on coding, algorithm design, and software engineering principles equipped students with the necessary skills and knowledge to tackle complex programming tasks. Collaborative activities further enhanced their ability to work in teams, solve problems creatively, and produce high-quality software solutions.

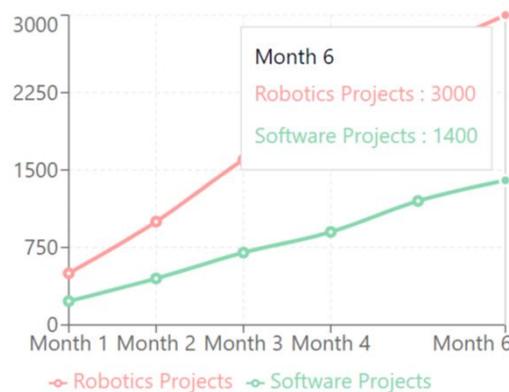


Figure 4. Monthly Progress During Challenge

The diagram visually compares these figures with two bars labeled "Before Challenge" and "After Challenge" for software projects. The first bar, representing the annual output of 300 projects, is dwarfed by the second bar, which illustrates the dramatic increase to 1400 projects in just six months. This visual contrast highlights the effectiveness of the challenge in promoting software development as a key area of focus for engineering students.

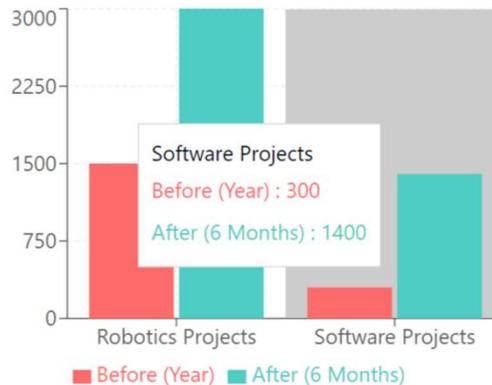


Figure 4. Comparison of quantity of software projects (before – after)

Analysis of Results

The significant increases in project output for both robotics and software development can be attributed to several factors introduced during the challenge. First, the hands-on, experiential learning approach encouraged students to actively engage with their studies and pursue innovative ideas. By providing a structured framework for project development, the challenge helped students navigate the complexities of robotics and software engineering, transforming theoretical concepts into practical applications.

Second, the collaborative nature of the challenge fostered a sense of community and shared purpose among students. Working in teams allowed participants to pool their skills and knowledge, overcome obstacles more effectively, and achieve greater success in their projects. The mentorship provided by faculty members and industry professionals further enhanced this collaborative environment, offering students valuable guidance and support throughout the project lifecycle.

Third, the competitive aspect of the challenge motivated students to push their limits and strive for excellence. The recognition and rewards associated with successful projects served as powerful incentives, driving students to invest their time and effort into creating innovative solutions. This competitive spirit, combined with the supportive learning environment, created the perfect conditions for students to excel in robotics and software development.

Innovative Festivals: Food Tech and Craft Tech

As part of the six-month initiative, two unique festivals, "Food Tech" and "Craft Tech" were organized to expand the scope of the CDIO framework and offer students creative avenues to apply their engineering knowledge. These festivals aimed to explore the interdisciplinary applications of engineering and to engage students in innovative problem-solving activities outside traditional engineering domains.

The "Food Tech" festival challenged students to integrate engineering principles and technological tools into food preparation. Participants were required to approach food as an engineering problem, considering aspects such as process optimization, precision, and innovation. For instance, students used engineering techniques to design efficient cooking

processes, measure ingredients with high accuracy, and explore innovative ways to enhance food quality. This festival demonstrated the versatility of engineering by applying its principles to a non-traditional field, encouraging students to think creatively and explore new applications of their skills.

The "Craft Tech" festival focused on blending traditional handmade art with modern technology. Students were tasked with creating functional or decorative items that combined craftsmanship with engineering techniques. Projects included integrating sensors into handcrafted items, using 3D printing to enhance artistic designs, and developing interactive art pieces. This festival highlighted the importance of creativity and interdisciplinary thinking, showing students that engineering solutions can also be aesthetically appealing and culturally significant.

CONCLUSION

The six-month initiative at ETUT, centered around the CDIO framework, has yielded significant insights into the enhancement of engineering education. This approach has effectively bridged the gap between theoretical knowledge and practical application, thereby fostering a more engaging and relevant learning environment for students. The findings from this initiative underscore the importance of experiential learning in preparing students for the challenges they will face in their professional careers. The feedback collected from participants further reinforces the positive impact of this initiative. Students reported that their involvement in CDIO-based activities not only improved their technical skills but also enhanced essential professional skills such as teamwork, communication, and critical thinking.

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author(s) received no financial support for this work.

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