

# BUILDING SCALABLE INDUSTRY COLLABORATION IN ENGINEERING EDUCATION THROUGH THE CDIO FRAMEWORK

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## **ABSTRACT**

TheFIRMA is an ICT learning environment located at Turku University of Applied Sciences (TUAS), Finland. It was established in 2015 through the merger of several previous learning environments. Over the past decade, theFIRMA has evolved into a scalable and dynamic platform that exemplifies how industry collaboration can be integrated into engineering education using the CDIO (Conceive-Design-Implement-Operate) framework, effectively bridging academic theory with real-world, project-based learning experiences. The aim of this paper is to analyze how theFIRMA has applied CDIO principles to foster authentic learning experiences and align educational outcomes with industry demands. The scope encompasses the project office's establishment, key milestones, and its dual impact on students and industry stakeholders. By participating in projects such as web and app development, graphical design, and end-user training, students gain disciplinary knowledge and personal and interpersonal skills. Industry partners benefit from cost-effective solutions and access to emerging talent. Key milestones include the establishment of the competence track, increased engagement in projects, and participation in externally funded R&D initiatives. These developments have been underpinned by CDIO Standards – notably standard 6. Engineering Learning Workspaces, standard 7. Integrated Learning Experiences, and standard 8. Active Learning – which have shaped theFIRMA's practices and outcomes. The conclusion emphasizes theFIRMA's role in preparing students for successful careers while strengthening ties with industry. Despite challenges such as balancing academic schedules and project demands, theFIRMA's innovative strategies have ensured continuity and impact. As it embarks on its second decade, plans include expanding international collaborations, enhancing digital assessment tools, and deepening long-term industry partnerships. This paper provides insights into theFIRMA's journey while enriching engineering education through CDIO implementation and industry engagement.

## **KEYWORDS**

University-industry collaboration, project-based learning, ICT, R&D learning environment, Standards: 6, 7 and 8.

## INTRODUCTION

IT engineering education faces a constant challenge to keep pace with rapid technological advancements and evolving industry requirements. Employers increasingly emphasize not only technical expertise but also transferable skills such as problem-solving, adaptability, teamwork, and communication. The World Economic Forum's "Future of Jobs Report 2020" identifies analytical thinking and innovation, active learning and learning strategies, complex problem-solving and emotional intelligence as essential skills for the future workforce. Similarly, studies by Binkley et al. (2012) and Van Laar et al. (2017) underscore the importance of 21st-century skills, including communication, collaboration, leadership, and digital literacy. For engineering educators, it is important to incorporate employability skills into the curriculum to effectively prepare graduates for successful careers in the engineering sector (Manna, Joyce & Nortcliffe, 2023).

The CDIO framework provides a robust foundation for modernizing curricula to ensure students graduate with relevant and practical skills. Its emphasis on active learning, hands-on projects, and interdisciplinary teamwork aligns well with contemporary industry expectations (Crawley et al., 2014). CDIO Standards (cdio.org), particularly Standard 6 (Engineering Learning Workspaces), highlight the importance of providing students with professional environments that support collaboration and practical learning, Standard 7 (Integrated Learning Experiences) focuses on combining technical knowledge with personal and interpersonal skill development, and Standard 8 (Active Learning) emphasizes experiential methods that engage students in real-world problem-solving.

In this context, theFIRMA was conceived as a scalable learning environment to bridge the gap between academic theory and industry practice, fostering authentic learning experiences through real-world projects. A core feature of theFIRMA is its focus on integrating disciplinary knowledge and personal and interpersonal skills into engineering education. By working in teams on client-driven assignments, students learn to manage timelines, communicate with stakeholders, and address unforeseen challenges – competencies that are essential for employability (Andrews & Higson, 2008).

This paper explores theFIRMA's ten-year journey, analyzing its alignment with the CDIO framework and its contribution to the theme of "Industry Collaboration and Perspectives." It highlights how scalability has been a central consideration in theFIRMA's design, enabling the model to adapt and grow to meet increasing demands from students and industry partners. We discuss the integration of CDIO principles into theFIRMA's operations, highlight key milestones, and reflect on the lessons learned from a decade of project-based industry-focused education.

## THE EVOLUTION OF THEFIRMA

### *Establishment and objectives*

TheFIRMA was established in 2015 by consolidating multiple learning environments within TUAS' ICT unit. Its primary goal was to provide students with hands-on learning opportunities by participating in real customer projects. TheFIRMA operates like a company, offering services such as web and app development, graphical design, and end-user training to small and medium-sized enterprises (SMEs) and other organizations (Säisä, Määttä, & Roslöf, 2017). More detailed case references are presented on theFIRMA website: <https://thefirma.fi/>. The establishment of theFIRMA combined the strengths of earlier learning environments

“Education Support Centre Finland,” “Network Support Centre Finland,” “ICT-portti,” and “Citizen’s Helpdesk” to create a unified, scalable, and student-driven learning environment. The integration of these learning environments aimed to streamline operations, establish consistent processes, and broaden the scope of activities, ensuring a more efficient and impactful learning platform for students (Säisä, Määttä, & Roslöf, 2017).

Aligned with CDIO Standards 6 (Engineering Learning Workspaces), 7 (Integrated Learning Experiences), and 8 (Active Learning), theFIRMA aims to: 1) Integrate interdisciplinary skills into project-based learning, 2) Foster collaboration between academia and industry, and 3) Equip students with personal and professional competencies essential for their careers.

### **Key Milestones**

#### *2015-2017: Establishing Operations*

The initial phase of theFIRMA focused on consolidating multiple learning environments to form a unified structure within the TUAS ICT unit. TheFIRMA operates as a student-led organization, with a student CEO overseeing operations, student project managers coordinating projects, and a student marketing manager handling promotional activities (Määttä, Roslöf & Säisä, 2018). In the beginning, a few dozen students were working in theFIRMA on yearly basis.

As the number of projects and students at theFIRMA grew, it became necessary to implement a more structured approach to manage the increasing activity. Beginning in the academic year 2016–2017, a course titled *ICT Services and Projects* was introduced to establish an organized framework for theFIRMA’s operations (Määttä, Roslöf & Säisä, 2018). Course was available as a free-choice course for all the ICT students. Course faced challenges, including a high dropout rate caused by students underestimating the course requirements, overestimating their time management skills, and being unprepared for the responsibility tied to customer projects, which led to staffing shortages, delays in internal development projects, and additional workload for both teaching staff and student project managers who had to handle the fallout from disappearing participants (Määttä, Roslöf & Säisä, 2018).

In 2016, theFIRMA competence track was launched as a pilot program, admitting approximately ten motivated students annually from information and communication technology and business information systems programs. Instead of traditional classroom learning, these students developed their skills by working on theFIRMA’s client projects.

Additionally, theFIRMA engaged in externally funded R&D projects, such as "SparkUp Portti" which provided opportunities to pilot and validate implemented project and learning processes while expanding its visibility among industry partners.

#### *2018-2020: Expanding Scope*

Building upon its foundation, theFIRMA shifted focus to broadening its operational scope and enhancing learning opportunities. In 2020, the official Software Engineering and Project Management (SEPM) competence track was introduced, with 32 students selected in its first year. Alongside project work, this track incorporated theoretical lessons and practical exercises to support skill development. The program quickly gained popularity, and after the first year, 65–79 motivated students with versatile and multicultural backgrounds have been admitted annually.

During this period, international collaboration efforts were also strengthened through cooperation with AGILE@SoC, a project-based learning environment established at Singapore Polytechnic in 2019 (Säisä et al. 2020). The partnership facilitated joint projects, enabling students to develop interdisciplinary and intercultural competencies while working on real-world assignments across institutions (Säisä et al. 2020).

During 2018–2020, several externally funded R&D projects were launched to address digitalization and sustainability challenges. Projects such as Inside the Box and Hot Potato focused on advancing the digitalization of SMEs. Additionally, TRY OUT! and Open DaaS concentrated on developing digital solutions to promote circular economy practices. These initiatives emphasized multidisciplinary collaboration, bringing together students and faculty from various fields to tackle complex challenges, foster innovation, and support teamwork-driven problem-solving.

### *2021-2025: Scaling Impact*

In the most recent phase, theFIRMA has prioritized enhancing quality, leveraging digitalization, and strengthening partnerships to ensure long-term impact. Quality improvements have focused on refining assessment tools, standardizing project workflows, and incorporating feedback mechanisms to optimize learning outcomes and project performance. Digitalization has played a central role in modernizing operations, including the implementation of advanced digital platforms for project management, communication, and performance tracking. These tools have improved efficiency, transparency, and collaboration in theFIRMA projects. Moving forward, this phase aims to reinforce these developments while maintaining adaptability to evolving industry needs.

In 2023–2024, theFIRMA collaborated with Open ICT, part of the University of Applied Sciences Utrecht in the Netherlands, to promote international project-based learning. As part of the partnership, projects were carried out simultaneously in both countries, enabling students to work across borders, exchange knowledge, and enhance their technical and teamwork skills through real-world assignments.

Between 2021 and 2025, theFIRMA has been involved in several R&D projects. Pelimo promoted multicultural education with a mobile game for schools. EntreFox supported 55+ entrepreneurs' well-being and skills. VERKKO offered business coaching for entrepreneurs in Southwest Finland. DigiReactor developed digital product development skills and built a digital product platform, and Digio advanced digital solutions for small businesses.

Currently, over 200 students participate in theFIRMA each year as part of their studies. Most of the students are from dedicated SEPM competence track, but some of the students are from other competence tracks of ICT unit of TUAS. They can choose tasks aligned with their interests, such as project management, web programming, app programming, testing, and UI/UX design. This flexible structure allows students to build personalized learning paths, enhance their skills, and smoothly transition into industry jobs after graduation.

## **CDIO IMPLEMENTATION IN THEFIRMA**

Bachelor of Engineering students have 240 ECTS degree program, where the curricula consist of 210 ECTS core competence studies and 30 ECTS optional studies. The core competence studies consist of 75 ECTS basic studies, 90 ECTS professional studies, 30 ECTS practical training and 15 ECTS bachelor thesis. Bachelor of Business Administration students have 210

ECTS degree program with otherwise similar structure, but with 60 ECTS professional studies instead of 90 ECTS. Basic studies of each degree program are the same for all in same degree program. Professional studies are dependent on the competence track that students choose at the end of their first year. Table 1 describes the professional studies of engineering students in Software Engineering and Project Management -competence track.

Table 1. Professional studies of engineering students in Software Engineering and Project Management -competence track

Module name	Course name	Scope	Timing
<b>Introduction to Software Engineering</b>	Introduction to ICT Projects	10 ECTS	2 <sup>nd</sup> year fall
	Introduction to Web Development	5 ECTS	
<b>Software Development</b>	Project Management	5 ECTS	2 <sup>nd</sup> year spring
	Object-Oriented Programming with Python	5 ECTS	
	Back-end Development	5 ECTS	
<b>Full Stack Development</b>	Software Engineering and Modelling	5 ECTS	3 <sup>rd</sup> year fall
	Advanced UI and UX design	5 ECTS	
	Front-end Development	5 ECTS	
<b>Project Skills and Entrepreneurship</b>	Innovation project	10 ECTS	3 <sup>rd</sup> year spring
	Statistics and Probability	5 ECTS	
<b>Software Business</b>	ICT Projects	10 ECTS	3 <sup>rd</sup> year spring
	Technical Sales	5 ECTS	
<b>Software Engineering Practices</b>	Mobile Application Development	5 ECTS	4 <sup>th</sup> year fall
	Advanced ICT Projects	10 ECTS	4 <sup>th</sup> year

During the Introduction to ICT Projects -course students complete 3 ECTS (81 hours) of project work and 7 ECTS of theory and assignments related to theory. During the ICT Projects -course students complete 4 ECTS (108 hours) of project work and 6 ECTS of theory and assignments related to theory. During the Advanced ICT Projects -course students complete 5 ECTS (135 hours) of project work and 5 ECTS of assignments. In addition to these courses, students can complete up to 30 ECTS of project work as internships, 30 ECTS of project work as optional studies and 15 ECTS as their thesis at theFIRMA. Thus, students can complete up to 87 ECTS by working in theFIRMA projects.

TheFIRMA operates throughout the year. In the beginning of academic year in September roughly 120-130 students participate theFIRMA projects. Half of the students are second year students just entering to the competence track and to theFIRMA. Half of the students are fourth year students, that have already done a lot of project work at theFIRMA. Students apply for three most interesting projects and fill in the application and skill profile in Project Gate, which is a custom-made in-house software done by theFIRMA for handling the projects and resources. Usually, project teams are composed in a way, that there are junior and senior level students in the same project. Thus, senior level students can mentor junior level students while they are learning new skills and technologies.

In the beginning of spring semester, fourth year students continue with the projects where they have been working in the fall semester or if the project is finished, they will apply to new projects. Second year students have finished their projects – or at least their part within the projects by the end of fall semester. Third year students start their course and apply to projects as well. New project groups are composed based on the student's applications.

Spring semester ends in the end of April. After that, students mainly do internships in theFIRMA. The application process follows the same structure than in any company. Students interested in doing internship at theFIRMA apply with application and CV. Student CEO and Vice CEO interview all the applicants and choose together with TUAS staff members suitable interns. Usually, students work full-time at theFIRMA from April to mid of August, completing one or two internships, each lasting 7 weeks.

TheFIRMA's project workflow is deeply rooted in the CDIO process, which encompasses conceiving, designing, implementing, and operating solutions for industry partners. This workflow begins with initial discussions to identify client needs and define project goals. Collaborative planning follows, involving students, TUAS staff members, and industry representatives to ensure a comprehensive project design. TheFIRMA sends an offer for the potential client that describes the project in detail, schedule and price. Once a project is initiated, students work in teams to execute their plans using project management methodologies suited to the project's scope, such as agile or waterfall approaches. Finally, the operational phase ensures the delivery of final solutions to the client, often accompanied by post-project support and evaluation.

This systematic approach is further reinforced by adherence to CDIO Standards. Integrated Curriculum ensures that projects are embedded into students' academic programs, allowing them to earn credits while gaining practical experience. Engineering Workspaces provide students with a professional environment conducive to teamwork and client interactions. Integrated Learning Experiences merge technical and interpersonal skills development, aligning with the demands of real-world engineering projects. Active Learning emphasizes student ownership of their educational journey through activities such as self-assessment, peer feedback, and direct client engagement. The impact of these implementations is significant. Students develop enhanced employability skills, often securing roles in local and

international companies. For industry partners, theFIRMA offers cost-effective solutions while creating opportunities to engage with and mentor emerging talent. Figure 1 presents part of theFIRMA staff and students in 2024.



Figure 10. TheFIRMA staff and students

## LESSONS LEARNED

Looking back, in the beginning there were a few dozen students working in theFIRMA. Nowadays, more than 200 students are working in theFIRMA on a yearly basis. Some might be working only 80 hours and others might be working several hundred hours. Once the students gain enough experience, they usually find jobs in the IT field. This is great because it aligns with the primary goal of theFIRMA. However, at the same time, it also presents a significant challenge in managing projects due to the constantly changing resources.

Students have a dedicated office, where they can cooperate in projects, ask for help when needed, hangout, network with fellow students, and do homework. The office space has become the heart of theFIRMA, aligning with CDIO standard 6, Engineering Learning Workspaces, which emphasizes the importance of a physical learning environment. However, students provided feedback that it was challenging to find common working times with peers from different cohorts. To address this, we allocated dedicated time slots in the schedules of students in the SEPM competence track. These designated time slots allow students to gather at theFIRMA's office and collaborate on their projects more effectively.

In addition, theFIRMA arranges several different kinds of events for the students. Bread and Games is arranged a few times per semester, during which students can freely play together with digital and board games. Tech-club is arranged twice a month. In this event, volunteering students teach peers about software, project management or technical topics that they have

learned and found useful in their project work. These events foster a sense of community among students, encouraging collaboration, knowledge sharing, and peer support, which are essential elements for maintaining an engaging and inclusive learning environment.

Standard 6 also emphasizes the importance of a digital learning environment that leverages digital technologies to enhance both the student learning experience and teaching effectiveness. While theFIRMA has made progress in developing its digital learning technologies, there remains room for further improvement to fully optimize these tools and support evolving educational needs. In previous years, students were applying to projects using Microsoft Forms. It became evident that theFIRMA needed more efficient way to handle the applications as the number of students – and applications – was rising. Starting from fall 2023, students apply for their three most interesting projects and fill in the application and skill profile using Project Gate, which is a custom-made in-house software developed by theFIRMA for handling the projects and resources.

Currently, students fill in self- and peer assessment forms in Microsoft Forms. Additionally, students return project working hours in Excel sheet on a weekly basis in theFIRMA Itslearning workspace. Handling the self- and peer assessments and weekly working hour submissions require a significant amount of manual work. To alleviate this problem, we are now developing Project Gate 2.0, which will automate the assessment processing and working hour tracking.

TheFIRMA applies CDIO standard 7: Integrated Learning Experiences by combining technical knowledge with personal and interpersonal skill development through real-world projects. Students work in multicultural teams to design and implement solutions while considering social, economic, and environmental impacts. Collaboration with industry partners ensures practical experience and supports professional growth. Curriculum design ensures that second-year students can build foundational skills through accessible learning experiences, while gradually progressing to more demanding projects alongside senior students – fostering peer learning and collaboration across cohorts and supporting individual study paths.

CDIO standard 8: Active Learning is being adopted to theFIRMA by incorporating experiential and hands-on learning methods through client-based projects. Students actively engage in problem-solving, designing, and implementing real-world solutions. This approach not only enhances personal and interpersonal skills but also fosters critical thinking, self-reflection, and lifelong learning habits. Regular feedback and collaboration further support students in applying their knowledge to new contexts and challenges.

TheFIRMA follows a structured project process applied to all projects. Each team prepares key documents, including a kickoff form, project plan, final report, and closing summary. Learning goals are set at the start and reflected upon at the end. For ongoing projects, a handover document replaces the final report to support continuity between teams. Students also complete self and peer assessments, while customer feedback is gathered during and after the project.

## **CONCLUSIONS AND FUTURE WORK**

As theFIRMA enters its second decade, it focusses on several key areas. These include expanding international collaborations to expose students to global engineering practices, enhancing digital tools for project management and assessment, and developing long-term partnerships with industry to co-create educational content and research opportunities.

TheFIRMA exemplifies how the CDIO framework can be effectively implemented to foster industry collaboration in engineering education. Over the past decade, theFIRMA has evolved into a vibrant learning environment that not only enriches student learning but also contributes to regional economic development. By combining hands-on projects with theoretical learning, it equips students with technical expertise and professional skills, ensuring their readiness for the workforce.

Looking forward, there is a need to further streamline digital workflows and improve automation in project management and student assessment processes. Plans for the development of Project Gate 2.0 aim to enhance data tracking, feedback collection, and resource allocation, supporting scalable growth and operational efficiency.

The leadership of theFIRMA has been rather light. TheFIRMA has two responsible teachers, student CEO, student vice CEO and QA team, that does the testing and auditing for the projects. Student CEO has been an active role from the beginning of launching theFIRMA and its usually one-year vacancy. Student CEO is typically in charge of handling the resources together with the teachers, meeting potential customers, drafting offers and other administrative work related to theFIRMA.

As the work of theFIRMA CEO has grown, the student vice CEO role was added five years ago. The student vice CEO oversees the Citizen's Helpdesk and assists the CEO where needed. From the fall of 2023 the Software Engineering and Project Management - competence track has had more than 200 students, significantly increasing the workload for both student CEO and student vice CEO. It has become evident that there is a need for more roles in theFIRMA management. Thus, the new role student Head of Operations (HOO) has been added. Student HOO is responsible for checking the weekly returned project working hours and for developing the quality process of theFIRMA in cooperation with TUAS staff members and theFIRMA QA team.

Additionally, strengthening ties with industry partners remains a priority to ensure projects remain relevant and aligned with current market needs. Efforts to introduce more advanced technologies and methodologies, such as AI-driven tools and data analytics platforms, will help theFIRMA maintain its competitive edge as a modern learning environment. Continued collaboration with SMEs is supported through active networking and outreach, aiming to build long-term, mutually beneficial partnerships.

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