25 YEARS WITH CDIO – A LINKÖPING PERSPECTIVE

Svante Gunnarsson

Department of Electrical Engineering, Linköping University

Helena Herbertsson

Department of Physics, Chemistry, and Biology, Linköping University

Annalena Kindgren

Deans Office, Faculty of Science and Engineering, Linköping University

ABSTRACT

The CDIO Initiative is a community of practice aiming at improving and developing engineering education via the CDIO framework. Starting with a project with four participating universities 25 years ago, the CDIO Initiative has developed into a network of universities from all over the world. The framework is based on the fundamental documents the CDIO Syllabus, which supports the process of defining **what** an education program should aim for in terms of knowledge and skills, and the CDIO Standards which help define **how** the education program should be designed and run to enable the students to reach the learning goals. The paper gives a summary of the development of the CDIO Initiative over the 25 years, with emphasis on the first years, followed by a description of the adoption of the CDIO framework at Linköping University (LiU). The CDIO framework offers a common language for questions related to education, and it is, to various extent, implemented in all education programs within the Faculty of Science and Engineering at LiU. The CDIO Syllabus has been extended to also cover education programs in, for example, natural sciences, and the extended document, denoted the LiTH Syllabus, is a key component in the system for quality assurance via the use of course and program matrices, respectively. Most programs include an Introduction to Engineering course plus design-implement experiences on several levels. The fact that the CDIO framework is tightly integrated into the education has several possible explanations. First, there has always been strong support on the management level for the use of the CDIO framework. Also, the way to organize the management of the education programs plays an important role, and in the program boards as well as in individual courses there is close collaboration with industry and other parts of society.

KEYWORDS

25 years of CDIO, program development, quality system, Standards: 1- 12

INTRODUCTION

In October 2025 it was 25 years since the first meeting withing the CDIO Initiative, or the CDIO Project as it was called during the first years, was arranged at LiU. Thirteen people from the four participating universities met to start forming the project and planning the work forward. From that initial meeting, the CDIO Project has developed into the worldwide network of the CDIO Initiative with participating institutions from all parts of the world. See (CDIO Initiative, 2026) for an updated presentation of the framework and the network. Since LiU was one of the four original partners and has been active within the network since the start, it gives reasons to summarize and reflect upon the development over this period. The paper has two main purposes, and the first one is to give a summary of the development of the CDIO Initiative during the first years, since such a summary hasn't been presented before. The second purpose is to give an overview of how the CDIO framework has affected the engineering education programs at LiU and discuss which lessons that can be learned from that.

25 YEARS OF THE CDIO INITIATIVE

Background and motivation

For a thorough presentation of the background and motivation of the CDIO see Chapter 1 of (Crawley *et.al.,* 2014). Also, Chapter 10 of the same reference gives an excellent historical development of engineering education in different parts of the world, and CDIO is placed in a historical context. The emphasis in this paper is on the 25 years since the first meeting, but there were, of course, contacts and collaborations between the participating partners long before that, and these links were essential for forming the team and the application for funding of the project. These aspects are not treated in this paper.

The first years

One engineering education program was selected at each of the participating institutions, and these programs were

- MIT: Aeronautical Engineering led by Ed Crawley
- KTH: Vehicular Engineering led by Sören Östlund
- Chalmers: Mechanical Engineering led by Johan Malmqvist
- LiU: Applied Physics and Electrical Engineering led by Karl-Fredrik Berggren

There were three meetings per year, and normally two of those were arranged in Sweden and one at MIT. In addition to the activities at the meetings, considerable work was carried out at each of the participating universities between the meetings thanks to external funding. The work was organized in five working groups

- Curriculum
- Teaching and learning
- Workspaces
- Assessment
- Students

The first four working groups were formed at the meeting in October 2000, and the student group, which was very valuable for the project, was formed at a somewhat later stage. The work between and at the meetings involved, among other things, the following activities

Syllabus survey

This involves asking a selected set of stakeholders about their expected proficiency of the graduates. See Chapter 3 of (Crawley *et.al.,* 2014).

Curriculum benchmarking

This involves various activities for clarifying how the courses in a program fit together, how the courses are run, and how the assessment is carried out. One example of a mapping of connections between courses is given in Box 4.1 in Chapter 4 in (Crawley *et.al*., 2014).

Curriculum and course development

The development of several new courses started, plus revisions of existing courses. Of extra importance were various versions of Introduction to Engineering, inspired by Standard 4 in the CDIO Standards, and design-implement experiences, implied by Standard 5. Examples from both categories can be found in (Crawley *et.al.,* 2014) and in publications that can be accessed via the Knowledge Library at the CDIO-website (CDIO Initiative, 2026).

Workspace development

Parallel to the development of design-implement experiences, the need for new workspaces was identified and thereby developed, and some examples are given in (Crawley *et.al.,* 2014).

Expansion and consolidation

After the initial years, the project gradually shifted over to a network of interested institutions. The intention is not to give a complete overview of the development of the network, which after some years started to be named the CDIO Initiative, but to point out some of the highlights:

- Among the first institutions to join the network one can mention DTU (Denmark), USNA (USA), Queens University (Northern Ireland), University of Pretoria (South Africa) and Singapore Polytechnic.
- One of the first meetings with participants from new institutions was in Vadstena, just outside Linköping, 2003.
- During the following years, many more institutions from all parts of the world joined the network
- The first meeting held outside Sweden or USA was at University of Pretoria, South Africa in 2005.
- The 1st International CDIO Conference was arranged in Kingston, Canada, 2005 and the 2nd conference in Linköping the year after.
- The first version of the CDIO book was published in 2007, and the second edition (Crawley *et.al*., 2014) was published in 2014.
- Contacts and collaborations with other organizations within engineering education were established, and, for example, at the SEFI conference in Ankara in 2005, there was an entire session with papers from the CDIO community.
- After some years the governance structure was revised, and the first election of co-directors and members at-large of the CDIO Council, according to the new procedure, was held during the conference at MIT in 2013.
- There are of course many other milestones and highlights to mention, but that is left for future work.

Fun fact

As mentioned, the first meeting in the CDIO Initiative was held in Linköping, but there is another interesting connection between Linköping and the CDIO Initiative. André Oscar Wallenberg, shown in Figure 1, was born and grew up in Linköping. After some years in the Navy, he moved to Stockholm and initiated the activities of the Wallenberg family within banking and industry. Since the CDIO Initiative was funded by the Wallenberg foundation during the first years, his change of career had an impact on the development of engineering education worldwide almost two hundred years later.

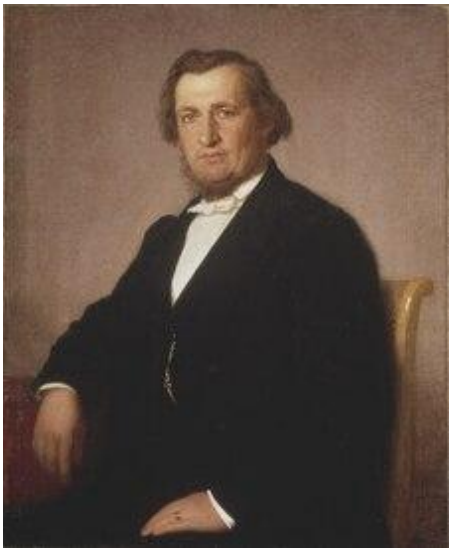

Figure 1. André Oscar Wallenberg. Born in Linköping, 1816.

25 YEARS OF CDIO WITHIN LINKÖPING UNIVERSITY

Overview

During the first years the efforts within LiU were concentrated on the Applied Physics and Electrical Engineering program. After some years the program management working with the Engineering Biology program saw a need to strengthen the engineering aspects of the program, see (Kindgren *et.al*, 2005), and in that process the CDIO framework was found very useful. For example, an Introduction to Engineering course was introduced, see Box 11.2 in (Crawley *et.al*, 2014). During the first years, the framework was also adopted within two of the three-year engineering programs, as reported in (Granath & Bjerner, 2005). Examples of the impact of the CDIO framework within Mechanical Engineering are given in (Hallberg, 2016, 2018). The CDIO framework was also found to be useful during the Bologna process via the focus on learning outcomes for programs and courses. One component in this process was the introduction of course matrices (previously denoted ITU-matrices), as reported in (Gunnarsson *et.al.,* 2007). A few years later, it was decided that all five-year engineering programs should have a Bachelor's project during the second semester of the third year of the program, and this led to several design-implement experiences being introduced. With this step, most of the five-year engineering programs included an Introduction to Engineering course in year one, and design-implement experiences in year three and year five, i.e. according to Standards 4 and 5. Another important activity is the extension of the CDIO Syllabus into the LiTH Syllabus and the tight integration of this document into the quality assurance system. In the following section, some of the key components of the implementation of the CDIO framework are presented in detail. However, it should be stressed that one of the most important outcomes is that the CDIO framework has given a common vision of education within the Faculty of Science and Engineering – a common terminology. Finally, the implementation and extensive use of the CDIO framework would probably not have happened without solid support from the top management, i.e. Dean and Board, of the Faculty of Science and Technology.

Introductory courses

Like within programs at other participating institutions, Introduction to Engineering courses was developed. The first one was developed for the program Applied Physics and Electrical Engineering, and it was given for the first time during the fall semester of 2002. See Box 4.4 in (Crawley, *et.al*, 2014). In addition to a series of lectures dealing with, e.g., group dynamics, oral and written communication, and the engineering role, the main part of the course is a project carried out in groups of six students. The course ends with a project conference where the students present their results in a conference-like format. Since the program has a wide scope, the project tasks range from Biomedical Engineering via Applied Physics to Automatic control. As mentioned above, similar courses were introduced in other programs, and one example of a project within Engineering Biology is given in (Wetterö, *et.al*., 2006).

Design-implement experiences

There were of course design-implement experiences within the engineering programs at LiU already before, but the CDIO Initiative meant a significant step in ambition and volume. A key step was the introduction of the design-implement experience in Electronics during the third year of the program Applied Physics and Electrical Engineering, which was introduced in 2002. The course became an immediate success and was highly appreciated by the students from the start. A thorough presentation of the course is given in (Svensson & Gunnarsson, 2012). As pointed out, in that paper the key success factors are clearly defined learning outcomes, a suitable and well-working organization of the course, suitable workspaces and equipment, and sufficiently challenging tasks. In addition to the course in Electronics, a set of almost ten different design-implement courses were developed or revised within the Applied Physics and Electrical Engineering program during the first years of the CDIO Initiative. The courses are connected to the specializations the students chose during the last part of the program. Examples of courses are presented in (Karlsson *et.al*, 2006) and (Larsson *et.al*, 2017). Nowadays, almost all programs include capstone courses connected to the specializations in the last years of the curriculum. It should be stressed that in the process of developing design-implement experiences, it was very valuable to have teachers with solid industrial experience involved.

LIPS project model

In the process of developing the design-implement experiences it was recommended by people with industrial experience to use some kind of project model in these courses. Therefore, the project model LIPS was developed and introduced. Detailed information about LIPS can be found via the web site (LIPS, 2026). The structure of LIPS is shown in Figure 2.

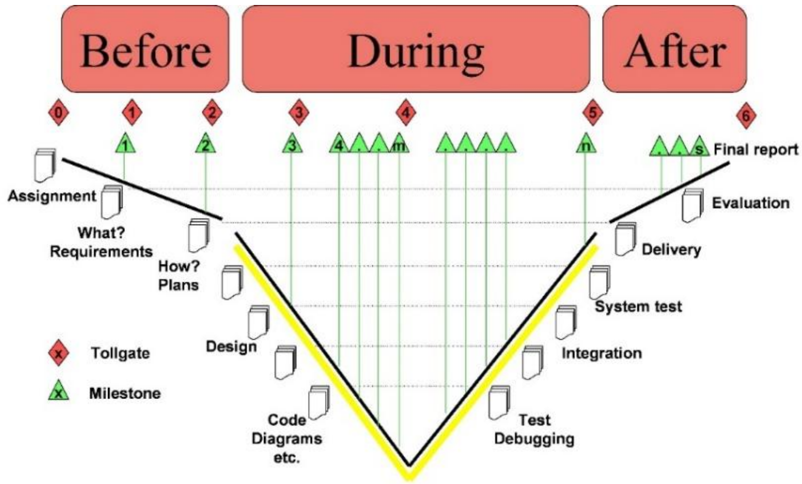

Figure 2. LIPS project model.

The project model provides a common structure for the work with suggested roles in the project teams, well defined decision points, and regular meetings for reporting and feedback. There are several other ways to manage development projects, like, e.g., agile methods, but LIPS provides a common language concerning the phases of the project and documentation. The model is flexible in the sense that, e.g., the amount of documentation can be chosen depending on the complexity of the task. One feature of using a project model with regular meetings between the project teams, the customer, and the supervisor is that it enables continuous assessment during the execution of the project. This is further elaborated in (Svensson & Gunnarsson, 2005). An important document in the LIPS model is the reflection document that is written at the end of the project. The purpose of this document is to give the student the opportunity to collect lessons learned from the project work. This involves technical issues as well as aspects related to the planning of the project and collaboration in the team. Also, the document gives feedback to the teacher responsible for the course, in addition to the regular course evaluation. Some observations from the use of reflection documents in project-based courses are given in (Gunnarsson *et.al.,* 2023). For example, the students point out that writing the document gives an opportunity to compare each other's impressions and opinions, and the document also marks the end of the project.

Reflection documents

The use of reflection documents in the project-based courses inspired the introduction of reflection documents as a mandatory part of the Master's or Bachelor's theses, giving the students one more opportunity for reflection, but also providing feedback to the program management about the contents and execution of the entire education program. Some initial experiences were presented in (Kindgren *et.al*, 2012). In 2023 a web-based system, Reflex, for managing the documents was introduced. Since all texts from the documents are stored in a searchable database, this enables systematic analysis of the reflections. The system Reflex and two case studies of how the contents of the documents can be analyzed and used for program development are given in (Gunnarsson *et.al*, 2025).

LiTH Syllabus

In addition to engineering programs, the Faculty of Science and Engineering offers Bachelor's and Master's programs in, for example, natural science subjects. To incorporate these programs into the system for program and quality management, a need to extend the CDIO Syllabus was identified. Since Section 4 of the CDIO Syllabus is based on a characterization of the role of the engineer, a corresponding description of the role of the graduates was proposed, and Section 5 of the Syllabus was introduced. This extension, together with some additional modification, led to what is called the LiTH Syllabus.

Dissemination within LiU

The CDIO framework has also been disseminated to other disciplines. For many years LiU had been offering Bachelor's and Master's programs in Biomedicine, but around 2017 it was found that revisions and updates were needed. Until then the intended role of the graduate had been within academia or health care, and one important part of the revision was to put a stronger emphasis on roles in the life science industry. Based on these needs, it was found that the CDIO framework could be a useful tool. Some examples of outcomes of adaptation and use of the CDIO framework in this new context are given in (Fahlgren, *et.al,* 2018, 2019).

Quality assurance system

The LiTH Syllabus and the CDIO Standards are important tools in the quality assurance system that is used at LiU, and this is described in some details in (Gunnarsson, *et.al*., 2019). The key component of the quality system is a report that is written every sixth year for each program and is based on a set of criteria, which are defined on university level, but based on the European Standards and Guidelines (ESG). One criterion is about fulfillment of the learning goals at a program level and for that the course and program matrices, which are based on the LiTH Syllabus, are crucial. Another criterion is about the execution of the program, and for that part the components of the CDIO Standards are vital.

Collaboration with Brazil

LiU has had privilege to collaborate with colleagues in Brazil and share experiences of the use of the CDIO framework. Presentations have been given for guests visiting LiU, but also on several occasions in Brazil, including at IME in Rio de Janeiro, ITA in Sao Jose dos Campos, and SENAI SIMATEC in Salvador. There have also been discussions with the working group dealing with the revision of the guidelines for engineering education in Brazil. During the fall and winter 2015/2016 two of the staff members from IME spent six months at LiU to learn more about engineering education at LiU and the use of the CDIO framework. This visit led to a joint plenary session at COBENGE 2016, which is the Brazilian national engineering education conference. Some results of the implementation of the CDIO framework at IME are presented in e.g. (Rezende, *et.al,* 2022). The paper points out how useful the CDIO framework has been in the process of adapting the engineering programs to the new guidelines. The collaboration with Brazil has continued with UFG in Goias as reported in, e.g., (Diaz & Gunnarsson, 2023).

REFLECTIONS

An obvious question to ask after 25 years with the CDIO framework is whether the engineering education within the Faculty of Science and Engineering has higher quality than it would have had without implementation of CDIO? It is of course impossible to give any certain answers to that question. Many things have changed in the surrounding world affecting the expectations of the industry concerning knowledge and skills of the graduates, the attitudes and expectations of the students, developments within engineering and science as well as general pedagogical approaches to teaching and learning practices.

Longitudinal study

During the first years a longitudinal study was carried out by Ellinor Stiwne and co-workers. The study followed two cohorts of students following the Applied Physics and Electrical Engineering program over several years using surveys and interviews. The data collected resulted in several conference papers and contributed to one PhD thesis. See (Jungert, 2009). One cohort of students carried out the studies before the changes implied by participation in the CDIO Initiative had been implemented, and one cohort of students followed the re-designed program. The survey gave strong indications that the students who had followed the re-designed program felt better prepared for professional life after graduation than the first cohort. More data is given in the reference mentioned above, but the overall impression from Stiwne's work is that the CDIO Initiative has had positive effects on the education program.

Engineering education program of the year - Årets Teknikutbildning

For some years, the association of Technology Industries of Sweden (Swe: Teknikföretagen) gave the award Engineering education program of the year (Swe: Årets Teknikutbildning), and 2007 it was given to the Applied Physics and Electrical Engineering program. In translated form, the justification of the award reads "The Applied Physics and Electrical Engineering program (Y) combines, in a successful way, deep and broad knowledge and gives a degree that is suitable for many different roles in industry. The CDIO framework and the experience of having worked in an industry-like project model LIPS give excellent understanding of the requirements in industry".

Contributing factors

As mentioned, it is not possible to "prove" the positive impact of the CDIO framework on the quality of the education programs within the Faculty of Science and Engineering, but since the framework has a strong position, it is worth pointing out some contributing factors behind this:

- There has always been solid support from top management, i.e. the Dean and the faculty management level, within the Faculty of Science and Engineering.
- The education programs are managed via Program Boards consisting of teachers, students, and representatives from industry, and there has always been strong support from industry concerning the fundamental ideas behind the CDIO framework.
- Within the Faculty of Science and Engineering, there is a long tradition of close interactions with industry and other parts of the surrounding society, and this is very valuable when it comes to finding suitable tasks for design-implement experiences.
- The development of the design-implement course in Electronics described above was led by a teacher who, in addition to being a brilliant teacher, had solid industrial experience. As mentioned, this course became an immediate success, and it served as an "early success" and a good example for others, which is very important in change processes.

Another thing that has been important is the systematic working method that has been built up. The development of the programs takes place according to an annual process that is known to everyone. It is crucial that all parties involved take responsibility for their parts, both at the Dean's office and at the different departments that the courses are commissioned from. So, when starting new educational programs, there is a basic idea to relate to, which facilitates the process. Not everyone needs to find their own solutions, since there is a structure that can be filled with different content.

CONCLUSIONS

The CDIO Initiative started 25 years ago, and it has grown from a project with four participating universities to a global network of institutions from all over the world. The paper has given a brief overview of the start and the development during initial years of the CDIO Initiative together with an overview of the impact of the CDIO framework within the education programs at the Faculty of Science and Engineering at LiU. The main lessons learned from these 25 years concerning the implementation of and use of the CDIO framework are strong and persistent support from the management level, a suitable organization for management of the education programs, including participation from students and representatives from industry, close contacts and interactions with industry and other parts of the surrounding society, and inspiring and well-designed learning activities. One of the key challenges for the future is the rapid development of artificial intelligence (AI) and the use of large language models (LLMs). This has a strong impact on both the goals for and the execution of engineering education. The starting point of the CDIO framework is the characterization of the role of an engineer (see page 50 of Crawley et.al, 2014), and a challenge for the future is to reformulate the role into an AI-supported one.

ACKNOWLEDGEMENTS

The authors wish to thank all teachers, staff members, and students who have contributed to the successful implementation of the CDIO framework over the past 25 years. The authors received no financial support for this work.

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BIOGRAPHICAL INFORMATION

Svante Gunnarsson is Professor in Automatic Control at Linköping University, Sweden. His research interests are modelling, system identification, and control in robotics. He is also the CDIO coordinator within the Faculty of Engineering and Science at Linköping University. He served as Chair of the Organizing Committee of the 2nd International CDIO Conference 2006.

Helena Herbertsson is Senior Lecturer in Chemistry and Assistant Dean at the Faculty of Science and Engineering at Linköping University, Sweden. As Assistant Dean she is primarily focused on education at undergraduate and Master level.

Annalena Kindgren is Head of Faculty Office within the Faculty of Science and Engineering. She has had various roles connected to the education programs at the Faculty of Science and Engineering and has had an active role in the implementation of the CDIO framework. She was also part of the Organizing Committee of the 2nd International CDIO Conference 2006.

Corresponding author

Svante Gunnarsson, Department of Electrical Engineering, Linköping University, 58183 Linköping, Sweden. Email: svante.gunnarsson@liu.se