REFLECTING ON REFLECTIONS – LEVERAGING STUDENT FEEDBACK FOR CONTINUOUS PROGRAM DEVELOPMENT

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ABSTRACT

A system, named Reflex, for handling reflection documents is presented. Writing a reflection document is a mandatory last step when carrying out Master's or Bachelor's theses within all education programs at the Faculty of Science and Engineering at Linköping University. In the reflection document the students are expected to reflect on both the thesis work and the outcome of the entire education program. The reflection is structured according to the four sections of the CDIO Syllabus plus additional aspects around the process of the thesis work and the program as a whole. Reflection documents have been used for more than ten years, but via the introduction of Reflex in 2023 the process is entirely electronic and all texts from the reflections are stored in a searchable database. This enables efficient and systematic analyses of the texts, which can be used for evaluations of entire programs as well as selected aspects. Two examples of such analyses are presented in the paper. In addition, the thesis work process is presented, together with a description of how the system Reflex works.

KEYWORDS

Reflection, thesis, program evaluation, CDIO Syllabus, Standards: 2, 11-12

INTRODUCTION

Reflections for learning and continuous development is a wide field, and the literature in the field is comprehensive. The aim of the paper is to present an example of such an activity in terms of a reflection that is carried out as a last step of the thesis work and how that can be used also for continuous development of education. In literature, the work in (Kolb, 1984) about experiential learning and Kolb's learning cycle is a key reference. According to (Kolb, 1984) the learning cycle consists of the stages (i) Concrete Experience, (ii) Reflective Observation, (iii) Abstract Conceptualization, and (iv) Active Experimentation. See also (Gibbs & Habeshaw,1989). Within the CDIO community there are several references where reflections in different forms have been studied, where (Junaid *et al.*, 2018) and (Cosgrove & O'Reilly, 2019) are two examples. In addition, (Cheah, 2022) presents an excellent overview of the field with an extensive list of references related to reflections. Also, in project-based activities reflection at the end of the project is often used as a last step. See, for example, (Andersen & Schwenke, 2013) and (Lööw, 2009).

There are many examples of the use of reflections within the courses at the Faculty of Science and Engineering at Linköping University. In many cases this takes place within project-based courses. The reflection document at the end of the Master's and Bachelor's thesis was introduced around 2011 as a mandatory last step of the thesis work in all education programs within the Faculty of Science and Engineering at Linköping University. One purpose of the reflection document is to make the student reflect upon the execution of the final major task before graduation, and a second purpose is to give feedback to the program management concerning how well the education program has prepared the student for the intended role as engineer. The reflection document is structured according to the four sections of the CDIO Syllabus. In addition, there is one section dealing with the thesis work process and a concluding section. For each section there are some guiding questions supporting the students when writing the reflection. The sections and the guiding questions are presented in the Appendix. During the spring semester of 2023 the new web-based system, named Reflex, was introduced. Reflex is based on a combination of various administrative systems, but the technical details will be omitted here. The main messages of the paper are the following:

- Reflex is a web-based system for management of the reflection documents that are written by all students as part of the thesis work.
- Reflex has solid connections to the CDIO framework via CDIO Standard 12 about program evaluation. In addition, the reflection document is based on the CDIO Syllabus.
- Since the reflection document is mandatory, this gives an evaluation system with 100% response rate.
- Reflex enables various types of analyses about the students' view of their thesis work and education program.

It should be stressed that the paper is not claimed to be a scientific contribution concerning student satisfaction or similar. Instead, it is intended to present the implementation of a system that systematically collects and stores students' reflections, is easy to use for both students and examiners and enables various types of analyses based on the collected data.

THE CDIO FRAMEWORK

The fundamental aim of the CDIO framework is to educate students who are "ready to engineer" and to raise the quality of engineering programs. See (Crawley *et al.*, 2014) and the web site (CDIO Initiative, 2024). The framework relies on four key components:

- A “definition” of the role of an engineer.
- Goals for the desired knowledge and skills of an engineer listed in the document the (CDIO Syllabus, 2024).
- Goals for the properties of the engineering education program collected in the document (CDIO Standards, 2024).
- Methods for systematic development and management of education programs.

According to the CDIO framework, see (Crawley *et al*., 2014) page 50, the goal of engineering education is that every graduating engineer should be able to *Conceive-Design-Implement-Operate complex value-added engineering products, processes, and systems in a modern, team-based environment.* Adopting this definition, it is natural to design and run an engineering education program with this in focus. The CDIO Syllabus is a list of the desired knowledge and skills of a graduated engineer, and the (CDIO Standards, 2024) is a set of twelve components that are crucial for designing and running an engineering program that enables the students to reach the desired knowledge and skills. Linköping University was one of the four original participants in the CDIO Initiative, and during the first years the efforts were concentrated on the Applied physics and electrical engineering program. Gradually the framework was applied within other engineering areas, such as Engineering biology and Mechanical engineering. The CDIO framework is nowadays in widespread use within the faculty of Science and Engineering at Linköping University and the CDIO Syllabus has been extended and adapted to enable programs in, e.g., natural sciences to be included. The framework has also been disseminated outside the technical faculty and has been applied successfully in the re-design of the Bachelor’s program in biomedicine.

MASTER’S THESIS WORK PROCESS

Reflex is used both at Bachelor and Master level, but the focus here will be on Master level, where the execution of the thesis work follows the structured process which is described below. This represents the process for the students following the five-year programs, where the thesis work is carried out during the spring semester of year five. The steps related to the reflection document and Reflex are presented in italics.

1. During the fall semester of year five the student starts looking for suitable tasks for the thesis work via discussions with e.g. suitable companies and potential examiners at the university. With the successful outcome of these discussions the student is assigned an examiner and a supervisor at the university and an industrial supervisor when the work is going to be carried out in industry.
2. In the next step the student registers for the thesis work in the administrative system Ladok.
3. *After the student has registered for the thesis work, Reflex automatically sends an email to the student asking the student to, via an included link, enter the name of the examiner and the specialization the student follows within the education program. Additional information related to the student is taken from Ladok.*
4. The first two to three weeks of the thesis work are spent on developing a planning report, which includes the problem formulation, an initial theory base with references, and a time plan for the work. The document is iterated until it is approved by the examiner, and the actual work can start.
5. After roughly ten weeks of work there is a mandatory half-time check where the student presents how the work has developed and how well it follows the time plan. Feedback is given from both the examiner and the supervisors.

6. *The nominal time for the thesis work within the five-year education programs is 20 weeks, and after 15 weeks from when the student registered Reflex automatically sends an email to the student stating that a reflection document is ready to be filled in together with a link to the web-based form.*
7. At the end, the thesis work is presented via a written report and a public oral presentation. The oral presentation is followed by a discussion (opposition) by another student, where the task is to discuss the work from a technical viewpoint and bring up e.g. assumptions and limitations for the work. After the oral presentation the student carries out the final revision of the report, which then, in most cases, is uploaded to the university database and by that is made publicly available.
8. *To be able to cover the entire thesis work the student typically fills in the reflection document as the very last step of the thesis work process. i.e. after both presentation and opposition.*
9. *Once the reflection document has been filled in, the system Reflex sends an email to the examiner stating that there is a reflection document to evaluate. The task for the examiner is not to evaluate the opinions of the student but rather to check whether the student has made a serious attempt to reflect upon the thesis work from different viewpoints. The examiner can either approve the document directly or ask for revisions, based on comments that are sent to the student. Also, when the document is approved the examiner can give some final comments to the student and, of course, reflect on the reflections if there is something in the working process that ought to be reconsidered.*

The first big advantage with Reflex is that the process is integrated into one system with several steps generated automatically and that no documents need to be sent back and forth. The second big advantage is that all texts are stored in a searchable database, and that the documents can be filtered according to, e.g., education program, specialization, and department. Two examples of analyses of reflection documents are presented below. The reflection document is mandatory but not anonymous, and parallel to the reflection document the student has the possibility to fill in a brief anonymous course evaluation regarding the degree project course.

USE CASES

To illustrate how the material collected in Reflex can be used, two use cases are presented. The use cases are taken from two of the biggest five-year engineering education programs at Linköping University. The purpose of the use cases is to illustrate how the text that are collected via Reflex can be analyzed, both manually and via AI-tools. The case studies are not meant to be research studies concerning student satisfaction, but that can be an interesting topic for future work.

Industrial Engineering and Management

The first case is from the five-year Industrial Engineering and Management engineering program, which annually admits approximately 180 students. In the fall of 2023, the program development team, consisting of teachers, supporting staff, and students, manually analyzed students' reflections on the program in general, collected under the concluding section. See the Appendix. Each team member read 10 randomly assigned reflections and made individual notes on what students highlighted in various areas. The team then reviewed these reflections as a group and compiled a collective thematic analysis. Here is a summary of the collective findings:

Contribution of the Thesis Work to Educational Goals

The students expressed high satisfaction with their thesis work, highlighting several key benefits:

- Increased responsibility due to less instructions
- Ability to structure and solve problems
- Collaboration
- Interaction with the industry – practical and academic knowledge tested on real-world problems at case companies
- Independent work
- Improved communication skills in presenting technical and scientific results, both orally and in writing.
- Analytical thinking

Sustainability Perspectives in Education

Opinions on sustainability integration are mixed:

- Some students appreciate the inclusion of sustainability but a lack of SDG (Sustainable Development Goals) in one of the relevant profiles
- Others feel the coverage is insufficient and superficial
- Social sustainability is notably lacking
- One sustainability dedicated course is recognized for its focus on sustainable development
- Some students perceive sustainability as being consistently integrated into all courses, while others believe it constitutes only a minor component of the overall education

Suggested Improvements

- Reconsider the use of ADA as a programming language
- Balance technical and economic credits, with more flexibility in technical courses
- Increase the use of English in coursework
- Strengthen industry connections and practical applications
- Distribute mathematics courses more evenly
- Technical focus in applied mathematics.
- Offer a technical track in applied mathematics

Preparedness for Working Life

Students unanimously feel well-prepared for their careers and are satisfied with their education.

The team also explored the utility of Chat-GPT in compiling the raw data. While the AI-generated results exhibited partial alignment with the team's conclusions, the analysis was not deemed entirely accurate. Nevertheless, the team derived numerous new insights from the non-AI revision and confirmations pertinent to the development work for program enhancements. The students also underscore the significance of having their reflections read by their teachers rather than an AI tool to keep motivation and the feeling of meaningfulness for the task. They articulated a preference for a "real" recipient of their thoughts and opinions. The Reflex system has facilitated the team's engagement with students' reflections on the design and content of the programs in a straightforward and comprehensible manner. Hence, the team will continue utilizing Reflex for development purposes and during this year's revision, the team will review another section of the reflection documents to assess the progress of skills.

Mechanical Engineering

The second case study examines reflection documents written by students enrolled in the five-year engineering program in Mechanical Engineering, which admits approximately 120 students annually, and the Mechanical Engineering Master's program, which admits around 30 students each year. During the same period as the first case, in the fall of 2023, the program development team for the Mechanical Engineering programs conducted an analysis of four key questions related to the thesis process namely: (1) How has the complete process of completing the degree project within Linköping University worked? (2) A degree project is to correspond to 20 weeks of full-time work. How well does 20 weeks of full-time work correspond to the time you have used? (3) What aspect of your Master thesis gives you the greatest satisfaction, considering both the result and the execution? (4) What would you do differently, given the opportunity to repeat the degree project? Based on these, the questions guiding the team's analysis of the students' reflections were:

1. What are the students' perceptions of the thesis process, and what areas for improvement can be identified?

2. Can analytical tools be utilized to facilitate the review process, and if so, which tool and how should it be applied?

Early in the process, it became clear that manually reading all the reflection documents in full each year for every program managed by the team would be too time-consuming. As a result, a parallel question emerged regarding the potential use of tools to streamline the analysis (see question 2 above). One team member conducted the analysis using three approaches: manually, with the aid of NVivo14 — a qualitative analysis software commonly used in research — and automatically, using Kahubi and ChatGPT, both of which are AI-assisted tools. The results of the automated analyses were compared with the manual method to evaluate their accuracy and alignment, to determine whether these tools could be employed for systematic analysis in future evaluations.

The analysis revealed that students are generally very satisfied with the thesis process, and no significant systematic issues were identified in either of the two programs. The challenges raised were primarily specific cases, such as instances where supervision had not worked effectively or where the assignment from or interaction with the company had been problematic. Through the students' reflections on what they found challenging, issues such as time management and method selection were identified. The team recognized that this information is valuable to share with those supervising the students. In this way, the results of the analysis not only benefit the program development team but also provide actionable insights for the instructors involved. Since no major areas for improvement or systemic problems were identified, the team concluded that this serves as a solid baseline for future analyses. This baseline will enable comparisons over time to monitor if conditions worsen or remain stable.

Following the analysis, ChatGPT was deemed the most suitable tool for facilitating the analytical work compared to NVivo14 and Kahubi. However, it became evident that crafting an effective prompt is crucial, particularly one capable of capturing outliers, such as cases where the process had not functioned well. This is important because ChatGPT generated general conclusions tending to be overly positive when most responses are positive. To address this limitation, the team emphasized the importance of complementing the AI analysis with random sampling and a thorough review of selected reflection documents to ensure a more balanced and reliable assessment. During team discussions, it was noted that the Reflex system significantly simplified the process of collecting all reflection documents in a centralized location, making them accessible to a wider range of stakeholders. Additionally, Reflex facilitated the aggregation and extraction of information specific to individual programs, enabling systematic analysis of how each program's students perceive the thesis process. This integration of tools and methods has enhanced the team's capacity to identify trends and areas for improvement in a structured and efficient manner.

SUMMARY

Writing a reflection document is a mandatory last step in all Master's and Bachelor's theses within the Faculty of Science and Engineering at Linköping University. A web-based system, named Reflex, for managing reflection documents has been presented. Reflex has solid connections to the CDIO framework via CDIO Standard 12 about program evaluation. In addition, the reflection document is based on the CDIO Syllabus. Since the reflection document is a mandatory part of the thesis work, this gives a 100% response rate. The system enables various types of analyses about the students' view of their thesis work and education program, and two case studies have been presented. In the case studies both manual analysis and analysis using AI-tools have been used.

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BIOGRAPHICAL INFORMATION

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APPENDIX

The significance of knowledge of the subject for the execution of the degree project

To what extent has the knowledge of the subject you have gained during the courses given in the programme been sufficient for the execution of the degree project?

What new knowledge has it been necessary to acquire in order to carry out the degree project?

To what extent have the degree project and the study programme enabled a scientific approach in the degree project?

The significance of your personal and professional skills and the approach you have taken for the execution of the degree project

To what extent have the courses given in the programme given you the ability to solve problems and take the initiative? To what extent have they given you the ability to take responsibility as required by the degree project?

To what extent have the courses given in the programme given you the ability to make the ethical assessments within engineering that the degree project required?

To what extent has the work involved experimentation, simulation, testing, and other investigative activities?

What resources have you used to find the literature required to carry out the work?

How much time did you devote to planning the work, and how did the planning help you in the execution of the degree project? How much did the planning report and the mid-way review help you in the execution?

The significance of working in a group and communication during the degree project

If the degree project has been carried out together with another student, how has the work been divided between you, and how has collaboration worked?

To what degree has the work been carried out independently of the supervisor and examiner?

What has been easiest and what has been most challenging when writing the report from the degree project, and when preparing and giving the oral presentation?

To what extent have your language skills (in English or another language) been sufficient?

To what extent have the courses of the programme given you the knowledge and skills necessary to examine and comment on the work of someone else, in the role of opponent?

The degree project from an engineer's perspective – planning, development, realisation and operation of technical systems, taking into account commercial and societal needs and demands

To what extent has it been natural for you to place the degree project into a commercial and societal context, including environmental and other aspects of sustainability?

Can your degree project be seen as part of the development of products, processes or systems? If so, in what way?

The degree project process

How has the complete process of completing the degree project within LiU worked? Consider the steps of finding a topic for the degree project, having an examiner and supervisor at LiU assigned to the degree project, writing the planning report and holding the mid-way review, submission and opposition.

A degree project is to correspond to 10 - 20 weeks of full-time work. How well does this correspond to the time you have used?

What aspect of your degree project gives you the greatest satisfaction, considering both the result and the execution?

What would you do differently, given the opportunity to repeat the degree project?

Summary

In what way has the degree project contributed to satisfying the learning objectives of the study programme?

How has sustainability been addressed in your education?

If you have any suggestions about how the study programme can be improved, please describe these.

To what extent do you feel ready to embark on a career?