Implementing and assessing soft skills in the engineering curriculum

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ABSTRACT

This paper addresses the crucial need for engineering students to acquire both soft and hard skills for a successful career. While technical skills are essential, soft skills like communication, collaboration, problem-solving, leadership, and adaptability are equally vital. Traditional engineering education programs often neglect soft skill development, leaving students without structured guidance. This paper presents a strategic curriculum approach within an Industrial Design Engineering program that emphasises progressive skill development. It includes a competence profile and continuous self-assessment to encourage student reflection and growth. Additionally, a transformative process is introduced in a third-year capstone project, helping students identify and actively improve personal and interpersonal skills. The results underscore the importance of systematic soft skill development through reflective practice and assessment, offering valuable insights for engineering education.

KEYWORDS

Competency development, curriculum enhancement, skill progression, personal development, engineering education.

INTRODUCTION

For engineering students, having both soft and hard skills is essential for a successful career. Skills that are used to solve a specific task or situation are called hard skills (math, engineering, sketching, etc). Rovida and Zafferi (2022) describe Soft skills as a set of non-technical competencies that are typically not taught in traditional classroom settings but are essential for success in various professional settings. There is no absolute list of soft skills, and researchers describe them differently (Caeiro-Rodríguez, et al., 2021). Typically, soft skills include communication, collaboration, problem-solving, critical thinking, leadership, teamwork, adaptability, time management, and interpersonal skills.

Rovida and Zafferri (2022) distinguish them into four areas *personal traits, methodological* (way of working), *social*, and *organisational*. See

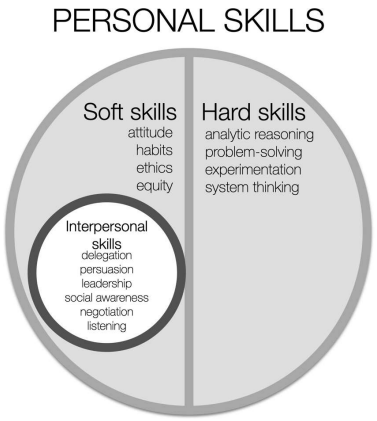
Table 1. Classification of soft skills according to (Rovida & Zafferi, 2022)

Personal	Methodological	Social	Organisational
Flexibility Responsibility Professionalism Learning to learn Problem-solving Digital thinking Planning Result orientation Personal branding	Imagination and creativity Talent development	Communication/ information Teamwork Human aspects of technology Positivity Work ethic and integrity Empathy Engagement Leadership	Interpersonal relationship Courtesy Awareness

Caeiro-Rodríguez, et al (2021) identified 18 fundamental characteristics or abilities that were grouped into five categories: *Technical skills*, *Metacognitive skills*, *Intrapersonal skills* (attitude), *Interpersonal skills* (teamwork and communication) and *problem-solving skills*. The frameworks described above are also similar to the 21st-century skills that are divided into three areas: *Learning skills* (including critical thinking, creativity and collaboration), *literacy skills* and finally, *Life skills* (leadership, taking initiative, being productive and having social skills). Other frameworks, like the *16 Habits of Mind* (Costa & Kallick, 2000) – focus on ways of thinking valuable for success in learning and life.

Another well-known concept in engineering education is CDIO (CDIO, 2023). In CDIO, the CDIO syllabus offers universal goals for engineering education. In CDIO, a skill refers to an ability to perform an activity in a given amount of time and energy.

In CDIO, personal hard skills include analytic reasoning, problem-solving, experimentation, and system thinking. Soft skills are skills that aid a person in interacting with others. In CDIO, soft skills are, for example, attitudes, habits, ethics, and equity. Interpersonal skills refer to the abilities of a person to communicate effectively with others and, hence, are often considered part of the soft skills category. Interpersonal skills in CDIO include teamwork and communication, delegation, persuasion, leadership, listening, negotiation, attitude, and social awareness (see Figure 1.



CDIO Syllabus 3.0

2 personal and professional skills and attributes
- 2.1 analytic reasoning and problem solving
- 2.2 experimentation, investigation and knowledge discovery
- 2.3 system thinking
- 2.4 attitudes, thought and learning
- 2.5 ethics, equity and other responsibilities

3 interpersonal skills: collaboration, teamwork and communication
- 3.1 teamwork and collaboration
- 3.2 communications
- 3.3 communications in foreign languages

Figure 1 Mapping of CDIO syllabus into Soft, Hard, and Interpersonal skills.

Importance of soft skills

Soft skills are essential for developing a shared understanding of the design problem and for generating creative solutions that meet the needs of stakeholders. On the other hand, hard skills are technical skills specific to a particular job or industry, such as programming languages, CAD software, engineering principles, and mathematical analysis. Hard skills will help them understand and solve technical problems, while soft skills will help students work effectively with others and navigate the complexities of the workplace.

Teaching soft skills

Despite this growing interest in introducing soft skills in the curricula, there is no common understanding about essential skills or how to teach or assess them (Caeiro-Rodríguez, et al., 2021). Many traditional engineering education programs often focus primarily on technical skills, neglecting the development of soft skills, and students rarely feel that they work with the development of soft skills in a structured way during their education. In a survey of more than 11000 students at Swedish universities in 2007, students' experiences of support for professional development were disappointing, and 90% of students perceived that they rarely discuss their individual development with teachers (Högskoleverket, 2007).

Soft skills are difficult to teach to larger groups through traditional lecturing (Pulko & Parikh, 2003). It is also generally accepted that soft skills cannot be learned passively, and students need to adopt an active role where they can experience their capabilities, strengths, and weaknesses in relation to soft skills (Caeiro-Rodríguez, et al., 2021).

Several authors suggest that soft skills can be developed through problem-based learning and design thinking projects. In CDIO *Design implement experiences* and *Integrated learning experiences* are fundamental concepts used in developing and evaluating programs. Here, Design-implement experiences are used to create a deeper conceptual understanding of disciplinary skills and appreciation of ethical and sustainability aspects. Integrated learning experiences lead to the acquisition of disciplinary knowledge and personal and interpersonal skills (CDIO, 2023).

In design projects, students are encouraged to work in teams and learn to communicate effectively, collaborate, and develop leadership skills. Often, this part is not supported by the course curriculum, sometimes even without lectures, feedback and support and is often regarded as something you just learn through experience. In a paper that reviews the promotion and teaching of soft skills in Higher Education across 5 European countries, Caeiro-Rodríguez, et al. (2021) write, *"Many times, soft skills are included through the whole curriculum, but not in any specific subject or module. Curricula usually show several courses where some soft skills are trained and assessed, despite in many cases there is not a clear definition about how it is done."*

This paper presents the development of a strategic approach used in the curriculum to ensure the development and assessment of soft skills throughout an Industrial design engineering program and gives practical examples used in specific courses.

IMPLEMENTATION

When developing a program, it is crucial to have a holistic view, break down the program's overall goals, create courses that build on each other, and create systematic progression throughout the program. Courses should complement each other, and there should be an incentive and support for students to develop their knowledge and skills in a self-regulated way.

Supporting soft skills development and progression in the curriculum

To support the development of progression in the curriculum, a competence profile (Wikberg-Nilsson & Törlind, 2016) has been created for the Industrial design engineering (IDE) program to function as a framework supporting both students' and teachers' understanding of what competencies they need to build to work as an Industrial Design Engineer. The competence profile includes both hard skills and soft skills. When developing the curriculum, it is important to identify where soft skills should be developed, how to ensure progression in the program and how to support and assess soft skills. In the implementation, students continuously evaluate their progress in different areas by continuous self-assessment against a competence profile. This approach encourages students to reflect on their learning and the development of these skills. For the complete curriculum program, 16 Habits of Minds (Costa & Kallick, 2000) is used, where students reflect and assess their abilities in the different habits throughout the programme.

Supporting personal development of soft skills in a capstone course

To support students in developing soft skills, a process was developed and implemented in a third-year capstone project for bachelor students in 2018 and has been improved during the last five years (Törlind & Eklöf, 2021). Parallel to the design project, students had to identify personal or interpersonal skills they wanted to develop during the course. Through peer feedback, coach meetings and peer discussions, students created a development plan and worked with it throughout the course. Often, soft skills relate to personal traits and habits that can be hard to change. It was apparent from the results that old habits could be changed quite fast when students recognised them and created an action plan. Results highlight that students like to be challenged to change their professional conduct. They get support from teachers and other students and have to force themselves to work with something that negatively impacts their usual way.

The results from both the implementation on the program level and the experience of enhancing the development of soft skills in courses highlight the importance of reflective practice, systematic and continuous assessment, and a strategic progression of soft skill development throughout the program.

CONCLUSION

Developing soft skills is vital for engineering students. In this implementation, we identified a lack of systematic soft skills development and described how we implement soft skills development in the Industrial Design engineering program. We have also developed a process for systematic personal development. The result from the implementation of soft skills and the approach of working and supporting students' professional conduct is appreciated. From the feedback, we can also see that students

believe their teamwork has improved (allowing discussion of personal issues). In the end, we got happy students, better teamwork, and empowered students.

ACKNOWLEDGEMENTS

I wish to acknowledge Lars Eklöf for supporting and co-developing the personal development approach we have implemented in the D0045 course over the last six years. I also want to thank the teaching team for IDE for all the ideas and the possibility to continuously develop and improve the IDE programme.

REFERENCES

Caeiro-Rodríguez, M., Manso-Vázquez , M., Mikic-Fonte, F. A., Llamas-Nistal, M., Fernández- Iglesias, M. J., Tsalapatas, H., . . . Tolstrup Sørensen, L. (2021). Teaching soft skills in engineering education: An European perspective. *IEEE Access*, pp. 29222-29242.

CDIO. (2023). *CDIO*. Retrieved from www.cdio.org

CDIO. (2023). *Standards 3.0.* Retrieved from http://www.cdio.org/content/cdio-standards-30 Costa, A. L., & Kallick, B. (2000). *Describing 16 habits of mind. Habits of Mind: A developmental series.* Alexandria, VA.

Högskoleverket. (2007). *Studentspegeln, Högskoleverkets rapportserie 2007:20 R.* Högskoleverket.

Pulko, S. H., & Parikh, S. (2003). Teaching 'soft' skills to engineers. *International Journal of Electrical Engineering Education, 40*(4), 243-254.

Rovida, E., & Zafferi, G. (2022). *The importance of soft skills in engineering and engineering education.* New York: Springer.

Törlind, P., & Eklöf, L. (2021). Strategic development of personal and interpersonal skills. *E&PDE Conference.* Herning, Denmark.

Wikberg-Nilsson, Å., & Törlind, P. (2016). Student Competence Profiles: a complementary or competitive approach to CDIO. *Proceedings of the 12th International CDIO Conference.* CDIO.

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