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Applied engineering education for soft skills in the context of sustainability and mobility

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Abstract

Purpose – The purpose of this paper is to address the need to rethink the traditional approach to education in the university engineering curriculum. The paper examines two engineering projects led by university students in Sweden: the design and construction of a solar-powered car taking part in the Bridgestone World Solar Challenge and the creation of a business model for the ownership phase of an electric car together with Polestar.

Design/methodology/approach – An extensive literature review was conducted. Students were interviewed and surveyed on their impressions of their learning experience in the two projects and student logbooks reviewed. Problem-based learning (PBL), the Conceiving, Designing, Implementing and Operating approach and the ABCD procedure are used. Results are compared to theories from the literature.

Findings – PBL in real-world settings can increase engineering students' technical knowledge and improve their technical skills as they solve complex problems or propose solutions to such problems. Such projects also strengthen students' commitment, self-confidence and self-esteem as well as promote co-operation and creativity. These are soft skills largely absent from traditional engineering education.

Practical implications – Innovative, student-led learning in the applied engineering curriculum can foster students' soft skills in ways that teacher-led, lecture-style learning does not.

Originality/value – This research offers a timely perspective on an issue of current interest in engineering education: student-led learning versus teacher-led learning. The paper also provides two illustrative student-led projects that focus on sustainability and mobility.

Keywords Sustainability, Mobility, Learning models, Soft skills, Engineering education, Student-led learning, Project-based learning

Paper type Research paper

Introduction

Existential global challenges are currently much discussed by practitioners and politicians and much studied by researchers and educators. In the area of transport transformation, which is in focus in this paper, one such challenge is the demand for a transition toward greater sustainability and greater mobility. For example, the call is for the transport industry to aim for zero-emission sustainability and mobility. According to the European Commission (2020), in its vision statement for a green and digital transportation transformation strategy, "Greening mobility must be the new licence for the transport sector to grow". Laszlo *et al.* (2014) even advance the argument with the claim that sustainability is not enough; they argue that businesses must "flourish" as if life will exist on earth forever.

Some of this conversation and research pertains to the 17 sustainable development goals – including energy, infrastructure, innovation, economic growth and quality education – that the United Nations (2015) has adopted. These goals provide organizations, institutions and others with enormous opportunities to contribute to positive social change (Bansal *et al.*, 2019).

Research published before and after the UN's adoption of quality education as a sustainable development goal reflects an interest in how higher education, in particular engineering education, might achieve these goals. For example, Anderson *et al.* (2017) advocate moving beyond "instrumental-solutions teaching" to conceptualized teaching as a "societally valuable intervention". Lindgreen *et al.* (2021) describe the demand for research that has "societal relevance" and "societal impact". Crawley *et al.* (2007) and Lehmann *et al.* (2008) call for changes in the engineering curriculum that would better prepare students for the complex and intertwined economic, social and environmental aspects of working life. Cukierman and Palmieri (2014) argue engineers should have the abilities needed to solve "complex technical challenges, working in interdisciplinary teams and dealing with social and cultural issues". They and other researchers (Chamorro-Premuzic *et al.*, 2010; Rodriguez *et al.*, 2021) refer to these abilities as "soft skills".

Most engineering programmes today focus narrowly on the technical skills (i.e. the hard skills). These skills include, for instance, computer, analytical and logistics skills. Cosgrove and O'Reilly (2020) argue, however, that the epistemology for engineering education should better integrate theory, practice and reflexivity. According to Crawley *et al.* (2007, p. 1), rethinking is needed in engineering education:

> The purpose of engineering education is to provide the learning required by students to become successful engineers – technical expertise, social awareness, and a bias towards innovation.

Lehmann *et al.* (2008, p. 284) write that present and future engineers must be able to [. . .] analyse, develop, create and form part of cognitive and social interrelations among human beings, with the aim of facilitating the development of technology and analysing its positive and negative impacts on society.

Guerra (2017) and Mulder *et al.* (2012) have also addressed the need for change in engineering education. They call for training in critical, holistic and systemic thinking applied to real-life situations. Holmberg *et al.* (2012) describe a project on Education for Sustainable Development at Chalmers University of Technology in Sweden that aimed to improve the quality of the required courses on sustainable development. The goal of the project was to identify cross-disciplinary, long-term solutions through the creation of a neutral arena/organization and bottom-up, individual engagement.

Researchers who study higher education, however, disagree on how to address this change in practice (Rodriguez *et al.*, 2021). Various learning models have been developed in recent decades such as, for example, problem-based learning (PBL), Experiential Learning (ExL) and the Conceiving, Designing, Implementing and Operating (CDIO) approach that focuses on all phases of a product, process or system lifecycle. In a review of 299 research articles on engineering education published in *The European Journal of Engineering Education* (between 2017 and 2021), Svensson (2021) found that 81articles mentioned "problem-based learning", "project-based learning" or "active learning". In a literature review of project-based learning, Kokotsaki *et al.* (2016) found that students think solving practical problems is challenging and engaging. Nevertheless, there is limited understanding of how such learning models can teach engineering students to solve the so-called wicked problems related to sustainability and mobility. Nor is it clear how to organize learning settings suitable for such instruction (Guerra, 2017).

Research question

The authors agree that engineering education requires greater emphasis on teaching the soft skills needed to meet the goals of transportation, sustainability and mobility. Therefore, this research addresses the following question:

RQ1. What is the relationship between engineering students' engagement and motivation in applied projects and the development of the soft skills needed to advance sustainability and mobility thinking?

Theoretical background

The literature on learning approaches and models in education is extensive. Some researchers take a general perspective while others focus on a specific area or issue. Kurucz *et al.* (2014) and Olsson and Gericke (2016) studied sustainability in management education and adolescent education, respectively. Harms (2015) examined entrepreneurship education while Gremler *et al.* (2000) studied experiential learning exercises in business school marketing courses. Barr *et al.* (2009) described lessons learned from the commercialization of technology that influenced their improvement experiments in pedagogy.

Other researchers have focused specifically on the learning approaches and models used in engineering courses and programmes. For example, in their experiment conducted with 52 engineering students, Ostuzzi and Hoveskog (2020) researched the use of a framework for peer-assessed distance learning. Rampasso *et al.* (2018) used an action research experience to promote students' understanding of social and environmental aspects of operations management in a mechanical engineering course. While no single approach or model seems to link these research studies, they often use the same words and terms, directly or indirectly associated with the soft skills such as teamwork, inter- or multi-disciplinary, hands-on, sustainable and communication.

Two topics from this literature on engineering education are of particular interest: applied engineering education and soft skills in engineering education.

Applied engineering education

Traditionally, higher education has featured teacher-led instruction that is viewed as the most economical way to teach large numbers of students (Behr, 1988). Nevertheless, student-led learning exists in which students work with some degree of independence. Bachelor exam projects, Master/PhD thesis research and applied projects in practice are examples. Several learning models, as described in the Introduction, promote this form of active learning by students that is based in theories, for instance, on ExL (Kolb, 1984), the reflective practitioner (Schön, 1983) and especially on PBL (De Graaf and Kolmos, 2003). The benefit of the PBL approach is that students engage more with their problem-solving learning than they do with their lecture instruction. De Graaf and Kolmos (2003, p. 658), who studied PBL in engineering education, state:

> Usually, the problems are based on real-life problems which have been selected and edited to meet educational objectives and criteria. However, it could be a hypothetical problem. It is crucial that the problem serves as the basis for the learning process because this determines the direction of the learning process and places emphasis on the formulation of a question rather than on the answer.

Figure 1 visualizes how applied student-led learning projects can adapt to a university context by complementing the more theoretical and teacher-led model.

The pedagogical support for applied student-led projects has developed over many years. Two studies are exemplary. In a large meta-study, Freeman *et al.* (2014) analysed 225 articles that measured student performance in science, engineering and mathematics by comparing the effectiveness of active learning with lecture instruction. They found that "students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning" (p. 8410). In an engineering education investigation, Rodriguez *et al.* (2021) found that more active and applied teaching methods explain the increased motivation and learning outcomes among students.

Soft skills in engineering education

Despite many scholars' and other commentators' consensus that engineering education requires "rethinking" (Crawley *et al.*, 2007), with more instruction in the soft skills, it is not clear how best to develop and organize that instruction (Cinque, 2016; Schulz, 2008). It is not even clear which of the soft skills should be taught. For example, the World Economic Forum (2020) described the complexity of "jobs reset" in its report that identified such varied skills as critical thinking, problem-solving, resilience, stress tolerance and flexibility as among the top skills employees will need in the future. As a possible organizing scheme, Table 1 presents the authors' framework of five categories of soft skills as derived from four papers in the soft skills engineering literature.

The five soft skills in this framework correlate with the competencies needed in sustainable education that Wiek *et al.* (2011) identified in their comprehensive literature review of 43 documents (28 journal articles and books and 15 reports and white papers). Another possible soft skill, although not identified in the four papers, is systems thinking. The authors of this paper suggest systems thinking is also a soft skill. Systems thinking allows people to look at entities rather than as disconnected parts. In its "One Planet Framework" that deals with engineering education, The Lemelson Foundation (2020, p. 10) observed:

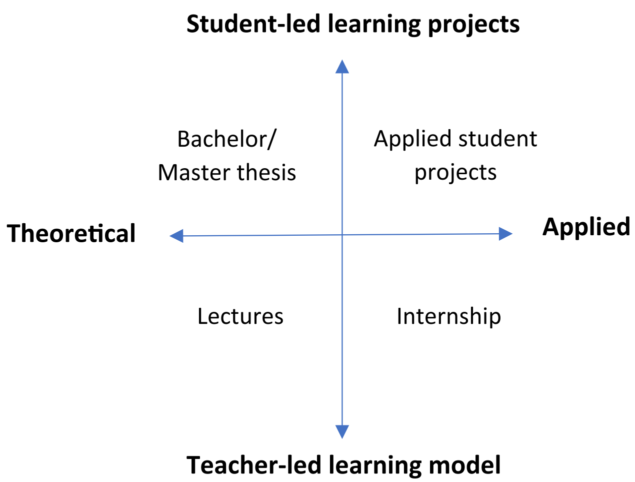

Figure 1.
Applied student-led projects in the university context

Table 1.
Soft skills as described in previous research

Soft skills	Shakir (2009)	Chamorro-Premuzic *et al.* (2010)	Rodriguez *et al.* (2021)	Cinque (2016)
1. Creativity	Critical thinking and problem-solving skills	Critical thinking; attention to detail, planning and organizing skills	Problem solving skills – time and project creativity and management	Content-reliant/ methodological skills such as continuous improvement and management skills
2. Co-operation	Teamwork, leadership skills communication skills	Team skills, communication skills; interpersonal and emotional intelligence	Interpersonal skills – social interaction, empathy and leadership	Social skills (i.e. communication, teamwork and leadership)
3. Self-confidence	Life-long learning and information management skills	Self-management; insight maturity	Intrapersonal skills; self-direction and the ability to prioritize	Personal skills (i.e. learning skills, tolerance for stress and creativity/ innovation)
4. Commitment	Entrepreneurship skills	The ability to work under pressure; willingness to learn; imagination/ creativity and initiative	Meta-cognitive skills – willingness to learn, critical/ analytical and innovative thinking	Content-reliant; methodological skills such as continuous improvement; analytical skills
5. Self-esteem	Ethics and professional morality	Professionalism; taking responsibility	Ethics and global awareness	Personal skills (i.e. professional ethics, and self-awareness

> [. . .] engineering education must expand the boundary of systems thinking, for example by considering the ecological and social systems they operate in, and to develop more holistic and integrated systems thinking mindsets.

Design/method

The two projects (the HUST Project and the Polestar Project) described in this paper differ in scope and duration. The HUST Project (Halmstad University Solar Team) focuses on students' technology development as they design and build a solar-powered car to participate in the Bridgestone World Solar Challenge (BWSC) in Australia. The Polestar Project focused on students' development of soft skills in the context of sustainability and mobility during an eight-week period. Both projects are integrated in the engineering curriculum of courses taught at Halmstad University in Sweden in which the aim is to emphasize transportation, sustainability and mobility issues as featured in engineering education. Students in the HUST Project raced their solar-powered car in the 2019 BWSC and are now preparing to participate during 2023. Students in the Polestar Project identified business opportunities in the ownership phase of a climate-neutral car manufactured by the Swedish electric vehicle manufacturer, Polestar. The authors contribute to the creation and organization of the student projects: the HUST Project by the first author; and the Polestar Project by the second author. Almost an equal number of students participated in the two projects: 25 engineering students (primarily candidates for a Bachelor's degree) in the HUST Project; and 26 engineering students (primarily candidates for a Master's degree) in the Polestar Project. Ten students participated in both projects.

The authors began their research with an extensive literature investigation on sustainability, mobility and engineering education. From the literature, the authors produced a theoretical framework (Table 1) to use as a guide for interviews and the survey. Informal, unstructured interviews were conducted by the authors with the students throughout the projects about their impressions of their learning experience in the projects. In addition, an online survey (Microsoft Forms) was emailed to all students still enrolled at the university (approximately 30 students). The survey aimed to learn the students' reflections on their participation in the projects. Nine surveys were returned, anonymously. Students in the HUST Project kept logbooks during the project in which they recorded their reflections on their technical outcomes and their exposure to various soft skills. Eighteen students submitted their logbooks which the authors reviewed. In addition, the authors frequently met with the students and heard their contemporaneous narratives about their experiences in the projects. Jointly, the authors coded and organized the study's data and prepared the analysis.

The results of this study are presented consistent with the CDIO approach (Crawley *et al.*, 2007) to engineering education reform with a project-based focus. The students' comments are identified by participant group codes.

Results

The HUST Project and the Polestar Project dealt with the sustainability and mobility challenges currently facing the automotive industry. This focus is both timely given the European Commission's 2020 Sustainable and Smart Mobility Strategy aimed at achieving a clean, digital and modern economy in the transport sector. For the automotive industry, this goal presents a significant challenge (Kukkamalla *et al.*, 2021).

The HUST Project

The Halmstad University engineering students in the HUST Project were challenged to design and build a solar-powered car that they could race in the 2019 BWSC and now a new group is working with the aim to participate in autumn 2023. The BWSC is a biannual, international event in which solar-powered cars compete in a race of 3000 kilometres in the Australian outback from Darwin to Adelaide (Betancur *et al.*, 2017). In 2017, engineering students at the university were invited to join the HUST Project although at the time the project had no designs, no budget and no suitable infrastructure. The project was planned in three phases. Student participation was voluntary.

In the first phase, when the initial planning occurred, the students commented that their co-operation skills improved:

> My ability to work in a group has improved a lot. I've gotten a lot better at listening to others, and I have realised how important good communication is This is something I've never experienced before. [S4]

After six months of project organization (acquiring financing, sponsorships, mechanical engineering expertise and more), the project entered its second phase. Team members knew their responsibilities. Design and construction of a prototype could begin:

> This has been challenging for me. I still have more to learn. The HUST Project helped me understand the dynamics of working with others. [S6]

In this second phase, a core group of students took more and more initiative. They committed many evenings and weekends to the project:

> The HUST Project is driven by initiative. If no one does anything, nothing will happen. We take charge of the future of this project. Our goals will only be reached if we take the initiative to solve our problems. [S3]

During this phase, the students' creative, problem-solving skills improved – for example, organising skills (leadership, marketing and planning) and engineering skills ((mechanical and electrical):

> I gained new insights about the future of electric mobility. Our work in the HUST Project really taught me a lot about the whole project management spirit. I now have experience in manufacturing and designing. [S4]

In the third phase, the HUST Project team completed the construction of its first solar-powered car that they called the *H3* ("Heart Three" with reference to the city coat of arms of Halmstad). The *H3* was then shipped to Australia on a 60-day voyage. The HUST Project team (17 students) then flew to Australia, at their own expense, where they had to pass tests and scrutinization before getting the number plate and the certificate to start the race. When the *H3* solar-powered car encountered battery problems during testing, the team had to rebuild a battery pack, generously provided by a team from Durham University in the UK. Because of the reduced capacity and lower speed of the car, the *H3* was unable to complete the race under its own power. Thus, the *H3* was eliminated from the race's Challenger class but, anyway, participated in the race and drove many parts of the race and got valuable experience and came in position 23.

The students agreed that their self-confidence and self-esteem had increased as they completed a complex task in which frequent problems arose:

> I tried things I had never done before. It was ok to fail because we were here to learn. By learning new things, you prove you can do new things. [S3]

> The most motivating thing in life is feeling included and respected. Being with people who are trying to help is the best feeling. [S6]

The Polestar Project

The Halmstad University engineering students in the Polestar Project were challenged to identify business opportunities in the ownership phase of the climate-neutral, electric vehicle manufactured by Polestar. Polestar is the Swedish premium electric performance car brand founded by Volvo Cars and Geely Holding. In April of 2021, Polestar announced Project 0 Polestar – the project to manufacture a climate-neutral car by 2030 that would reduce greenhouse gas emissions (www.polestar.com). The initial focus of Project 0 Polestar is the manufacturing phase of the car's lifecycle, enabled by innovative and circular design (e.g. circular batteries and recycled materials) and renewable energy throughout the supply and production chain. Polestar will subsequently explore the ownership phase of the climate-neutral car's lifecycle to gain insight into additional business opportunities. According to Jonsson and Gärdfors (2021), Polestar challenges the established automotive industry with its emphasis on sustainability, mobility and its unorthodox, online marketing strategy.

Polestar representatives, working with university lecturers and researchers, challenged the students to develop a business model for Polestar that created and captured value during the ownership phase of the car's lifecycle (i.e. a business model that produces recurrent revenue streams). For this challenge, the students were tasked with preparing a complete business model for the Polestar car for a post-sale time frame of their choice: 0–2 years for existing cars; 5 years for cars with small adjustments; 10 years for new cars. The students divided into five teams. Four groups chose the five-year time frame; one group chose the 10-year time frame. Teams developed their co-creation and co-operation skills as they created a business model that they then presented in workshops led by the second author. In four workshops, the students were the only participants. In the fifth workshop, which the students thought the most valuable, students from other engineering programmes and Polestar representatives also participated:

> The workshop was a great experience. I learned a lot from the other team members who had specialized competences. [S9]

The students used the planning method known as backcasting in which a successful future outcome is defined before policies and steps are then worked backward from that outcome to the present. Broman and Robèrt (2017, p. 20) argue that "backcasting from visions framed by a principled definition of sustainability is a more generic, intuitive, and practical approach [than forecasting] for supporting sustainable development". Their Framework for Sustainable Development uses the backcasting procedure in a design for sustainability labelled the "ABCD procedure". With this inspiration, the students structured their task into four phases: Creating Awareness (A); Baseline (B); Creative Solutions (C); and Devising a Plan (D).

In the Creating Awareness (A) phase, the students created a business model vision after studying the literature on sustainability, mobility and business models (Snihur *et al.*, 2021). In the *Baseline* (B) phase, the students studied relevant micro, meso and macro structural change trends (e.g. artificial intelligence [AI], the Internet of Things [IoT] technology, circularity and gamification) and their relationship with context-relevant, sustainable/mobility development goals. During these two phases, the students demonstrated initiative as they committed to the project:

> The work gave me a new thought process. [S7]

In the Creative Solutions (C) phase, the students created, presented, tested and refined various business models prototypes. Creativity and problem-solving skills were required as they applied theories pertinent to the electric vehicle industry to the practical challenges they faced. Their main tool – used as a boundary object (Arias and Fischer, 2000) for business modelling and communication with stakeholders – was the Flourishing Business Canvas (FBC). Elkington and Upward (2016, p. 131) describe the FBC as follows:

> [. . .] a collaborative visual design tool that, by providing a common language for an organization's stakeholders, allows them to effectively work together to describe their enterprise's business model and imagine future preferred ones.

Using the FBC, the students presented their business models prototypes and received feedback from the Polestar representatives. This learning environment provided the students with creative opportunities to build and practise their problem-solving and cooperation skills. The students also increased their self-confidence as they took responsibility as FBC knowledge experts in the workshops:

> My top learnings from this experience are long term thinking, value creation and value destruction/unintended impacts ideas, storytelling, and use of alternative futures. [S8]

In the Devising a Plan (D) phase, the students focused on how best to communicate their ideas to Polestar and, when and if appropriate, to its stakeholders. Advisors at the local science park provided students with training in business model presentation well as an opportunity to practice pitching a business model idea to different groups of stakeholders. The students also created an action plan with an impact statement for their business models.

The students observed that their self-esteem increased in this phase when their business models were received favourably by the Polestar representatives.

The students presented various innovative ideas in their business models related to the sustainability and mobility issues facing the automotive industry at present and in the future. They proposed that AI, the IoT technology and battery swapping would play an important role in transportation sustainability and mobility. For example, an occasional driver could book a rental car as needed. High-speed internet connections in cars could provide current weather and traffic information. Car owners could locate and join vehicle convoys that provide mutual safety. Such developments might even reduce the number of privately owned cars, thereby reducing greenhouse gas emissions as well as geo-political dependence on fossil-fuel producing nations:

> Overall, even if the project was very demanding, my top two learnings were co-creation as well as multi-value thinking – social, environmental, and economic. [S1]

Discussion of results

The two automotive projects revealed that experiential, student-led learning positively influenced the students' creativity, task commitment and ability to co-operate. Both projects also revealed an increase in the students' self-confidence and self-esteem. These are the soft skills needed to solve problems or propose solutions to problems. The students took the initiative as they either designed/built a solar-powered car "from scratch" (the HUST Project) or developed a company business model (the Polestar Project) when initially they knew little about the company or business modelling. The students themselves confirmed these results in their interviews and informal commentaries.

As they worked in teams, the students learned the value of, among other things, joint problem-solving, clear communication and a shared work ethic. They gained an appreciation of the importance of the soft skills that are essential in the modern workplace and which are typically not in focus in engineering education. In short, student-led, creativity/discovery learning motivated the students more than teacher-led, rote memorization/lecture learning.

A review of the projects' trajectories is useful in tracking how these soft skills developed:

- Co-operation. The students engaged in teamwork as they defined their projects in the context of sustainability and mobility in the automotive industry.
- Commitment and creativity. The students demonstrated other teamwork skills as they designed their prototypes: the H3 solar-powered car; the Polestar business model.
- Self-confidence and self-esteem. The students presented their completed projects: the H3 solar-powered car on the track in Australia and the new group work towards participation in 2023; the presentation of the business models to the Polestar representatives.

This study shows that time and space are required to develop students' soft skills. Guerra (2017), in his paper on sustainability in engineering education, makes this point. He recommends that initiatives for developing soft skills should be based on open inquiry, on arenas and in situations that nudge reflection, flexibility and adaptability. However, the two automotive projects experienced both time and space constraints. First, both projects had to be completed in a fixed time frame: before the BWSC in October of 2019 (the HUST Project); before the conclusion of the engineering course in December of 2021 (the Polestar Project). Although there was some overlap of students in the two projects, students in the more complex HUST Project generally had no prior experience with project teamwork of this size and complexity. Sequential scheduling of short-term projects before long-term projects for the same students could provide them with useful student-led, project experience. Second, as complementary add-ons to university courses, neither project had a dedicated space allocation. Initially, this deficiency was critical for the HUST Project. Thus, external funding was essential. Because applied projects are likely to require financing, engineering university departments might explore the possibilities for applied project funding.

Conclusions

In the ideal classroom, students use integrated thinking, engage in multi-disciplinary collaboration, and develop the soft skills that help them acquire/create new knowledge and experiment/learn in new ways. In such classrooms, students can learn to manage "real-world" situations and their challenges (Kurucz *et al.*, 2014) as they nurture "the seeds of change" (Geels, 2002). This is the learning approach that this paper addresses in its analysis of two student-led, university-level applied engineering projects.

As the literature summary presented in this paper shows, researchers have strongly supported this approach in their call for a change in the traditional, teacher-led engineering curriculum. A frequent theme in this literature is the need to integrate soft skills acquisition with technical engineering education (Chamorro-Premuzic *et al.*, 2010; Rodriguez *et al.*, 2021). However, researchers disagree on which soft skills to prioritize and how best to teach them (Bilodeau *et al.*, 2014; Rampasso *et al.*, 2018). From this literature, the authors of this paper identified frequently cited soft skills from the engineering education literature and assembled them as five categories: creativity, co-operation, self-awareness, commitment and self-esteem.

The two applied projects described in this paper present empirical evidence of how students developed these five soft skills during the projects. Both projects had an automotive setting in which industry sustainability and mobility were in focus. In the HUST Project, students design, build and race a solar-powered car; in the Polestar Project, students created and presented a business model for the ownership phase of an electric car. According to their responses (interviews, surveys and logbooks), the students were very positive about the soft skills focus that the successful completion of their projects required. They were especially appreciative of the improvement in their communication and co-operation skills and of the increase in their self-confidence and self-esteem.

This analysis of the two student-led projects contributes to the discussion on the future of engineering education. The research supports the rethinking movement in engineering education that promotes student projects as complementary to teacher lectures. It also offers two illustrative projects in the Swedish automotive industry that focused on sustainability and mobility.

Research limitations and future research

No claim is made that the results of this research can be duplicated because the research settings for the projects are specific as far as place and time. However, this research may inspire the initiation of similar projects and studies in which applied engineering projects complement more traditional engineering courses.

More research is needed in applied project engineering education. Comparisons between this learning model (PBL) and other models in other settings (e.g. different industries or geographic locations) would be useful in evaluating their relative effectiveness. It is also suggested that researchers might focus on the follow-up of applied university engineering projects (in particular, automotive sustainability and mobility projects) with students and former students. This research could study if and how these students have used the soft skills and knowledge acquired in their applied projects in subsequent courses or in work environments. It is also recommended that researchers continue to study and track course and programme variables related to applied learning projects such as complementary or stand-alone status, elective or required enrolment and duration/location. A quantitative approach for such research would be useful.

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