On the need of advanced applied courses in automatic control for the Swedish process industry and how to meet it

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Automatic control is a key competence required by the process industry to face the challenges imposed by fierce competition, reduced profit margins and strict regulations. The principles and applications of automatic control in the process industries are crucial for delivering efficiency, safety, and sustainability–without sacrificing profitability. While Sweden has a strong tradition in engineering education, an imbalance exists in the emphasis on theoretical lessons over practical application. The broadness of topics in systems and control academic journals, from embedded control systems in robots and unmanned autonomous vehicles to aerospace applications, including applications in manufacturing industries such as mineral, metal, pulp and paper, energy, food, and petrochemical highlight the need for a versatile skill set in this field. Therefore, a predominantly theoretical education might leave graduates poorly prepared for real-world industrial demands. The need for practical knowledge driven by the industry has been changing the trends and challenges students and educators face in automatic control education. Recent studies highlight the importance of blending theory with practice to meet old and new challenges and demands:

- Addressing curriculum challenges: Stoica et al. [1] discuss the broader challenges in autoamtic control curricula, particularly in motivating students and aligning education with current trends in industry and research.
- Technological Shifts: Rossiter [2] emphasizes the need to update control engineering curricula and delivery methods to stay relevant in the 21st century. This includes incorporating new technologies and addressing the evolving needs of industry.
- Enhancing learning: Educators are exploring innovative approaches to enhance student learning. Gallarta-Sáenz et al. [3] highlight the use of competition-based cases to improve the learning experience in control engineering. Moreover, there is a shift towards more inductive teaching and learning methods in engineering education. Prince and Felder [4] provide a comprehensive overview of these methods, which emphasize student-centered learning and active engagement.

The lack of applied activities in program courses might leave graduates unprepared for system integration, hardware implementation, troubleshooting, and the use of industry-standard tools. The so called "theory-practice gap" is a widely recognized issue in general engineering education. A significant modernization in automatic control education is under way to meet the demands imposed by Industry 4.0 and . This includes: (i) updating course content to reflect the latest technological advancements, (ii) adopting more engaging and student-centered teaching methods and (iii) addressing the challenges of motivating students and aligning education with industry needs. Here, a way to leverage the strong presence of consulting companies and training providers in Sweden to accelerate the modernization is discussed.

Swedish universities, including Uppsala universitet, Lunds universitet, Umeå universitet, Linköpings universitet, Kungliga Tekniska högskolan, Luleå tekniska universitet, Mälardalens universitet, Sveriges lantbruksuniversitet and Chalmers Tekniska Högskola AB, offer numerous automatic control courses, from introductory to advanced. These courses often emphasize the mathematical and theoretical aspects of control systems, such as system modeling, stability analysis, and control design methodologies. However, the question remains whether these courses address the need for advanced, applied automatic control courses for the industry. Courses like the advanced mechatronics course at KTH, which utilizes project-based learning with industrial collaboration, demonstrate a move towards bridging the theory-practice gap. Luleå uses laboratories to motivate students and to demonstrate how theory for designing and tuning PID controllers is applied in practice. Other institutions also rely on laboratories, seminaries and simulators to deliver the concepts students must dominate to meet the intended learning outcomes of the respective courses. Many times, these outcomes target applications of automatic control in robotics, which is in itself an important application, but should not completely overshadow applications in the process industry. In fact, the petrochemical industry was one of the first to welcome advanced control algorithms (i.e Model Predictive Control) and nowadays it seems that these solutions are becoming more acceptable despite the remaining dominance of PID controllers. New processes are being developed and implemented in large scale, for example hydrogen production and carbon sequestration, which might

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need advanced control strategies to achieve stable and profitable operation.

Strong applied control engineering education is essential for Swedish engineering graduates to meet industry demands. Employers seek candidates with hands-on experience in hardware and software, system integration skills, and troubleshooting abilities. Familiarity with industry-standard automation methods and technologies is also highly valued. In 2025, the Swedish government will distribute 34 Million SEK to different tertiary education institutions to develop courses that make students more prepared to the green transition and the technical challenges that come with it (Regeringskansliet [5]). However, beyond university courses, industry-specific training providers and consulting companies offer practical industrial automation courses, addressing the theory-practice gap for professionals. These companies are usually in a privileged position, compared to universities, working with industrial plants as direct clients. This allows consulting companies to have a dialogue with process and automation engineers, operators and project leaders, to understand the technical challenges in the plant, and to deliver tailored practical courses in automatic control that refresh or complement the knowledge that engineers, operators and other plant personnel obtained previously in tertiary or secondary education. Two evident differences between course takers of courses offered in educational programs at universities and courses offered by training providers are: the maturity level and perceived need for knowledge. These factors combined can arguably make it much easier to develop and deliver courses for industry professionals than for students, but nonetheless many lessons can be learned from industry suppliers.

Sweden has the means and the opportunity to provide high-quality automatic control education in secondary and tertiary education and for industry professionals. While there have been previous successful examples of collaboration between the industry and academia within the field of automatic control, it is in most cases only scratching on the surface in relation to the demand. Collaborations between universities, industry-specific training providers and consulting companies, and the industry have the potential to accelerate the modernization of automatic control curricula in academia and meet the need of practical advanced automatic control courses for the process industry. While the list of obstacles towards the goal can be made long – from proposal deadlines and an extensive focus on the number of papers in the academia, to tight schedules and reluctance to share process data in the industry – both sides need to come out of the trenches and join forces. Hopefully, a transparent dialogue between all parties involved can minimize the deviation between the set point and the measured variable.

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