PROFESSIONALISM FOR ENGINEERS: SOFT SKILLS IN ENGINEERING EDUCATION TO PREPARE FOR PROFESSIONAL LIFE

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ABSTRACT

A strong set of hard and soft skills are required for an engineer to succeed in today's team-based workplaces. In order to prepare students for the profession, engineering education needs to focus on both. However, traditional engineering programs do not place enough emphasis on the development of soft skills, despite the guidelines specified in CDIO Standard 2: Learning Outcomes. Our proposition is that by focusing on soft skills such as self-motivation and personal leadership skills, students will be better prepared for professional practice and their academic performance will benefit as well. In this paper we present an innovative approach for teaching soft skills that we have implemented in the course "Professionalism for Engineers, PE" offered in two 5-year programs in computer science. A variety of tools are presented in the class and students get experience using them in mandatory assignments. Reflection is a fundamental assessment method in the course and reflective writing based on the Gibbs reflective cycle (Gibbs, 1988) is applied, as well as the Dialogue Seminar Method, to develop the students' reflective ability and to allow them to learn from their own and others' experiences. Among the lessons covered, students say the most rewarding include lessons that involve students from other disciplines, such as psychology students, and the use of the Dialogue Seminar Method with groups of students from years 1, 2, and 3. The effect this course has on academic and professional performance is hard to assess this far. Based on the experiences of the PE, a new course has been developed for two 3-year programs in computer engineering and engineering electronics. The new course is described in this paper. Students in the 5-years programs who have finished the PE will be mentors in the course.

KEYWORDS

Personal development, personal effectiveness, social competence, communication, teamwork, motivation, ethics, financial acumen, Standard 2: learning outcomes.

1 INTRODUCTION

Employability after higher education depends on many factors, including subject-specific knowledge, understanding and skills, emotional intelligence, work and life experience, career development, and reflection and evaluation (Dacre Pool & Sewell, 2007). One's professional success and failure are affected by possession and use of soft skills in addition to technical skills or intelligence (Goleman, 1995). Today's information technology (IT) workplaces are dynamic, distributed and complex (Joseph et al., 2010) and it is also common for engineering environments to be multidisciplinary (Nguyen, 1998). Therefore, industry expects that engineers are both technically proficient in the field and know how to behave within the organization (Nguyen, 1998). In most software engineering organizations the work is performed in teams and better results are accomplished if the teams consist of engineers with different types of personality traits with roles suited to their abilities (Capretz & Ahmed, 2010). Although engineering development is a team effort, the ability to work individually is

still required and involves soft skills such as self-awareness, self-monitoring, and self-correcting (Faheem et al., 2013). According to Tong, new engineering graduates that held both technical and non-technical skills, e.g. interpersonal communication, planning, and people skills, as well as team management skills, are preferable employees (Tong, 2003). However, engineering students are not trained for professional cooperation that requires, e.g. understanding of colleagues, empathy, and self-criticism (Backlund & Sjunnesson, 2012) and it is common for engineers to learn soft skills on the job (Kumar & Hasiao, 2007). Furthermore, students do not fully understand and/or underestimate the impact of soft skills on their employability and only begin to develop an understanding after they have been hired and are working at a job (Parts et al., 2013).

Soft skills are important not only for success in professional life but also for success in personal life (Cimatti, 2016). Soft skills affect an engineering student's performance during their education (Thinyane, 2013). Soft skills refer to the personality traits and attitudes that affect a person's behavior (Roan & Whitehouse, 2007) and describe personal and social skills. Personal skills are self-oriented and refer to what a person understands and develops by herself e.g. having the capacity and desire to continue to learn, plan and achieve goals (Cimatti, 2016). Social skills are other-oriented and refer to skills a person develops in relating to other people, e.g. communication, networking, decision making, and assertiveness (Cimatti, 2016). According to Goleman (1995), soft skills are defined as emotional intelligence, which is the capacity to recognize one's own and others' feelings and is necessary for self-motivation and emotion management. Soft skills and emotional intelligence affect success or failure in one's profession and life (Cherniss et al., 2006; Goleman, 1995). For example, self-efficacy, self-confidence and self-esteem are the links between the hard skills and employability (Dacre Pool & Sewell, 2007). Soft skills lead to the development of hard skills and make it possible for an engineer to keep hard skills up to date in changing circumstances (Cimatti, 2016). It can be viewed like software on the computer, controlling and managing the hardware. Emotional intelligence is a combination of interpersonal and intra-personal competences with 12 elements that can be categorized into four domains: *The self-awareness domain* contains the element of emotional self-awareness. *The self-management domain* contains emotional self-control, adaptability, achievement orientation and positive outlook. *The social awareness domain* contains empathy and organizational awareness. Finally, *the relationship management domain* contains influence, coaching and mentoring, conflict management, teamwork and inspirational leadership (Goleman & Boyatzis, 2017). Furthermore, communication, motivation, problem solving, time management, professional ethics, and the ability to learn are examples of some of the non-technical skills that are often considered to be more important than technical skills for the engineering professional role (Kumar & Hasiao, 2007; Woratschek & Lenox, 2002). According to engineers, the five top essential skills they need in their work include: communication skills, problem-solving, teamwork, application of ethics, life-long learning, and an understanding of business (Courter et al., 2000).

In this paper, the course Professionalism for Engineers (PE) is presented together with the pedagogical basis and the lessons learned from the course so far.

2 IMPLEMENTATION OF CDIO STANDARD 2: LEARNING OUTCOMES

Two 5-year programs in computer science (Computer Science and Engineering, D, and Computer Science and Software Engineering, U) at Linköping University in Sweden have four aims and related goals. The aims are based on the international CDIO Syllabus for modern undergraduate engineering education programs, which presents knowledge, skills,

and attitudes necessary to become successful young engineers formed by the CDIO Initiative™ (Cajander et al., 2011; Crawley & Lucas, 2011). In order to ensure that students achieve the soft skill program aims by the time they graduate, and to meet the demands of the profession of the engineering field, a new course, PE, has been designed and given in both the D and U programs (Berglund & Heintz, 2014). The CDIO Standard 2: Learning Outcomes1 and the following CDIO soft engineering skills topics are the focus of the PE course:

- 2.4.5. Awareness of One's Personal Knowledge, Skills, and Attitudes
- 2.4.6. Curiosity and Lifelong Learning
- 2.4.7. Time and Resource Management
- 2.5.1. Professional Ethics, Integrity, Responsibility and Accountability
- 2.5.2. Professional Behaviour
- 2.5.3. Proactively Planning for One's Career
- 2.5.4. Staying Current on World of Engineering
- 3.1.1. Forming Effective Teams
- 3.1.2. Team Operation
- 3.1.3. Team Growth and Evolution
- 3.1.4. Leadership
- 3.2.3. Written Communication
- 3.2.6. Oral Presentation and Inter-Personal Communications
- 4.2.2. Enterprise Strategy, Goals, and Planning
- 4.2.3. Technical Entrepreneurship
- 4.2.4. Working Successfully in Organizations

The PE course is based on four main soft skill areas: **personal effectiveness**, **personal development**, **social competence**, and **the engineering professional role**, see Figure 1. These topics were chosen based on what the industry and the engineers themselves has described as required skills, presented in more detail in the Introduction.

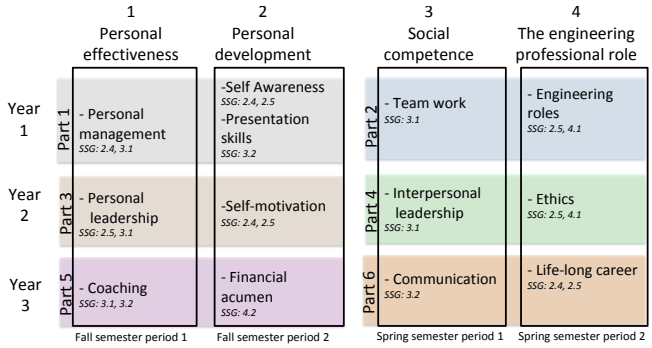

Figure 1. The content and structure of the course showing the related program soft skill goals (called SSG in the figure) and where in the course they are presented.

The PE course is designed according to the principle of constructive alignment, so students learn through relevant activities that are aligned with the intended learning outcomes (Biggs & Tang, 2011). The teachers' roles are to help the students achieve the intended outcomes (Biggs & Tang, 2011), so they are mentors in the course. Tools are presented in the course and the students gain experience using them in mandatory assignments throughout the

[1] CDIO Standards 2.0: http://www.cdio.org/implementing-cdio/standards/12-cdio-standards#standard2 (visited 2018-01-22)

course. The course is divided into six parts and students from years 1, 2, and 3 take it together over the three first years, with one credit earned per part. During the fall semester three parts are given, while in the spring all students take the same part, so students take parts 2, 4, and 6 in a different order depending on when they start the course. There is a progression in the topics studied in parts 1, 3, and 5, therefore the students have to study them in that order, while the topics in the spring semester do not build on each other, so they can be studied independently. For example in the personal effectiveness the students starts by learning how to manage tasks and time (part 1), then they learn to set up goals (part 3) and finally they learn how to coach themselves and other in order to be effective (part 5). In part 3 the students starts by learning setting goals in personal leadership and then they learn about self-motivation relevant for achieving the goals. In 2017 the course was taken by 389 students in total (186 students in year 1, 111 students in year 2, and 92 students in year 3). The course contains both in-class and out-of-class learning activities, as described in Figure 2. The in-class activities are: thirteen lectures, five obligatory workshops, twelve obligatory dialog seminars and two obligatory seminars. The out-of-class activities include practical work such as individual assignments and 12 individual reflection essays. The course topics are introduced through lectures and YouTube videos, TED talks, articles, and book chapters.

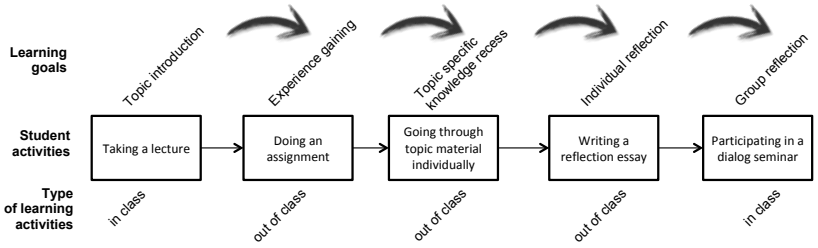

Figure 2. In-class and out-of-class learning activities

The Dialogue Seminar Method was developed in the research area "skill and technology" by the Royal Institute of Technology (KTH) in Stockholm, in cooperation with a Swedish high-tech consultancy company, Combitech (Göranzon & Hammarèn, 2006). The method has been used in training both experienced and young professional engineers with positive results in some high-tech companies (Backlund & Sjunnesson, 2012) and is used in the course to train students to increase their reflective ability and to allow them to learn from their own experience as well as that of others. To offer a more robust exchange between students with different experiences, the dialogue seminar groups are composed of 8-11 students from years 1, 2, and 3. Thus students in higher years can share their experience with younger students and hopefully serve as role models. Each student group has a teacher mentor and meets during the twelve obligatory dialogue seminars. Each seminar lasts about four hours. In order to be able to participate in the seminar, each student must perform the required assignment, write a reflection essay that is 1-2 A4 pages in length, submit it to the teacher mentor before the deadline, and bring a printed version of the text to the seminar for the other students in the group. The printed versions of the reflection essay are the entrance ticket for the seminar and participation is not allowed without them. In order to help students with the reflection process, the Gibbs reflective cycle is incorporated (Gibbs, 1988) so students think through phases of an experience or activity. The cycle guides the students through six stages of reflection as seen in Figure 3. Each stage contains topic-related questions to encourage in-depth reflection.

The Dialogue Seminar starts with a short introduction by the teacher mentor going through the agenda for the seminar. The first student then has 15 minutes and starts by handing his/her printed essay to the other students and then reading the text aloud. Next, the teacher mentor gives the group 10-12 seconds to collect their thoughts and prepare questions or

comments. The group then discusses the text. When the time is up the discussion is ended and the same is done for the rest of students in the group. At the end of the seminar the teacher mentor summarizes the seminar and thanks all the students.

Examination is done continuously through related assignments, individually written reflection essays, and active participation in all mandatory in-class activities: twelve dialogue seminars, two seminars, and five workshops. Grades 3, 4, and 5 can be achieved based on predefined criteria that are known by the students in advance. When students submit their assignments and reflection essays they state the grade they are aiming for with a justification motivation based on the criteria, allowing students to practice self-assessments that can increase the student´s responsibility for their own learning (Shepard, 2000).

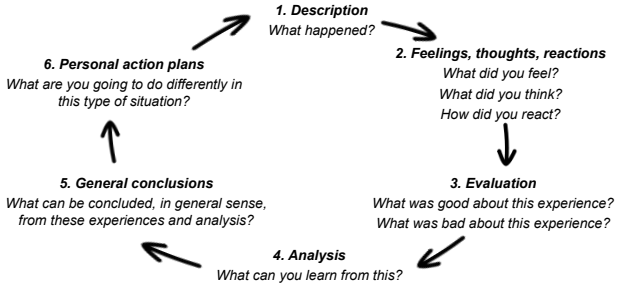

Figure 3. The review and reflection model in the PE course based on Gibbs reflective cycle.

3 THE PROFESSIONALISM FOR ENGINEERS COURSE CONTENT

3.1 Personal Effectiveness

Personal Management is the first topic covered. It covers planning and organizing activities in order to achieve goals, including both short- and long-term goals. An assignment consists of two parts that must be done: (1) Students obtain a calendar, plan the first period of the fall semester (to practice long-term planning) and also plan a week in detail (to practice short-term planning: weekly and daily). A workshop is scheduled where students work actively on this part of the assignment. (2) Students then keep a diary logging all their activities for the week they've planned in detail. The diary is then analyzed and a reflection essay is written based on it.

Personal Leadership topics cover understanding what one wants, being focused, and having a vision that is broken down into both short- and longer-term goals. The assignment is to identify goals to be achieved within 1-3 years and then a four-step analysis has to be performed: (1) Reflect on the current situation by answering specific questions such as *What do you like?* and *Do you have balance in your life?* (2) Define the desired situation by formulating an overall objective to achieve for an important area (e.g. education, health, social, organizational work, etc.) in a few years (the time frame is determined by the student), described by an overall SMART goal (Specific, Measurable, Accepted, Realistic, and Time-bound). (3) Create a personal development plan with sub-goals and related concrete activities. (4) Realize the plan by conducting the activities in step 3. The students also have to participate in a mandatory coaching workshop run by year 3 students studying the topic of coaching in the PE course. The year 3 students coach them in the analysis above.

Coaching highlights how to coach oneself and others and consists of six scheduled in-class activities with attendance mandatory at five, as seen in Figure 4. The assignment is to coach year 2 engineering students who are doing a Personal Leadership assignment. The

engineering students in year 3 are divided into sub-groups supervised and coached by psychology students in semester seven during three consultation workshops.

3.2 Personal Development

Self-awareness is an emotional intelligence skill rooted in the ability to recognize one's own emotions (Goleman, 1995). The assignment for this topic is to apply at least one positive habit over the course of 7, 14 or 21 days to cultivate a positive mindset. According to Achor (2012) students will: (1) Write down three things they are grateful for or happy about. It has to be three new things every day. (2) Write a positive message to someone in their social support network. (3) Meditate for two minutes. (4) Exercise for 15 minutes. (5) Take two minutes to journal the most meaningful and positive experience of the past 24 hours. Mindfulness is introduced for mediation.

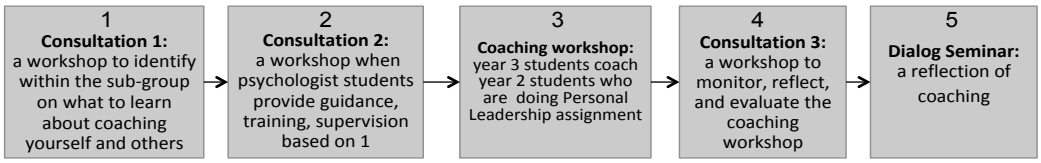

Figure 4. In-class coaching activities. Workshops 1-4 are performed without a teacher.

Self-motivation is about the ability to motivate oneself and others. The students' assignment is: (1) Do a test according to the Irrational Procrastination Scale, or IPS[2], assessing the procrastination behavior. (2) Identify what happens during procrastination by using the S-O-R-C-model (Stimulus-Organism-Response-Consequences) (Curry et al., 2003) for a week. Students identify triggers and specific situations that lead to procrastination (S), automatic thoughts, feelings, and physiological feedback (O), behavior and reaction in the situation (R), and both short- and long-term consequences (C). (3) Use a tool to increase motivation and reduce the procrastination behavior.

Presentation Skills focus on oral presentation techniques where attention is given to body language, oral performance, and visual presentation. Students participate in two mandatory seminars. In seminar 1 students give short, impromptu oral presentations to practice speaking in front of others. In seminar 2 students give a practice presentation for a project conducted in a programming course that students take in parallel with this course, and they receive feedback to enhance the presentation.

Financial Acumen is focused on developing an understanding of aspects of business and economic issues. Entrepreneurship gets special focus in the course and students can choose between two assignments: developing a business idea using the NABC business analysis method[3] or investigating and reflecting on an inspiring entrepreneur.

3.3 Social Competence

Teamwork refers to the ability to work with other people e.g. engineers, stakeholders, or customers. The students get introduced to group theories (Wheelan, 1994) and reflect on what leads to effective teamwork and personal effort in interaction with others. Students are then given an assignment where they identify two groups they have participated in, one in

[2] The IPS is available at: http://fbanken.se/files/241/Irrational_Procrastination_Scale_(IPS).pdf (visited 2018-01-22)

[3] The SRI International: https://www.sri.com/ (visited 2018-01-22)

which the group worked well and another in which the other group worked less well. The groups they choose can be a study group during their university education or groups formed in previous work or leisure activities. The students then reflect on each group and assess what stage each group is in, according to the Susan A Wheelan IMGD model by filling in a checklist (Wheelan, 1994).

Interpersonal Leadership covers how to interact positively with others and how leadership affects productivity, looking at, e.g. leadership theories, dysfunctional teams, empathy, etc. The assignment is that students interview an engineer or a student in year 4 or 5 to gain insight into the interplay between individuals, the effect of leadership on a group, and what aspects lead to success in collaboration. The reflection essay is then written based on the interview and the student's own experience of the topic.

Communication is significant in the engineering professional role and in studying communication, students learn various non-verbal and verbal communication tools, how to ask good questions and how to listen actively. The assignment requires each student to give two people constructive feedback on behaviors that need to be changed and two people positive feedback that emphasizes positive behavior. The feedback recipient can be another student, coworker, sibling, corridor mate, football team member, etc. The students are instructed to be honest in their feedback, address real issues and use the tools taught during the communication unit. The students write a reflection essay analyzing e.g. how they usually achieve their objectives in a group and how communication is linked with social competence, leadership, and success.

3.4 The Engineering Professional Role

Engineering Roles aims to give a better understanding of the engineering professional role. Students can choose between two assignments: (1) learn more about the practice by interviewing an engineer about e.g. what technologies he/she works with, what role he/she has, etc. (2) to have an understanding of the impact of the engineer's work on the environment and also to have the ability to develop solutions that minimize or prevent the environmental damages using system thinking concept.

Ethics covers four components: knowledge of codes and standards, skills that give the ability to identify ethical issues, reasoning that underlies the ability to make moral decisions, and motivation, which is the will to take action. In the course, students take part of the course content about ethics and technology e.g. *Software Engineering Code of Ethics and Professional Practice, the Swedish Engineer's Code of Conduct*, and *Linköping University's Code of Conduct for Students and Employees.* The assignment for the topic is to choose a corporation, find out the corporate ethics code or ethical policy and then identify the corporation's ethical goals and values. The student also addresses a situation where the ethical goals and values would play a role in the decisions made or actions involved.

Life-long Career focuses on having a balance in life with regard to work, health, relationships, and what brings happiness and joy in every day. It also covers building skills and knowledge continuously throughout the life of an individual. The assignment is to create a vision of life at least 10 years in the future, finding a job that the student would like to apply for in 10 years and reflecting on the competencies they need to develop and how they can

develop them. Students write a curriculum vitae for the job and create a LinkedIn[4] profile if they do not have one.

4 Lessons learned

Possible effects on academic and professional performance are hard to assess thus far. At the end of the spring semester students complete an evaluation about their experience of the course.

Soft Skill Topics - The students are asked to choose two topics from the thirteen they think are the most rewarding. Looking at the results of year 3 students who have studied all the topics we find that the top five topics are: coaching, self-motivation, life-long career, personal leadership, and personal management. These data indicate that the interaction with students from other disciplines is interesting. Focus on planning and management is required.

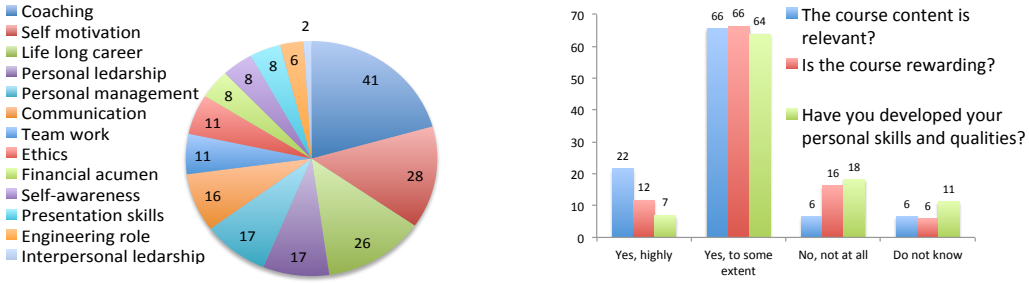

Figure 5. Left: The most rewarding soft skills according to the students. Right: The course relevance, how rewarding it was, and a student's personal development in the course.

Course Impact - Students are asked about the relevance of the course according to their own opinion, how rewarding the course is, and their development of personal skills and qualities during the course. Results show that 86% of the students find the course relevant, 78% of the students find the course rewarding and 71% of the students find that their personal skills and qualities have been developed during the course, see Figure 5. These data show that the attitudes towards the course are positive in the majority of the students.

The Course – When we ask students about what they think is the best part of the course we find that the dialogue seminars are very rewarding, since they permit students to discuss issues relevant to the engineering professional role with students from other years, they have the opportunity to share their own experiences while listening to others' and they get a chance to reflect on things that happen during the education along with others who are going through the same thing. The fact that they have to focus on soft skills is seen as positive. According to two students:

- "*The course forces us to talk and think about what we otherwise would not (for several years), partly because we are technologists and have little difficulty for soft topics*".
- "*This course leads to personal development in more areas than just programming.*"

The students appreciate the personal leadership topics and the tools for planning and managing their studies, as confirmed by the ranking of soft skill topics. In addition, the students find that it is helpful that the course is different from other courses, both in regard to content and pedagogy.

[4] https://www.linkedin.com/

Observations - There are some students who are skeptical at the beginning of the course, while other students defend the importance of the course during the dialogue seminars. Before implementing the Gibbs reflection model (Gibbs, 1988), the majority of reflection essays contained descriptions of situations, events, or experiences and students had difficulty with analyzing and reflecting on their experiences. In addition, teachers had difficulty grading the essays. The model forced the students to analyze and trained them in reflective writing, but it can also restrict them since the steps have to be followed. Still, the teachers find it easier to grade the texts when the steps are followed.

5 CONCLUSION

The PE course has many benefits, even though the students may only recognize them after the course is completed. Learning soft skills by interacting with teachers as mentors, students from different years, and students from other disciplines is rewarding for the students who participate. Personal leadership and management topics are ranked among the five top topics. Based on those PE experiences, a new course has been designed for two 3-year programs in computer engineering (Di) and engineering electronics (EI). The soft skill areas that are included are: **personal effectiveness** (personal management), **social competence** (teamwork and communication), and **the engineering professional role** (engineering roles). The course is studied only by year 1 students, gives 2 credits and will be offered during the second part of the spring semester at the end of the first year. The students will be divided into dialogue seminar groups with 6 students per group and each group will have a mentor who is a D or U student and has taken the PE course, so they are familiar with the soft skills areas and the dialogue seminar method. The dialogue seminars will take about two hours each. The course is graded pass/fail.

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