ONLINE COURSES FOR TEACHING ENGINEERING PROFESSIONALISM

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ABSTRACT

In today's team-based and distributed workplaces, engineers who work together to solve complex technical challenges require technical competencies but also require other engineering professional skills, e.g., the ability to work in multidisciplinary teams, the ability to deal with social issues, and self-awareness. Therefore, engineering educational programs need to prepare students for the demands of their future workplaces. The COVID-19 pandemic required changes in education, one of which was to switch to a distance-learning mode. Teaching professional skills for engineering students was already challenging, and it became even harder during the COVID-19 pandemic with the demand for distance-based learning through online courses. Transitioning to an online delivery format typically requires substantial re-tooling of traditional courses. Our study is based on converting an eight-week on-campus professional skills course, where the physical meeting had been a central component of the pedagogy, to an online course during the COVID-19 pandemic. Four professional skill topics were taught in the course. 74 students signed up for the course and 87% completed the course. In the paper we discuss both positive and potentially problematic aspects of online courses for teaching professional skills in engineering education.

KEYWORDS

Computer science education, software engineering, electrical engineering, personal management, social competence, communication, teamwork, engineering profession, CDIO Standard 2.

INTRODUCTION

Today's engineers need both technical competencies and professional skills when working together to solve complex technical challenges. The purpose of this paper is to investigate how online courses can be designed to teach professional skills using a reflective practice (Idrus, Abdullah, et al., 2009) and experiential learning with the key components of learning-by-doing (Kolb, 1984). These skills are included in the CDIO standard 2: learning outcomes for personal and interpersonal skills (Crawley, Malmqvist, Ostlund, Brodeur, & Edstrom, 2007; Malmqvist, Edström, & Rosén, 2020).

Engineering professionalism

The term *professional skills* (commonly called "soft skills") describes non-technical skills and human-focused competencies essential for the engineering profession (Berdanier, 2022) such as the ability to work in multidisciplinary teams, conflict management, communication, social justice, equity, leadership, and ethical reasoning (Itani & Srour, 2016; Matturro, Raschetti, & Fontán, 2019; Sahudin, 2022; Stevenson & Starkweather, 2010). The six critical core competences that are indicative of characteristics important to successful IT project management are: leadership, the ability to communicate at multiple levels, verbal skills, written skills, attitude, and the ability to deal with ambiguity and change (Stevenson & Starkweather, 2010). A literature review identifying factors influencing the employability of engineering graduates shows that the primary factors are professional skills, problem solving skills, functional (knowledge) skills, and academic reputation (Sahudin, 2022). Furthermore, six groups of professional skills that are of importance for engineers are: critical thinking, creative thinking, communication, teamwork, ethical perspective and emotional intelligence (de Campos, Resende, Fagundes, et al., 2020). Technological development and accelerated globalization has led to increased demands in engineers' professional skills with regard to communication, teamwork, and management skills (Itani & Srour, 2016). The COVID-19 pandemic required radical changes in society and the importance of professional skills in workplaces has become even more important after the COVID-19 pandemic for today's team-based and distributed workplaces (Malik & Ahmad, 2020). Therefore, educational programs in engineering need to prepare students for the demands of the workplace. In addition, focusing on professional skills even helps students in their studies since these skills have an impact on the students' performance in classes and academia (Berdanier, 2022). Professional skills can be developed and increased through education and training (Kyllonen, 2013). Therefore, university programs should focus on learning outcomes linked to professional skills (Finch, Hamilton, Baldwin, & Zehner, 2013) and courses focused on the learning of relevant professional skills for the engineering profession need to be integrated into the engineering curriculum (Jelonek, Nitkiewicz, & Koomsap, 2020). However, it is common for there to be a significant gap between the professional skills required by industry and the skills acquired by engineering graduates such as communication and systematic work planning (Gope & Gope, 2022).

Learning in Online Courses

Teaching professional skills to engineering students has many challenges, such as teaching classes with large numbers of students, limited time to cover the syllabus, and students' negative attitudes towards professional skills in the classroom (e.g., skipping lessons incorporating professional skills and students not being interested in developing their own professional skills) (Idrus et al., 2009). Students' attitudes about the importance of these skills is another challenge. Using the term "professional skills" instead of the more common term "soft skills" emphasizes the importance of these skills for the engineering profession (Berdanier, 2022). The COVID-19 pandemic also required changes in education, one of which was to switch from face-to-face to online learning, which has been challenging in many ways (Heng & Sol, 2021). Teaching professional skills to engineering students is challenging, and it became even harder during the COVID-19 pandemic due to the demands of distance-based learning through online courses (Atolagbe & Yan, 2022; Idrus et al., 2009; Malik & Ahmad, 2020), where the learning process is mediated by technology via the internet. Therefore, course designs need to be adapted for online teaching. Students achieve better learning results in online courses if they are properly guided by tutors

(Vlachopoulos & Makri, 2019; Zacharis et al., 2009) and direct guidance to access resources make students engage with the materials (Murray, Pérez, Geist, & Hedrick, 2012). Learning outcomes in online courses can be improved by increasing flexibility and learner autonomy, and through extensive use of digital technologies (Vlachopoulos & Makri, 2019). Active learning and incorporation of meaningful and multiple ways of interacting with students is very essential for the student engagement in online courses (Dixson, 2010). There are three important types of student interaction in online courses: student interaction with online content, student interaction with remote teachers, and student interaction with distant student peers (Abouhashem et al., 2021; Bernard et al., 2009; Luo, Zhang, & Qi, 2017). Teachers should build strong connections with their students via, e.g., frequent technology-facilitated dialogue and moderated student discussions (Huss, Sela, & Eastep, 2015). Constructive feedback, providing students with clear guidelines, and addressing reflective questions strengthens student engagement (Aderibigbe, 2020). Student interaction with the teacher is a critical factor for enhancing social interaction among peers in online courses (Cho & Tobias, 2016). When students think, reflect, engage, and learn collaboratively with other students in online courses they will be engaged (Aderibigbe, 2020).

Learning through reflection

Formal teaching, learning activities, and support programs are usually used to develop professional skills (Atolagbe & Yan, 2022). Reflection is an important way of learning (Daudelin, 1996) and formal reflective practices can encourage learning (Idrus et al., 2009). For example, spending one hour reflecting on a challenging situation (by, for example, using questions and guidelines, either alone or with another person) can significantly increase learning from that situation (Idrus et al., 2009). Kolb's Experiential Learning Theory explains the key components of learning-by-doing (Kolb, 1984). According to the theory, effective learning has four stages: (1) having a concrete experience followed by (2) reflective observation (the learner observes and reflects on the new experience based on their existing knowledge) which leads to (3) abstract conceptualization (the learner forms abstract concepts) which are then (4) used in future situations (active experimentation) when the learner applies the concepts to see what happens, resulting in new experiences. By creating a reflection practice, knowledge can be gained through dialog with others. The dialog seminar method has been shown to contribute to the development of professional skills for young (Backlund & Sjunnesson, 2012) as well as experienced engineers in industry (Backlund & Sjunnesson, 2006). The method's main purposes are: (1) establishing a common language among participants, (2) developing reflective and analogical thinking, and (3) developing experience-based knowledge (Göranzon & Hammarén, 2006). Individual reflection is gained by writing a reflection essay, which is then followed by group reflection via discussions with others in dialog seminars. This requires the participants to reflect and articulate their reflections in text, which can be challenging for students who may need tools to reflect in a structured way. The Gibbs reflection model is one of the most famous cyclical models of reflection giving structure to learning from experiences through six stages of exploring an experience: description, feelings/thoughts/reactions, evaluation, analysis, conclusion, and action plan (Gibbs, 1988). The Gibbs model has been used to reflect on professional skills for engineers (Berglund, 2018; Berglund & Heintz, 2014).

THE ONLINE ENGINEERING PROFESSIONAL SKILLS COURSE

An established on-campus professional skills course in two bachelor engineering programs (Berglund, 2018) was converted to an online course. The course in length is eight weeks and gives 2 ECTS credits. Four professional skill topics are taught in the course: personal leadership, communication, teamwork, and the engineering professions. The essentials of the course are a) *reflective practices*, wherein learning is gained by reflection, individually through written essays and together with others through discussions with other students in obligatory scheduled online dialog seminars, b) *experience development*, which is using obligatory assignments followed by the individual and group reflections. The learning objectives of the course are that after completing the course a student should be able to: (1) plan, prioritize, and perform their own work within the stipulated time, (2) reflect on their own skills and approaches, (3) reflect on what leads to effective teamwork and personal effort in interaction with others, (4) reflect on the education and their own learning, and (5) communicate with others in other roles as a colleague.

The Course Structure

The course contains four modules, and each module starts with a lecture that introduces the topic of the module. The dialog seminar method (Göranzon & Hammarén, 2006) is applied in the course and three online 3-hours dialog seminars are scheduled in the course. Before the seminar students do some preparatory work, including: (1) obligatory assignments that give the students experiences in the topic, (2) appropriate reading materials and/or online talks that stimulate individual reflection, and (3) writing an obligatory individual reflection essay in 1-2 A4 pages based on their experiences on the topic using the Gibbs reflection model (Gibbs, 1988) (enabling individual reflection, see Figure 1). All assignments must be handled in advance according to the course schedule using the university tool. The reflection essay is the entrance ticket to the online dialog seminar and no essay means no participation. Table 1 presents a summary of all activities in the course and the technology used for each activity.

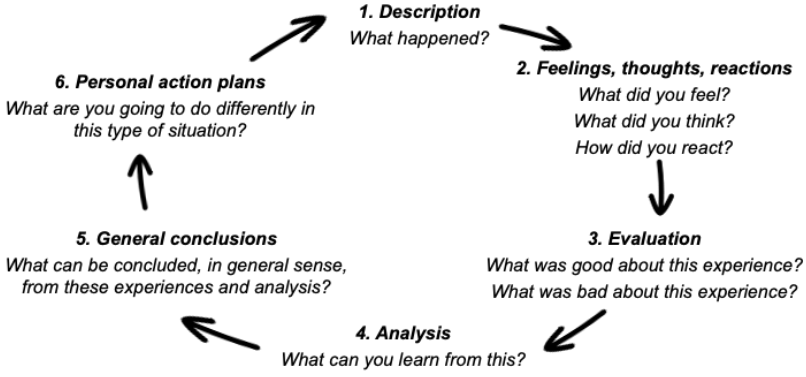

Figure 1. The Gibbs reflection model used when writing the reflection essay.

The students are divided into groups with about 8 students/group and each group is tutored by a seminar leader called a mentor. The mentors in the course are master students from two engineering programs in computer science who have taken an advanced professional skills course with 6 ECTS credits (Berglund, 2018; Berglund & Heintz, 2014). When a group meets in an online dialog seminar each student in the group has about 15 minutes. The first student

Table 1. The structure of the course

Goal	Activities	Online learning technology
Topic introduction	Lecture and workshop	Communication platform - Zoom
Knowledge gain	Study materials	Course web page
Experience gain	Obligatory assignments	University tool 1
Individual reflection	Obligatory reflection essay	University tool 1
Group reflection	Obligatory dialog seminar	Communication platform - Zoom
Student progress	Result reporting	University tool 2, result reporting
Information distribution	Written communication	E-mails

starts by reading out loud his/her own reflection essay (the possibility for individual reflection) and then the group discusses the reflection essay - asking questions and sharing their own experiences, which leads to group reflection and experience exchange. When the time is up it is the next student's turn. The mentor's tasks during the seminar are to make sure that students participate in the dialog, that discussions are focused on the relevant topic, and to keep track of time. All activities in the course are carried out online and the communication tool Zoom is used during interactive in-class activities. During the dialog seminars students are required to use video cameras so all the participants can see each other during the discussions to capture both verbal communication and non-verbal cues. The grades students can get in the course are *pass* or *fail*. In order to pass the students have to pass all the obligatory assignments and reflection essays. They have also to participate actively in all three obligatory dialog seminars.

The Course Modules

The course starts with an introductory lecture that introduces the course goals and outline. The course has the following four modules, see Figure 2:

1. *Personal management* focuses on planning, prioritization, and monitoring of one's own tasks as well as working with long- and short-term planning. The students have three mandatory assignments before writing the reflection essay: (1) A diary assignment: write a diary for 1 week capturing own activities (to increase self-awareness). (2) Self-analysis: analyze the captured data in the diary (to stimulate reflection about own personal management). (3) Planning: plan the rest of the semester (to practice long-term planning) and make a detailed plan for a week (to practice weekly and "day by day" planning) based on the insights from the diary and self-analysis.
2. *Communication* includes effective communication (Guo & Sanchez, 2005), active listening (Robertson, 2005; Tyagi, 2013), and giving as well as receiving feedback using the experience cube (Bushe, 2011). Two mandatory assignments are included in this module and need to be done before writing the reflection essay: (1) Providing feedback: each student must give constructive feedback to four different people. Two people receive positive feedback, and two people receive criticism. The feedback has to be formulated using the experience cube (Bushe, 2011) and a tool for receiving feedback (the feedback stair) is used to understand the reactions of the receiver of the feedback. (2) Practicing effective communication: for at least one week, each student must use at least one tool that makes communication more effective.

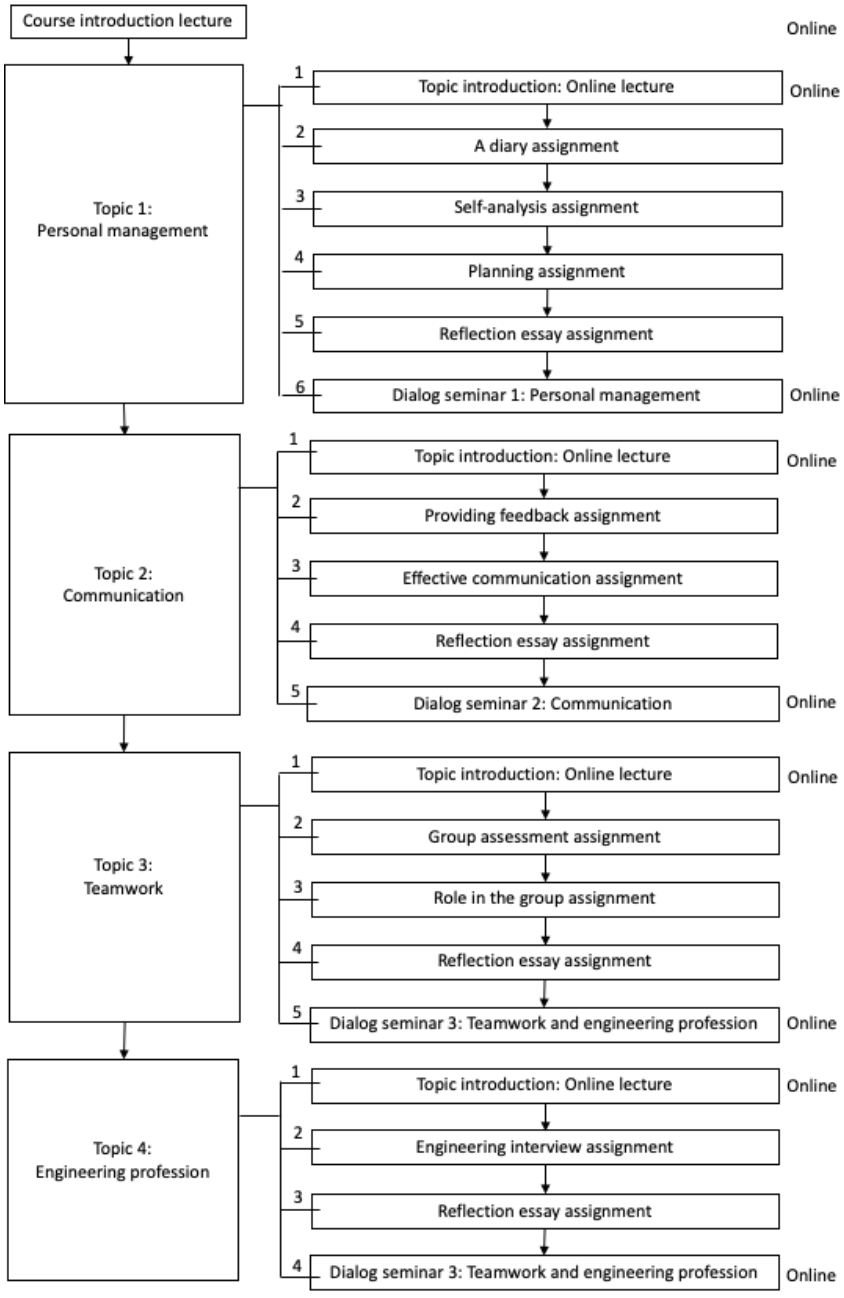

Figure 2. The course modules

3. *Teamwork* containes effective teamwork (Wheelan, 1994), personal effort in interaction with others, and different social phenomena that occur in teams such as social loafing (Liden, Wayne, Jaworski, & Bennett, 2004) and groupthink (Janis, 2008). The development of a group taught in the course is based on Susan Wheelan's Integrated Model of Group Development (IMGD) (Wheelan, 1994). Two mandatory assignments are included in this module and must be done before writing the reflection essay: (1) Group assessment: Each student identifies two work groups (one dysfunctional and one functional) that s/he works for or has worked in and with others. Then, they assess the stage the groups are/were at according to the IMGD model (2) Roles in the group: Identify the different

roles the group members had.

4. *Engineering profession* gives students a better understanding of what they are going to work with in the future. A mandatory interview assignment is included in this module and needs to be done before writing the reflection essay to help students get insights into real life, practice listening, and to develop their professional network. Each student interviews an engineer, who is not a friend or relative, and asks questions about their daily work and career.

COURSE EVALUATION

74 students signed up for the course in the year 2021 and 64 completed the course (87%). The course was evaluated with four surveys: one survey after each dialog seminar (about the topic and related assignments and seminars) and a final survey (about the whole course). Surveys 1-3 were created by the course examiner and sent to the students at the end of each seminar, while the survey 4 was created by the faculty and sent to the students by the central course evaluation system by e-mail after course completion. The response frequency was higher for surveys 1-3 (survey 1: 66 answers, 89.19%; surveys 2 and 3: 61 answers, 82,43%) and lower for survey 4 (19 answers, 25,68%). The results from the evaluations are presented below.

1. The course structure supports students' learning - According to survey 4 the students think that the pedagogical implementation of the course has been supportive of their learning (average score 3.21 on a scale from 1=not at all to 5=absolutely, standard deviation = 1.4). Most of the students find that the course is relevant to their education (average 3.89, standard deviation = 1.29). Looking at the students' comments about the course we see that the students who appreciate the course can see its relevance to the engineering profession as well as their own personal development, such as this comment:

> *"Important course for engineers. Fun course for personal development. Important topics to talk about and reflect on."*

The average overall grade the students give the course is 3.47 (standard deviation 1.26) in survey 4 and 3.48 in survey 3 (standard deviation 1.01). Looking at the comments from survey 3 we see that some of the students were skeptical about the course before they started the course and then changed their opinions as the course progressed, e.g.:

> *"A VERY good course. I did not think I would like it before I started, it felt fuzzy at first. But after the first dialog seminar, I really started to like it and appreciate how important it was to prepare one as an engineer after graduation."*

Students appreciated the content of the course and understood the importance of learning the topics highlighted in the course. Students felt that the course prepared them for their future professions, gave them an understanding of the engineering profession, and helped them to develop personally. Some students had positive attitudes towards the fact that the course was given online. However, some students thought that the dialogue seminar was rewarding, but that it did not feel natural to have it in Zoom. One of the challenges with having seminars in Zoom was that many students talked at the same time.

"Even though everything has been remote, it has worked very well. I thought it was very rewarding to write a diary like we did during the first assignment."
"Seminars in group worked very well in remote mode."

2. Course modules are rewarding - In the third survey at the end of the course the students were asked to choose the most rewarding modules of the course, see Figure 3. Students highlighted the following regarding the question about what they had learned from the assignments and seminars in each module.

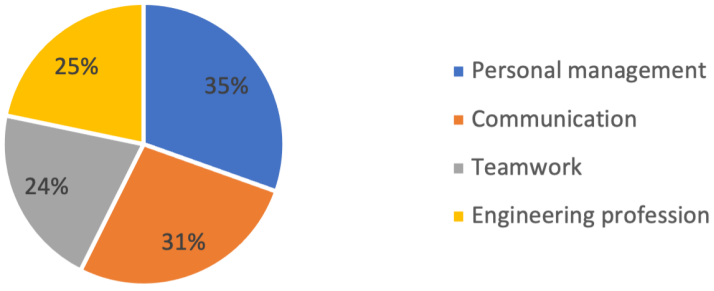

Figure 3. Most rewarding parts of the course

- **Self-insights gained from the personal management assignments:** Students got an understanding of their behavior and study situations regarding how they used their time, how they did things, how they didn't do the things they said they would, how little they studied, how much they played video/online games, and how much they used their mobile phones. The understanding led to self-insights such as better usage of time, doing the things they intended to, and that mobile usage should be reduced. One student wrote the following comment:

  "The task allowed me to take a step back and see myself in the mirror. Analyze how I feel today, what I do, how my studies are going. I have got a slightly changed picture of myself. And knowledge of something is the first step to being able to do something about it, improve it, understand it."

- **Learning about how to be more effective:** Some students mentioned that they got ideas on how to be more effective by doing the assignments and discussing them with other students. Students learned that there are several ways to plan and structure and that it is important to find what works best for yourself. One student wrote the following comment:

  "DIVIDE THINGS INTO SMALL GOALS. God what an effective tool!".

- **Learning about study techniques:** Students learned study techniques and studying effectively by, e.g., taking micro breaks while studying and using an app to lock the mobile phone and not be distracted while studying.

- **Learning about mental and physical health:** Students gained an understanding about how health affects one during the day in general and one's studies specifically. They came to know more about the impact and importance of mental health on one's studies, understood the impact of physical health, and said they would try to get more exercise.

- **The importance of giving well formulated positive feedback and criticism:** many students highlighted that it is difficult to give feedback in general and criticism specifically. However, they understood the importance of feedback and that they could become better at it by training. Furthermore, they came to understand that there are good and bad ways to give feedback and that it is important to be open to feedback.
- **Receiving feedback:** students commented that they learned about how people react when they receive feedback, and how to think about or manage one's own emotions and the emotions of others when receiving feedback. One student had the following comment:

  "One's reaction to particularly positive feedback often plays a big role in how the person who gave the feedback will communicate with one in the future."

- **Effective communication and active listening:** Students noted the importance of how a person formulates what s/he wants to say to communicate effectively and also the importance of listening, how to listen both in general and when receiving feedback specifically.
- **The leader role:** Students highlighted how important it is to have a leader in some groups, although a leader may not always be needed, and that a good leader can bring out the best in people.
- **How to work effectively in a group:** Students highlighted the importance of working effectively in a group and noted that many aspects affect the group work, e.g., communication, group formation, group processes, personal responsibility in group work, being able to take and give criticism within a group, and addressing conflicts before they explode, even if it is difficult. One student had the following comment:

  "I take with me how in groups you may need certain types of people and also that a leader may not always be needed."

- **Learning about the engineering profession** - Students reported that they gained insight into the skills that are considered important to an engineer and the importance of professional skills for the engineering role.

3. Seminars are rewarding - After each dialog seminar students were asked about how rewarding they thought the dialog seminar and the related assignments were on a scale from 1=not so rewarding to 6=very rewarding, see Table 2. In the fourth survey the students were asked to choose the most rewarding elements in the course, and according to the survey the dialog seminar was the most rewarding element of the course, see Figure 4. Many students commented that they wanted to choose other moments, but since they were forced to choose one, they chose the most rewarding one. The following issues were identified from students' comments on what worked well in the seminars and what should be changed in the seminars:

- **Learning together through discussions and experience exchange with supervision:** Students appreciated the opportunity to have discussions with other students since they exchanged experiences, shared knowledge, and gave tips to each other, which provided useful new perspectives on certain things that they might not otherwise have thought about, for example to take ideas that had worked for others and test them for themselves.

Several comments stressed the importance of having an open atmosphere during the discussions, that students and mentors respected each other, and that the safe atmosphere in the dialog seminars helped students share their own experiences, thoughts, and feelings. Students also addressed the importance of the seminar leaders for managing the quality of the discussions and creating a trustworthy and open atmosphere. Some of the students had the following comments:

> *"I think the dialog seminar has good structure and leads to good discussions. It was also good that our mentor could help by asking good questions when it got quiet."*
> *"It felt like you were in some kind of group therapy"*
> *"Everyone got to speak and the mentor did a good job of letting us talk, but at the same time keeping the discussion alive"*

Table 2. How rewarding are the seminars and related assignments according to the students

Dialog seminar number	Dialog seminar	Related assignments
1	4.64	4,21
2	4.57	3.92
3	4.77	4.87 (engineering profession)
		4.13 (teamwork)

- **Seminars made it possible to see differences and similarities:** Students mentioned that they developed an understanding that people work differently and that something that works for one person does not necessarily work for another person. Students also highlighted that they felt that they both recognized themselves in each other and understood that they had different challenges in some cases and similar challenges in other cases, e.g.:

> *"I've learned that we all sit in the same boat – even though we can't see each other in it. We all have similar problems and try to solve them in a similar way. Everyone has problems with social contact, motivation, and monotonous everyday life. It feels good to know that you are not alone and can take comfort from it. I also got a lot of good tips on how to do things better or differently."*

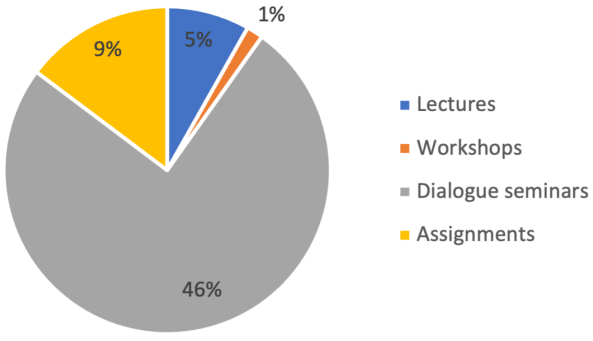

Figure 4. Elements of the course that have been rewarding.

- **Obligatory assignments, preparations, and seminars contribute to learning professional skills:** According to some students, the requirement of doing the assignments

before the seminar was troublesome, but doing the assignments helped them to get insights about themselves, gave them the opportunity to do things in different ways than they were used to, and forced them to reflect. It is also important that obligatory active participation in the seminar was part of the examination, since it forced the students to be active, ask questions, and contribute to the discussions. This led to students being engaged in the discussions, which was very important for their learning. Groups with less engaged students got less out of the discussions. The mentors adapted the structure of the discussions to the students' level of engagement.

DISCUSSION

In the online professional skill course, students learn professional skills through the activities in the course and knowledge is gained when performing course activities focused on the specific topic (e.g., obligatory assignments) but also during discussion among students in online seminars.

Focusing on the three types of interaction (student interaction with online content, student interaction with remote teachers, and student interaction with distant student peers) is important in online courses (Abouhashem et al., 2021; Bernard et al., 2009; Luo et al., 2017) even for teaching professional skills. In the course, lectures were scheduled and given online by the teacher with the possibility of interaction with the students (enabling student interaction with remote teachers). With a modification of having online dialog seminars, the dialog seminar method was applied in the same way as in the professional skills course with face-to-face teaching (Berglund, 2018; Berglund & Heintz, 2014), enabling both student interaction with distant student peers and student interaction with remote teachers. We believe that this contributed to the positive outcome of the course since students' engagement in online courses is increased when students think, reflect, engage, and learn collaboratively with other students (Aderibigbe, 2020). However, a challenge in online discussions is turn-taking, where students talk over each other more easily compared to face-to-face seminars. One of the benefits of online dialog seminars is that the students do not have to print the texts in advance to bring them to the seminar as is required for face-to-face seminars. The students can only share their texts on the screen, which is easier for the students and beneficial from an environmental perspective. Another drawback of online seminars is that in face-to-face seminars students interact with each other during the break, which is not possible in online seminars since students leave the online session during the break. Therefore, the students might get to know each other less in online courses, leading to less networking among the students.

To have a successful implementation of the dialog seminar method online it is important that the video camera is used during the dialog seminars. When groups work together remotely and use video in addition to audio the quality of their work is the same as in face-to-face work, which is not the case if only audio is used (Olson, Olson, & Meader, 1995). Using cameras in online teaching helps to build teacher-student and student–student relationships (Castelli & Sarvary, 2021). The camera provides "virtual eye contact" that can create engagement during the discussions. When students look directly into the camera it will give the impression that they are directly speaking to each other and looking right at each other. Another benefit of using the camera is the ability to communicate with nonverbal cues such as smiles, head nods, looks of confusion, and looks of boredom, which help the seminar leader to evaluate the situation in

real time and adjust accordingly to improve student learning. Students benefit similarly from being able to see other students during seminars since they can see how the other students react to things they say. The use of video helps build trust with other students in the group and develops a sense of identification with others (Falloon, 2011). Students learned during the discussions in the seminars when they exchanged experiences, shared knowledge, and gave tips to each other and they stressed the importance of having an open and safe atmosphere during the discussions so they could share their own experiences, thoughts, and feelings. The seminar leader plays an important role in creating a trustworthy and open atmosphere.

CONCLUSION

This paper describes students' experiences and lessons learned from an eight week reflective and online course in teaching professional skills that was applied in two bachelor engineering programs. According to our experience, professional skills can be taught successfully in online courses and applying a dialog seminar method in an online course is a suitable pedagogy for learning professional skills since, during the online dialog seminars, students think, reflect, engage, and learn collaboratively with other peers.

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BIOGRAPHICAL INFORMATION

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