

The Effect of Real-World Capstone Project in an Acquisition of Soft Skills Among Software Engineering Students

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Abstract— Research suggests that employers value various soft skills highly when recruiting software engineering (SE) graduates in the software industry; however, SE graduate students tend to lack those soft skills. This study examines the effects of a capstone course with a problem/project-based approach in the acquisition of soft skills. In this capstone, the graduate students worked closely on a real-world project with the customers from Finnish public and private organizations. Moreover, the study maps out the identified soft skills from the capstone course to the desired requirements of soft skills in various roles in the software industry. Thematic data analysis of reflections given by 48 students identified fifteen soft skill categories that are mainly acknowledged by the students after the completion of the course. In particular, we have shown that the majority of identified soft skills in this course correspond to the desirable soft skills in the software industry. To conclude, the approach taken in this course is a powerful means to improve the soft skills of the graduate students to meet the needs of employers, and thus increase their employment prospects.

Keywords—Capstone, Project/problem-based approach, design thinking, soft skills, Real-world project

I. INTRODUCTION

Skillsets that information technology (IT) professionals should possess in the modern technical jobs has dramatically changed due to the rapid evolution of information and communication technology (ICT), various software development approaches, a growing number of users, and competition [1]. Regardless of work setting, presently, there is a growing expectation that IT professionals should possess both hard skills also known as "technical skills" and soft skills also known in the literature as "non-technical skills", "people skills", "social skills", "generic competencies", or "human factor" [2] and incorporate such skillsets into their daily practice and decision-making. According to a Cimatti [3], "soft skills give hard skills the required plasticity to develop and keep up-to-date in changing circumstances" (p.99). For example, during software product development, IT professionals are expected to interact with various stakeholders such as customers or users of their software to capture their needs and deliver the value for them. In such circumstances, a set of soft skills aids in communication and promotes problem-solving, negotiation, conflict resolution, and team-building [2]. A recent report indicates that the employer views soft skills as an essential factor in hiring and career development of IT professionals and that current graduates lack these skills [4]–[6]. Thus, to accomplish this, upcoming IT professionals need to develop their soft skills in a realistic environment during their study.

Previous studies have emphasized that capstone projects can be an effective means to train both the hard and soft skills

of the software engineering students [7]–[11]. During the course of the capstone projects, students apply the previously learned skills, deepen the understanding of the acquired knowledge, extend the area of knowledge, and apply their knowledge and skills in a realistic simulation of professional experience in the university environment [12]. Additionally, capstones have been recommended by the Association for Computer Machinery (ACM)/ Institute of Electrical and Electronics Engineers (IEEE) [13], [14] in their curriculum guidelines on both Computer science and software engineering undergraduate programs as well as in Software Engineering Body of Knowledge (SWEBOK) V3.0 [15]. In her influential study, Cimatti [3] pointed that in order to acquire soft skills, only the realistic simulation of professional experience in the university environment is not enough and requires the support of more experienced people who have already achieved professional results is fundamental, followed by experts' seminars, coaching, and tutoring. A likely explanation is that universities and industry do not always see the importance of different skills in the same way [16], [17].

The aim of this study is therefore to (i) examine the effect of capstone course with the problem/project-based approach in the acquisition of soft skills among graduate students after working closely on a real-world project with the representative from public and private organizations; and (ii) map the results of the findings to the desired requirements of soft skills in various roles in the software industry identified from the previous literature.

The article is structured as follows: Section II provides the related work on the desired requirements of soft skills in various roles in the software industry. Section III provides 3-years of capstone development at LUT University, Finland. Section IV provides the methodological approach. We discuss the results in Section V, discussion (section VII) and finally, we present the limitation of research (section VIII), conclusion and future work in section IX.

II. DESIRED REQUIREMENTS OF SOFT SKILLS IN VARIOUS ROLES IN THE SOFTWARE INDUSTRY

This section details the desired requirements of soft skills identified by the previous literature in various roles in the software industry. Ahmed et al. [18] reported a reflection from the software industry about soft skills requirements in various roles and phases of software development. The study illustrated that communication skills, interpersonal skills, and analytical problem-solving skills, team player skills, organizational skills, and ability to work independently as well as the open and adaptable mindset to changes are the desirable soft skills in system analyst, computer programmer, software

designer, and software tester roles. They concluded that all soft skills are essential for software development and can help tackle the so-called software crisis. Besides, they reported that the software industry is paying attention to soft skills while hiring, but there is a need to acknowledge the role of these skills in software development further.

Similarly, Matturro et al. [2] conducted a study of software companies in Uruguay to determine their perception about the soft skills they consider the most valued to have by their teammates, being either the team leader or the other members of software development teams. The study illustrated *leadership, communication, customer orientation, interpersonal skills*, and *teamwork* are the most valued for team leaders, while *analytics* and *problem-solving*, *commitment, responsibility, eagerness to learn, motivation*, and *teamwork* are the most valued ones for team members.

Stevens et al. [19] interviewed 26 people from the software industry, local and regional government, private tertiary educators, and professional bodies. The authors applied the grounded theory to identify the crucial soft skills sought by IT employers to help tertiary educators clarify industry priorities. The study identified eight categories of crucial soft skills (i.e., communications, interpersonal skills, managing yourself, attitude, aptitude, understand business drivers, teamwork, and cultural fit) sought by IT employers.

Florea et al. [20] analyzed 400 job advertisements for software testers from 33 countries, of which 64% ask for soft skills. Of the advertisements asking for soft skills, there is, on average, a request for five soft skills, 11 testing skills, and five technical skills. The study found out that, *communication skills, team-player, fast-learner, independent-working, having openness and adaptability skills, work ethics, customer focus, pro-activeness, responsibility, ability to work under pressure, focus on details, focus on quality* and *commitment* were the essential soft skills desired by the industry.

The previous literature review shows that *communication, interpersonal, analytical and problem-solving skills, team player, organizational, ability to work independently, open and adaptable to changes, attitude, aptitude, commitment, responsibility, eagerness to learn, motivation, leadership, customer orientation, cultural fit, fast-learner, work ethics, understand business drivers, pro-activeness, ability to work under pressure, focus on details, and focus on quality* are the desirable soft skills in various roles in the software industry.

III. 3-YEARS OF CAPSTONE COURSE DEVELOPMENT AT (LUT UNIVERSITY, FINLAND)

In this section, we present an overview of the 3-year development activities of a human-centric capstone course designed and implemented at LUT University, Finland. Capstone course, as such, did not exist in the software engineering curricula in LUT University, and at the time of the latest accreditation of the programme, this course was added to the programme, as guided by the ACM/IEEE software engineering curricula guidelines. These guidelines state that the capstone should a) span a full academic year, b) emphasize group work, c) emphasize real implementation that d) goes over concept implementation. Also, the project should have a “real customer” other than the supervisor. The curricula did not make a full-year implementation possible, and as such, we designed the capstone for half a year implementation. Otherwise, the requirements were feasible. We took the design

thinking methods and agile practices in the project lifecycle as a starting point. The learning objectives of the course were as:

- Plan, estimate and monitor a software project iteratively and incrementally;
- Understand design thinking methods and usability techniques and, their practical application into a project’s lifecycle;
- Implement as software system from scratch;
- Familiarize with contemporary development tools and environments;
- Use modern software engineering practices to plan, monitor and deliver a realistic software project that meets the Stakeholders needs, is highly usable and sustainable;
- Understand the new business challenges and opportunities for their software projects.

The human-centric capstone course was offered for the first time in the academic year 2016–2017 with the title “Running a software project”. Details on course design and outcomes are reported by the authors in a previous study [21]. Although the applied approach in the first course was highly successful and led the students to acquire hard and soft skills, the course had some weaknesses. For example, the project idea was student-generated based on the project theme provided by the teaching team. Students could adaptively adjust the specifications during the project period if they had any challenges with their topic. Although the projects had open testing days (class internal and public), the projects were more of an innovation project than real customer-led implementation projects.

In order to correct the weakness, in 2017-2018 (the second iteration of capstone course), the course adopted the same Design Thinking (DT) and agile practice approach as in the first iteration with the real-world project topics. During this iteration, the project customers were searched from the university environment, and they provided the project challenges and mentoring to the students. The most significant change for the students was that the customers set the requirements, and they have to meet regularly with the customer. The students manage to solve one real challenge. The result showed that in half a year capstone project students had many difficulties maintaining their focus on development because of heavy workload creating feelings of stress (i.e., meeting with the customer, gathering their requirements, taking design thinking education and user interface (UI) design lectures, in parallel implement those new skills from the lecture towards the project.

Therefore, in our third iteration of the capstone project in the academic year 2018-2019, we tested a problem/project-based approach developed by Aalborg University [22]. In this approach, the semester project work is supported by 3-4 (theoretical courses) that provide the basis for the project work. In our case, the User Experience (UX) design course was organized separately in parallel with our course, and as such, the students in the capstone could focus more on the project management, stakeholder communication, and development. The following three learning objectives were extended (in addition to the original objectives):

- Collaborate in small groups towards a common goal to align with customer and end-user needs;
- Design a solution based on the problem presented so that it is meaningful and have an effect on individuals and communities;

- Client satisfaction with the project deliverables.

In order to help students to work in a real-world project with a real client, external to the university, the instructor responsible negotiated with the representative from Finnish private and public organizations to act both as the client and a mentor to the students. In this implementation, the following companies and tasks were given to the students (see table 1):

Table I. CAPSTONE PROJECTS IN in 2018-2019.

Customer organization	Project topic	Students per team
City of Imatra (<i>Public organization</i>)[23]	Ekolikko – digital service platform and currency for Imatra city to engage citizens and reward for everyday tasks.	5
City of Imatra (<i>Public organization</i>)[23]	eMenu – a digital platform for school food management.	5
Seepia Games (<i>Private organization</i>)[24]	Seepia – recreate one of company's existing games (i.e. Carrot Patch Heroes available on Facebook messenger) at a proof-of-concept level with an almost entirely new set of technologies.	6
Stora Enso Metsä Oyj (<i>Publicly listed</i>) [25]	Lockable – digitalize the process of locking and testing of safety locks in the mill.	6
Polytekninen Willimiesklubi Ry (<i>Private organization</i>) [26]	Kyykka.com (NKL) – Design an online tool that league organizer could upload game scores, statistics on teams, players and seasons.	5
Assetti Oy (<i>Private organization</i>) [27]	Assetti –a mobile application to manage company properties and handle the notes sent by tenants.	6
Seefo (<i>Private organization</i>) [27]	SeeFoDev –financial management tool targeted towards small companies.	6
Visma (<i>Private organization</i>) [28]	Pikadev –a recruitment platform, which applicants can show their programming skills to companies.	5
Savox (<i>Private organization</i>) [29]	Vision system configuration tool – a digital platform that updates different hardware connected to the system.	4

Also, the course adopted the team member evaluation, which was only visible to the instructors in order to evaluate the team members' contribution to the group and equitably distribute the grades. Further, in the beginning, each team were asked to collaborate with the companies to prepare the Intellectual property rights (IPR) agreement. The aim of this was to enable full utilization of the results after the project. However, the agreements missed a clause on what happens if the company needs or wishes the team to continue the work in the case of taking the product into production, i.e. transferring the ownership and maintenance to the customer.

In the following analysis of the capstone project, we focus only on the third implementation of the capstone course (i.e. the academic year 2018-2019) with the above-mentioned learning objectives.

IV. RESEARCH METHODOLOGY

A. Data collection

At the end of the course (the academic year 2018-2019), all the students were asked to write a report (response rate for the reflections was 100%). In particular, they were asked to reflect to the project life cycle with the following elements:

- project management;
- involvement and interaction with the customer;
- technical development aspects;
- future plans with the project;
- the overall team what team acquired from the course;
- what each individual acquired from the course.

All students returned their reports in written form. In addition, customer feedback on their experience was collected merely via emails and phone calls.

B. Data Analysis

Because the results presented in the current paper are based on the qualitative assessment of the reports made by students from each team, the process of data extraction and synthesis is described below.

Thematic analysis [30], was applied to the reports from the academic year 2018-2019 to elicit the key concepts that are evident in the data. Thematic analysis was chosen as appropriate because it is a commonly used method for describing, analyzing, and reporting themes and patterns in data [31]. Each report was read, and the researcher coded essential sections of the text, and emerging categories were obtained. According to Impellizzeri and Bizzini (2012), "Data extraction must be accurate and unbiased and therefore, to reduce possible errors, it should be performed by at least two reviewers" (p.499). Based on this recommendation, after the reports were coded, another member of the research team reviewed the initial data sets to confirm that the intended meaning was accurate and appropriate for further analysis.

Furthermore, there were no disagreements between the initial datasets. These categories are viewed as essential in determining soft skill acquisition among students. Each skill set labeled is defined by students' acknowledgment of how having a regular engagement with the customer, team members helped them to improve their different soft skills, and how essential these skills are to facilitate the relationship with stakeholders and team members.

C. Data Extraction

Using a template, the relevant data from the student report were registered in to 4 data fields. The metadata included, student ID and team name (S1, team name; S2, team name; [...]); soft skills acquired, coded text that reflects each soft skill set acknowledged by the student. Note that we used related literature to define the various intended soft skills and mapped the soft skills to these. The frequency of the soft skills results based on student's reflection demonstrate that students have acquired various categories of soft skills during the project period. The following section reflects and analyses the acknowledgment made by students on how to have regular engagement with the customer; teammates helped them improve their different soft skills.

V. RESULTS AND REFLECTIONS

After analyzing the sets of reflections, we identified fifteen soft skillset categories that are mainly acknowledged by the

students in this course. These categories have been labeled as external communication; internal communication; interpersonal; responsibility; eagerness to learn; critical thinking and problem-solving; teamwork and collaboration; organizational; ability to work independently; ability to work under pressure; openness to changes and adaptability; motivation; leadership; customer orientation; and conflict management. In some instances, there are some overlap across

these skillset categories. According to Fielden [33], “this should be viewed as a good interpretation of understandings and attitudes in general, which are never made up of isolated concepts but are all relative to each other” (p.5). Further, to understand the frequency of each soft skill categories emphasized by the students individually, we analyzed the data obtained after thematic analysis based on number of times each soft skill was acknowledged (see Fig.1).

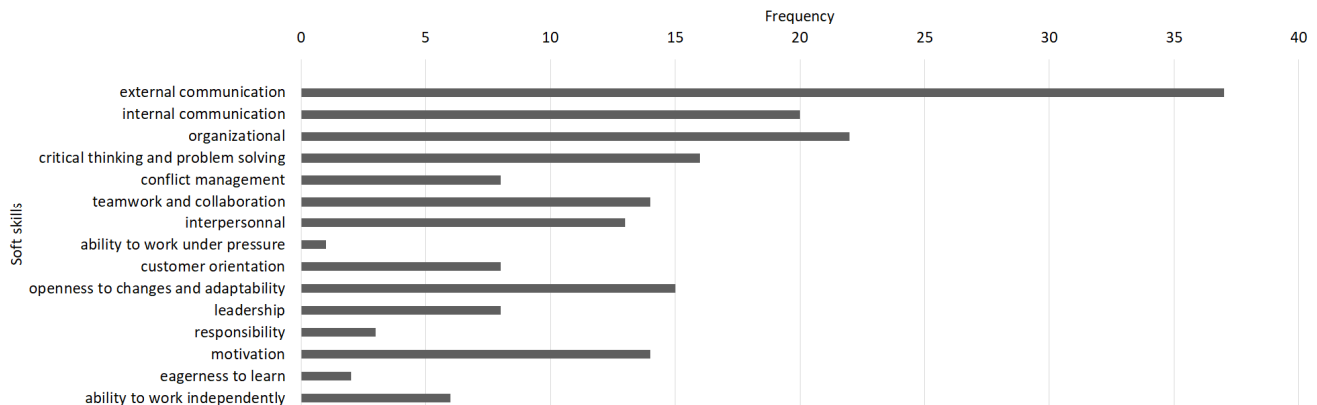


Fig. 1. FREQUENCY OF EACH SOFT SKILLS CATEGORIES ACKNOWLEDGED BY THE STUDENTS (NUMBER OF STUDENTS OUT OF 48 STUDENTS).

External and internal communication skills: According to the analyzed data, students have acquired communication skills such as external (information and ideas exchange with the client) and internal (information and ideas exchange within the team). This reflects the emphasized change in the course implementation nicely. The 2019 course emphasized the communication aspects both externally as well as internally. Out of this, external communication was the most identified soft skill. This may be because of frequent face-to-face meetings with the client, i.e., during the concept phase, development phase, implementation, and testing phase to provide regular status updates and the reviews of the project. For example, acquiring external communication skills, one of the student reflected, "Working with real customers has given me a lot of new experience and this process has solved many of my puzzles about how to cooperate with real customers, such as how to communicate with customers and whether we should rigidly design according to customers' original requirements when we think there is a better solution. I believe these experiences will bring me a lot of benefits in my future career" (S1, eMenu). Similarly, another student (S3, Savox) reported, "The real customer gave us some insight into how to communicate with customers to come up with consensus with the vision." Another student (S2, StoraEnso) reported, "I learned how to, as a team via project manager, interact with the customer and how important it is to communicate with the customer as often as possible."

Along with external communication skills, students also reported they had acquired **internal communication skills**. For example, (S4, Seepia) reported that besides planning and documentation, he learned clear internal communication is needed to provide a constant update to the internal project team members and keep them on same track with the defined goals. He reported, "The project taught me the importance of planning, clear communication and documentation to keep the team on the same track with defined goals". Further, (S5, StoraEnso) pointed, "Communication is important: You should communicate to other team members if you are having

trouble with some task, if you are late to a meeting or if you are not able to participate". Another aspect, which students reflected was, resolving team conflict, how regular meetings and discussions with the team members helped to solve the conflicting ideas: "There were times where there were conflicts of ideas, and we learned how to resolve them by having intensive team meetings and discussions" (S3, Ekolikko).

Organization Skills: Working with the company and the team during the capstone project led the students to feel they had improved their organizational skills. Many described how they had to respect the deadlines and be on time: "One big thing I learned is working with the team. Possibility to work and respect deadlines and to make a customer happy" (S4, eMenu). Other student wrote, "I needed to be on time for our meetings and do the tasks given to me" (S2, StoraEnso). Nonetheless, one student felt he has learned regarding tasks and allocation of activities to other team members and its effect on project contribution. "The project made me realize that it is not as easy to allocate different jobs to different people and expect them to make the same effort towards the project" (S3, NKL). "Lot of small tasks come up in the project, and they should be allocated according to personal skills and resourcing situation" (S2, StoraEnso). Similarly, (S2, eMenu) reported: "In teamwork, a clear task assignment scheme is also very important, otherwise, sometimes team members will carry out repetitive and useless work, or people in the team cannot define the task area of others, resulting in some unnecessary disputes."

Critical thinking and problem solving skills: Another aspect which students highlight is the critical thinking/problem-solving skills, which are acquired in conjunction with the customer/end users throughout the project: "Working with a real customer gave us the knowledge on how we can think that everything is going smooth and in the end, the customer changes his mind and some of the work can even go to waste. We also learned how to handle those

situations and not get ahead of ourselves in case we cannot implement those newly required features team” (S2, Ekolikko). Another student (S4, eMenu) pointed, “Because sometimes, customers cannot clearly express their will. At this point we need to have a better understanding of what the customers are trying to achieve and how the users are using the application”. Other students (S1, eMenu) also quoted, “for every project, we need to analyze provided data to find the potential requirements that customers did not mention.” Such a scenario may have provided students with an opportunity to come out of the box together in a team in recognition of a problem, adopt a new idea, gather the needs/requirements, or create a solution.

Conflict management: On the other hand, the students’ also reported, during the project period, they adopted compromise as conflict style, which involves a moderate level of assertiveness and cooperation [34] to reduce interpersonal conflicts. Reflections from the students showed that they had adopted this conflict style approach because of time constraints in the project, students within the team are more experienced, and had strong desire to resolve the issue: “I learnt to make compromises in situations where one or more team members have very strong opinion that I disagree with” (S2, Ekolikko). “We had to do compromises, because not everyone is going to agree on everything and still the work needs to be done” (S4, StoraEnso). “I learned to cooperate with teammates who had experience very different from mine so that we would come up to an effective solution” (S5, Seefo).

Teamwork and collaboration: When analyzing the reflections, our findings broadly indicate that mutual support from the team members, the balance of team member contribution, coordination, communication and utilizing GitLab were perceived by students as the most critical factors concerning the way they believe teamwork and collaboration skill was acquired. For example, a student from the team (S4, Team Assetti), pointed “Teamwork and collaboration was also really interesting in the project, as team was supporting and helping during the entire lifecycle of the project”. Similarly, other student (S3, Seepia) reported: “I also learned a lot about working as a team on a somewhat more structured software project and managing GitLab”. The result of the present study about the GitLab is aligned with the result from Tushev [35]. According to Tushev [35] GitLab, which falls under the tenets of collaborative learning theory, enforcing such a platform in class is expected to enhance student collaboration and their sense of teamwork.

Interpersonal The student indicated that the way they had opportunities to have an open discussion with a culturally diverse team and customer, respectful and supportive behaviour by other team members, helped them to build the interpersonal skills. The result is in line with Harris et al. [36] who points fostering an open discussion, respectful, supportive to one other is important in building the interpersonal skills. For example, student (S3, Seefo) reported, “I learned from this project how to cooperate with team members of different backgrounds. We respected, supported each other’s in different stages of the project”. This means student recognized that each other have unique personalities but the similar goal, i.e. to complete the capstone project successfully. They showed consideration for each other, respected and supported during difficult times during different stages of the project. Similarly, another student (S5, Ekolikko)

reported: “In this course, I learned how to openly discuss with team members and customer, be supportive and show respect and commitment to the team”. Further, the same student also expressed, “Working within a team of individuals with different mindset helped me to better myself and have better control over a different aspect of work and life”.

Ability to work under pressure: Out of 48 students, only one student mentioned they improved the ability to work under tight-deadlines due to the involvement of real customers: “A real customer also put some time pressures on work and the need of delivering something every once in a while.” (S1, Savox). The theme of ability to time pressure has previously been identified by Kuuttila et al. [37] in their review time pressure in software engineering in terms of the effects of time pressure on software development. The study showed that increased productivity and decreased quality under time pressure.

Customer Orientation: Customer orientation is regarded as a student’s ability to create and deliver superior customer value by acquiring customers’ needs and wants, analyzing those needs and wants, creating a plan, and disseminating those needs and wants. Students reported that having a real customer help them to improve their skills in customer-relations where they manage to help customers to meet their needs and wants. One student (S5, StoraEnso) reported, “Yes, I got to experience talking to a customer and letting the real users come up with solutions or functions for the actual project.” Another student (S4, Ekolikko), “We learned how to work closely with the customer, end users and deliver the solution on time with great satisfaction.”

Openness to changes and adaptability: The students described that collaborating with the real users and customers exhibited adaptability and openness to changes. One student from the team (S4, StoraEnso) put like this: “I learned how changes in customer’s thoughts could change the project itself, and we need to be ready for any changes even at the last phase of the project to see through that the project succeeds”.

Leadership: We also found that students took more **responsibility** than previously held capstone courses. For example, working in team, individually managing the project, having interaction with customer helped students to acquire the leadership skills in this capstone course. For example, one student stated, “Being a project manager in this course, I learned how to build a team, take responsibility, set the goals, motivate and inspire others to come together and share a common vision and execute the project” (S2, StoraEnso). Also, an interesting observation can be noted that the report is while working on the project, some students who were not leading the project also acknowledge the importance of leadership. For example, “My finding rests in understanding how important the role of the leader in a group of people is, especially when they have the same interest. If there is no leader, it would be rare if the team would produce something special. I think I can work on myself too and withdraw a bit from my habits” (S4, Savox).

The participants also described how an involvement of the real customer, collaborative team improved the **motivation** to complete the project on time one student (S3, Ekolikko) described: “I manage to set my goals, and felt more satisfied after working with the real customer in an interesting project topic/case, instead of practicing for the sake of practicing”. Further, students also demonstrated an **eagerness to learn**

skillset by learning and acquiring new knowledge to develop their skills further. For example, the student reported “One of the requirements from the customer was solution should be designed in Qt. It was a totally new language for me; however, I took the challenge which ended up being pretty useful for software like this” (S2, Savox). Similarly, other student reported, “During the tenure of working with the project, I got to learn new programming language” (S4, Ekolikko).

Student pointed that because of the technology and availability of the various tool, during the capstone project remote working was possible with the team: “I also noticed that working remotely is not that hard, because there are a lot of alternative choices to work with team even when all members are not in the same location”. (s4, eMenu.). This means, by working remotely, the student also exhibited their **ability to work independently**.

VI. MAPPING OUT IDENTIFIED SOFT SKILLS TO THE DESIRABLE SOFT SKILLS IN THE SOFTWARE INDUSTRY

One of the objectives of this study was to map out the soft skills identified by the previous literature with the identified soft skills from this study. To meet this objective, we compared our analysis presented in the section V with the skills identified by [2], [18]–[20]. Table II. maps out the identified soft skills from this study to the desirable soft skills in the software industry.

Table II. IDENTIFIED SOFT SKILLS FROM THIS STUDY TO THE DESIRABLE SOFTSKILLS IN THE SOFTWARE INDUSTRY

List of desirable soft skills in the software industry	frequency of each soft skill categories acquired (number of students out of 48)
external communication	37
internal communication	10
interpersonal	13
critical thinking and problem solving	16
team player	14
organizational skills	22
ability to work independently	6
adaptability and openness to changes	15
motivation	14
leadership	8
customer orientation	8
responsibility	3
eagerness to learn	2
ability to work under pressure	1
attitude, aptitude, commitment, cultural fit, fast-learner, work ethics, understand, business drivers , pro-activeness , focus on details, focus on quality	Not mentioned

As shown in Table II, we can observe that the majority of identified soft skills in this course corresponds to the desirable soft skills employers in the software industry. However, some soft skills couldn't be mapped out to the student's reflection since the student did not pinpoint every skill set what they acquired during the course. Nevertheless, we can assume that student may have acquired a skill set except “understand business divers” soft skills because, without those skill sets, they would not have completed the project on time with positive feedback from the customer. Further, with regards to “understand business divers” in this course, students were not

obliged to identify and monitor the key drivers of the business that reflects the performance of the business or the product.

VII. DISCUSSION

A. Soft skill set obtained in this course and its implication towards software industry

IT professionals may involve performing tasks in various roles with individual or team with different personalities that are shaped by cultural background, life experiences, and values [38], [39]. According to Smite et al. [40], “Large software development projects involve multiple interconnected teams, often spread around the world, developing complex products for a growing number of customers and users” (p.1). Succeeding with such level of development requires IT professionals to have excellent communication, coherent teamwork and collaboration skills. However, new graduate software developer may face many challenges in terms of soft skills such as communication, teamwork and collaboration, when transitioning to the workforce and entering into such level of large software development projects. At the same time, graduates nowadays are expected by the employers to not only obtain good degrees and excel in their academics but also to equip themselves with soft skills [41]. Therefore, the new graduate students need to have already knowledge of how to cooperate effectively in cross-cultural settings.

The acquisition of both types of communication skills during the project may help students to fulfill one of the requirements set by most of the employers and help them to find employment. On the other hand, having improved communication (i.e., external and internal) skills not increase the employability prospects among students but also to be more confident:

(i) when communicating with future customers with non-technical skills, understand customer empathy;

(ii) sharing technical knowledge with non-technical team members and to ask the right question of technical experts,

(iii) resolve conflicts which then leads to increased productivity and business sustainability[42].

Regarding, the teamwork and collaboration soft skill set student gained through this course, might be useful for students to handle the complicated situation, collaborate with a diverse workforce work, efficiently use the collaborative platform, collaborate with the number of customers and users, including experienced mentors and coaches.

The previous study of [43] have pointed skillful conflict management is not part of the dominant high-tech culture, and poor conflict skills at all levels of the technology development environment are the basis for impaired productivity, tremendous loss of revenue every year. The conflict management skillset student gained through this course might be useful to introduce such a skill set in the industry by the students after getting the foothold in the software industry. As critical thinking/problem solving is being required from students in their personal and professional life [44], the acquisition of such skill set from this course may enable them in future (i) to think creatively and make better decisions, (ii) increase innovation behaviour and opportunity perception [45].

Software industry frequently requires individuals to manage tasks within time, resource, and sequence of execution [18]. For IT professional(s), this requires strong organizational skills. Having soft skills acquisition from this course may help the student to establish a sense of trust and professionalism with their clients and associates in their future careers. Not all the students in the course will work as developers in the software industry, some students who may have various roles, such as project managers. In such a case, the organization skill acquired from the course may help students bridge their skill gap between the industry and academia with regards to project initiation and execution and effective project closing, defined as project managers' closing competence (PMCC). PMCC which consists of five dimensions identified by [46], i.e., knowledge and skills, external stakeholder management, leadership in the project team, and organization-level ability.

Thus, we believe this the skill sets obtained in this course will help students to facilitate open discussion, collaboration, team working, cultural and diversity awareness, respectful and supportive behavior in their future career.

B. Summarizing teachers reflection on third iteration of capstone course

Although not the primary focus of our study, this section also summarizes the course teacher's reflection on the third iteration of the capstone course delivered in the academic year 2018-2019. Research suggests in teamwork, especially in larger teams, some team members tend to freeride. The course implementation tried to prevent this by having a team contract signed by each team member and weekly reports on the work done. Regardless of this taken approach, it turned out some issues in one large team (6 members) or distributed (team members located in different cities); the team control failed. Such was identified during the peer evaluations at the end of the course. However, students did not reveal this during the project, but in the end. Even customers could not see this as project managers took care of customer communications (with a limited set of team members).

We also found that students took more responsibility than previously held capstone courses. For example, teams organized and had frequent meetings with their customers. In the case, the customer was not responding due to their busy schedule, teams continuously sent them an email or called to have the meetings and received their feedback. One of the reasons may be students were more customer-oriented, as reflected by the students in their report.

To conclude, all the customers were satisfied and felt that teams were able to (i) understand their needs, (ii) worked closely, (iii) communicated clearly and effectively, and (iii) executed the project promptly. One example is that customers representing the public organization recognized and rewarded the team Ekolikko as an appreciation for delivering the outstanding solution promptly. Likewise, one customer commercially implemented the project "NKL" [26], whereas team "Pikadev" started the startup. Furthermore, another customer from the private organization wanted the team to take the solution into production. Although the customer was happy with the prototype, we also learned that they decided not to continue because it was not technically the right approach for them.

VIII. LIMITATIONS OF THE RESEARCH

As Wagner et al. [47] state, "All research studies have some limitations, and this study is no exception" (p.279). The first limitations deal with the datasets, i.e., the student's reports to the project life cycle. In this study, students reflected on the predefined topics, including "overall team what team acquired from the course," and "what each individual acquired from the course to identify soft skills" instead of conducting a survey using the set of soft skills identified by the related research. Another limitation of the work is customer's feedback on student's soft skill acquisition. All the answers were collected from customers on overall project implementation and their satisfaction instead of students acquiring soft skills merely via emails and phone calls. This may have limited the result on customer's feedback. Future studies could include customer's feedback on student's soft skills development throughout the project life cycle. Additionally, the threat to generalizability in this study is reactivity, also known as the Hawthorne effect; this concerns research participation, the consequent awareness of being studied, and the possible impact this has on behavior [48], [49]. Some teams filled out the report in the classroom settings, which may impact their behavior and influence their views toward the reflection.

IX. CONCLUSION AND FUTURE WORK

Recent literature has highlighted the relevance of soft skills for software engineers (SE) graduate students to increase the employability prospects. Teaching these soft skills to graduate students at the university is vital. This work's strength lies in its attempt to examine the effects of capstone course with real-world problem/project-based approach in the acquisition of soft skills among graduate students after working closely with the representative from public and private organizations, including end-users and teammates. Moreover, the results of the capstone course's findings were then mapped with the desired requirements of soft skills in various roles in the software industry.

This study concludes that the capstone course emphasized in this study (i) affects students acquiring various categories of soft skills during the project period; (ii) fulfilled the majority of desirable requirements of soft skills set by the employers in various roles in the software industry. Besides the soft skills acknowledged by the students, an additional effect can be seen from the successful transition of the project into commercial products by some companies and students. Therefore, it can be concluded that the approach taken in this course is a powerful means to improve the soft skills of the graduate students to meet the needs of employers and thus increase their employment prospects. Additionally, our results also laid the groundwork for a new approach while teaching critical thinking in software engineering. For example, in their recent review, Bezanilla et al [3] indicated that teachers use and consider mainly three different methodologies to teach critical thinking (i.e. oral and written reflection and argumentation; reading, analysis and synthesis of resources; and case studies) and requires additional approach.

Overall, this third iteration of the capstone course has shown a several positive effects. The positive effects are: (i) better engagement of the teams due to external real-world customer; (ii) more effective development process due to the PBL approach, i.e., separation of theoretical aspects from the actual development; (iii) more complex requirements

management in projects. However, the course still has the potential for improvement in (i) timely communication in online team communication tools; (ii) an unequal load of team members; and (iii) overall project management. Therefore, in the 2020 course, the emphasis is given more towards holistic project management. For such, LUT University has invested in standard tools (You Track, Jira, and GitLab) that can be used by the students for the management of the projects.

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