Facilitating learning and startup formation in experience-based courses—A team-centered model

Cico, Orges[1]; Jaccheri, Maria Letizia[1]; Nguyen Duc, Anh[2]
[1]Department of Computer Science - Norwegian University of Science and Technology, Trondheim, Norway
[2] Department of Business and IT, University of South-Eastern Norway, Horten, Norway

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Facilitating learning and startup formation in experience-based courses—A team-centered model

Orges Cico
Department of Computer Science
Norwegian University of Science and Technology
Trondheim, Norway
orges.cico@ntnu.no

Letizia Jaccheri
Department of Computer Science
Norwegian University of Science and Technology
Trondheim, Norway
letizia.jaccheri@ntnu.no

Anh Nguyen Duc
Department of Business and IT
University of Southeast Norway
Bø i Telemark, Norway
anh.nguyen.duc@usn.no

***Abstract*—Context: This full research paper presents an experience-based course designed around a semester-long external Innovation Bootcamp. Objective: We evaluated the impact of the Innovation Bootcamp on students' learning and startup formations, measuring how it affected students' perceived challenges related to technical skills, soft skills, project management, and startup-formation mindsets. Method: We conducted design-based research comprising questionnaires, interviews, and focus groups with students and stakeholders participating in the Innovation Bootcamp. In total, 44 students answered the questionnaires conducted before and after the Innovation Bootcamps in both academic years. In the second year, 12 students answered the Berkeley Innovation Index questionnaire to measure their innovation mindsets. We also conducted four individual interviews (student cohort 1), four focus group interviews (student cohort 2), and six individual interviews with stakeholders participating in the Innovation Bootcamp in both years. Results: We found that perceptions of challenges regarding soft and project-management skills declined, while perceptions of challenges regarding technical skills did not vary during the course. Students exhibited increased motivation to engage in startup formation following close collaboration with external stakeholders only after developing their first minimum viable product. Contribution: The study's outcomes contribute to validating a new team-centered model that facilitates startup formation in experience-based courses. We also intend to help educators and researchers adopt Innovation Bootcamps in experience-based, software engineering–focused courses.**

Keywords — experience-based course, interdisciplinary course, soft skills, technical skills, project management, bootcamp, external stakeholders

I. Introduction

Experience-based learning allows students to develop skills by relying on their backgrounds and experiences [1] and learning experientially [2] on multi- and interdisciplinary teams in innovative courses [3,4].

Many previous studies have reported combining inter- and multidisciplinary teams for realistic product creation through startup practices in an academic setting [1–6]. Software-intensive courses with a focus on minimum viable product (MVP) creation are also common [7–10]; however, to the best of our knowledge, there is no model supporting student skills and startup-formation motivations incorporating external activities (i.e., an Innovation Bootcamp) in experience-based courses.

Over the last two years, we incorporated a three-day intensive Innovation Bootcamp into our Experts in Teamwork (EiT) course to have students work on real-life challenges while developing software-based solutions for social good. Students could also cooperate with industry, government, and academia. Since then, we have wondered whether a course model could facilitate external activities to promote students' learning and startup-formation mindsets. To this end, we formulated the following research question (**RQ**):

RQ: *How can a team-centered model facilitate students' learning and startup formation in an experience-based course?*

To address the **RQ**, we adopted design-based research [11], a dual-purpose methodology that aims to bridge theory and practice in education. It blends empirical educational research with the theory-driven design of learning environments to improve educational practices through iterative analysis, design, development, and implementation, with active collaboration among researchers and practitioners in real-world settings. Design-based research relates to educational action research and design science, but it emphasizes educational improvement [12]. Each iteration seeks to improve the previous artifact (the model) based on collected empirical evidence; in this paper, we present the second iteration of a model proposed in [13].

In the first phase of our investigation, we had students from cohorts 1 and 2 complete questionnaires determining the values of dimensions related to (1) technical-skill challenges, (2) soft-skill challenges (i.e., teamwork, communication, presentation, negotiation, and innovation), (3) project-management challenges, (4) startup-formation motivations, and (5) involvement of existing team members in startup formation. Student teams provided initial values for each dimension before Bootcamp Day 1. After Bootcamp Day 2, when the project's MVP had been developed and was ready to be pitched, student teams completed the same questionnaire to evaluate which dimensions varied in their answers. In cohort 2, the second year of our investigation, we asked students in the period between Bootcamp Days 1 and 2 (interim 2) to complete the Berkeley Innovation Index (BII) questionnaire to evaluate their potential to innovate and the Innovation Bootcamp's impact on the course relative to the startup industry context.

In the second phase, after completing the Bootcamp, we conducted interviews with (1) random students from each team (cohort 1) and focus groups (cohort 2) and (2) all stakeholders who participated in the course in both years.

We found that the perceived magnitude of challenges regarding soft skills and project management declined in the answers to the second questionnaire, a finding validated by the interviews with students and stakeholders and the students' project and process reports. The analysis revealed that students successfully explored soft skills related to face-to-face or online communication, brainstorming, and presentation, all of which boosted their confidence. Lean and agile practices, the Scrum Burndown Chart, and Smartsheet project-management tools also increased students' confidence in planning projects. However, we noticed no changes in their perceptions of the magnitude of technical-skill challenges.

The qualitative data revealed little evidence of stakeholder efforts to boost students' technical skills during the Bootcamp. Startup-formation motivation increased after Bootcamp Day 2, as revealed by the students' interviews, whereas existing team members' involvement in future startup formation ranged from a slight decrease in the quantitative data to positive reports during the interviews. The BII questionnaire investigation in student cohort 2 showed that the Bootcamp intervention gave students traits like those of startup company staff. However, it also revealed that students must widen their comfort zones and personal innovation mindsets.

The rest of the paper is structured as follows. Section II presents related work. Section III describes the course and Innovation Bootcamp settings. We present our study's design and methodology in Section IV. Section V presents the results and key findings. Section VI discusses the findings. Finally, Section VII concludes the study and identifies opportunities for future work.

II. Related Work

Kolb introduced experience-based learning as a tool for students to utilize their background competencies to develop their skills [1,2]. In the past 15 years, numerous research efforts have been made to introduce experience-based learning to higher education, such as Innovation Bootcamps, which are usually intensive, three-to-four-day, hands-on, experiential-learning events during which students exercise multiple design-thinking concepts, define problems, and design solutions for challenges and projects [14]. Incorporating bootcamp activities in software-intensive, experience-based courses deserves researchers' attention because of its benefits for students' technical, soft, and project-management skills, especially through close interaction with external stakeholders. Sidhu et al. [15] conducted a four-day intensive bootcamp on innovation and entrepreneurship to influence students' mindsets toward innovation. Using the BII open-project concept, their results were intended to measure whether entrepreneurial behaviors could be learned using pre- and post-tests conducted before and after the bootcamp. Moshirpour et al. [16] designed a bootcamp-based course focused on technical and programming skills to reinforce programming skills for non-programmers; they reported no soft or project-management skills. They conducted a survey at the end to assess student learning outcomes and satisfaction. Similarly, Hickey and Salas [17] introduced bootcamps as a new model for learning web and mobile development and software entrepreneurship. Their longitudinal study focused on activities like those in incubators and accelerators boosted by academic content. Efforts have been made from Pappas [8] in an experience-based course in introducing a hackathon as an external activity within an experience-based course in software engineering. Nandi and Mandernach [18], as well as Sakhumuzi and Emmanuel [19], have used hackathons as an instrument of informal and collaborative learning in software engineering project-based courses. However, we found no other studies that incorporated bootcamps in software-intensive, experience-based courses.

III. Course And Bootcamp Settings

A. The Course

Our MSc degree EiT course is based on Kolb's experiential-learning approach [1]. Students are expected to collaboratively identify and propose specific innovative solutions that can be tackled using software engineering (SE) to achieve the Sustainable Development Goals (SDGs) defined by the United Nations (UN) [20]. The course included resources (e.g., compendium and exercises related to team dynamics) provided by learning assistants and course leaders. The course-specific learning objectives and evaluation process are detailed in [21]. We introduced Innovation Bootcamp activities to the course over the past two years.

1) The cohorts. During both years, the cohorts comprised teams of students with different study backgrounds, including SE. The teams' main characteristic was their multi- and interdisciplinary composition. Each team's members were decided by the course leader before the start of the course considering discipline and gender balance. Diversity in skillsets and backgrounds contributed to the development of relevant, innovative solutions. Team size varied from five to seven students. Self-structuring was common, and a balanced environment for making decisions supported team sustainability. Finally, each team was required to apply group process theory [22] when coping with challenges and improving team dynamics.

2) Course enrollment. The course website, which was publicly available during both academic years, was announced to students by different faculty departments at NTNU. Recruitment occurred from October 1–30 in 2018 and 2019. After recruitment was finalized, a total of 21 and 23 students participated the first and second years of the course, respectively. Table I reports the cohort demographics (e.g., students' ages, genders, and academic backgrounds) for each academic year.

TABLE I. Course Demographics

	Cohort 1 (2019)		***Cohort 2 (2020)***	
	N#	Percentage	N#	Percentage
Gender				
Male	11	52%	15	65%
Female	10	48%	8	35%
Age				
18–25	9	43%	11	48%
26–30	11	52%	8	35%
31–40	1	5%	4	17%
Academic Discipline				
Software, Computer, Electronic Engineering	7	33%	12	52%
Other (Social Sciences, Psychology, Geology)	14	67%	11	48%

B. The Innovation Bootcamp

The event. The Innovation Bootcamp took place over 3 one-day-long events organized during the semester supported in between by online student–stakeholder communication. The Innovation Bootcamp days occurred approximately once every 30 calendar days. In the interim, students could tackle doubts and questions with stakeholders remotely. The Innovation Bootcamp days consisted mainly of intensive,

face-to-face collaborations between students and stakeholders to motivate students to develop relevant solutions and business concepts through MVP prototypes subsequently field-tested in realistic scenarios.

The course leaders and learning assistants provided support through state-of-the-art innovation tools and methods, which helped students set ambitious goals for developing their startups. The Bootcamps in both years followed similar course schedules involving several phases.

The Bootcamp-specific learning objectives for students were to (1) create useful SE products addressing real-world societal problems, (2) foster lean, innovative thinking, (3) develop project-management skills based on lean and agile methodologies, (4) learn to present and pitch products, (5) develop communication and negotiation skills, and (6) learn to tackle technical hurdles through stakeholder collaboration.

Bootcamp Day 1. We utilized practical exercises related to (1) thinking analogously, (2) brainstorming, (3) selecting ideas, and (4) proposing solutions. *(1) Thinking analogously:* We started the day with two hours of presentations by external stakeholders about societal challenges. The rest of Day 1 comprised several future-thinking exercises. The prearranged teams were given time to meet the stakeholders and express interest in their presented challenges. Each team could choose, at most, two stakeholders. *(2) Brainstorming and (3) selecting ideas:* To get them thinking, we presented the Futurescan poster with over 200 idea triggers. During the first part of this exercise, three or four people per poster carefully read all the triggers. For each blank spot, they looked for a complementary future prediction. For every prediction, they described potential new problems. After 30–40 minutes, every brainstorm team had a long list of potential future problems. At the end, every team could generate a potential creative idea and innovative solution to one of the presented challenges. *(4) Proposing solutions:* Each students team presented its idea tangibly using a business canvas model for 10–15 minutes to all the stakeholders and other teams. At the end of Day 1, the stakeholders and teams agreed on a project idea to develop.

Interim 1. Students interacted with stakeholders using online tools (e.g., Microsoft Teams and Slack) on a weekly basis. This interim period lasted approximately four course weeks (30 days). Students addressed various questions and doubts related to evolving Day 1 project ideas into MVPs. Stakeholders professionally answered students' concerns related to (1) the context of the presented challenges, (2) solutions already at the stakeholders' disposal, and (3) internal organizational composition and needs. The course leaders facilitated student–stakeholder interactions, helping avoid stagnation whenever students were reluctant to communicate with stakeholders remotely.

Bootcamp Day 2. Since interim 1 addressed most students' concerns, we dedicated Day 2 to idea development through (1) agile and lean methodology, (2) prototyping, and (3) business models. First, in a two-hour session, we introduced the students to the Scrum framework and lean canvas model to conduct project management and develop business ideas, respectively. Every team had to construct a Scrum Burndown diagram for every sprint and fill in the lean canvas business model. Students then tried to prototype useful SE products or services addressing relevant societal challenges with a focus on UN SDGs [20]. They then surveyed customers and developed business-to-business and business-to-customer canvas models and MVP prototypes. Invited startup entrepreneurs and experienced industry project managers helped students overcome challenges and technical issues during project development.

Interim 2. As during interim 1, students actively communicated with stakeholders using online tools for over 40 days. The students focused on MVP-related quality issues and testing, and the course leaders helped students realize the value of intellectual property (IP) rights by planning sessions exploring how students could protect their project artifacts. The active collaboration with stakeholders again proved vital.

Bootcamp Day 3. This day first focused on students' product or service presentations for a clear overview of the achievements and states of the developed MVPs. Second, each student team pitched its project to investors and innovation organizations. Funding acquisition and project sustainability were key points discussed.

1) External stakeholders. The external stakeholders belonged to different sectors. They presented a framework of practical social problems that could be addressed through SE, and their participation was key to fostering innovative ideas. Following the triple-helix model of innovation [23], we chose stakeholders from three crucial sectors: government, represented by the Communes of Trondheim (first year) and Overhalla (second year); industry, represented by Capeesh (first year) and industry cluster companies (second year); and academia, represented by the students and instructors.

IV. Methodology

To address the **RQ**, we adopted design-based research [11,12], a dual-purpose methodology that bridges theory and practice in education and blends empirical educational research with the theory-driven design of learning environments to improve educational practices through iterative analysis, design, development, and implementation, with active collaboration among researchers and practitioners in real-world settings. Each iteration seeks to improve the previous artifact based on collected evidence (Fig. 1).

We gathered the initial data by questionnaires and the supplementary data by interviews in both years.

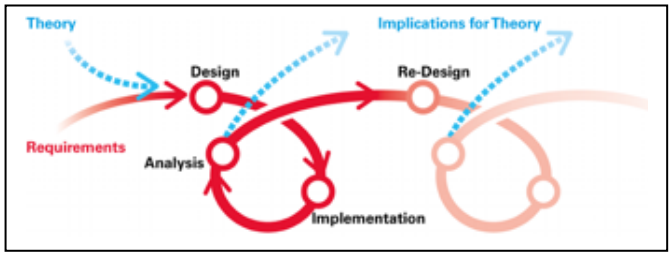

Fig. 1. Design-based research approach. Source adapted from [24].

A. Research Design Phases

We categorized our research into two phases: (1) research design and preliminary investigation (quantitative approach: questionnaires), and (2) "thick" understanding and data analysis (qualitative approach: interviews).

In the first phase, students were asked to answer questionnaires after the initial Bootcamp presentation (Day 1) and after early prototype development (Day 2) based on MVP using lean methodology. They rated the considered dimensions—technical skills, soft skills (e.g., teamwork, communication, presentation, negotiation, and innovation), project-management skills, startup formation, and involvement of existing team members in startup formation motivations—on a five-point Likert scale. To minimize bias, the respondents did not have access to their answers from the first survey when completing the second one. To evaluate the students' innovation mindsets, we also asked them to complete the BII questionnaire.

The second phase involved (1) interviews with randomly sampled students from each team (cohort 1) and focus group interviews (cohort 2) and (2) interviews with all stakeholders participating in all Bootcamp days in both academic years. The data gathered during Phase 2 complemented the data obtained during Phase 1. Embedding the data enables a deep understanding of the students' perceptions of the variations in skill challenges, innovation mindsets, and startup-formation motivations with existing team members.

B. Data Collection

We conducted the study during the spring semesters of 2018 and 2019. Each cohort comprised four teams with approximately five to six members, totaling 21 and 23 students in cohorts 1 and 2, respectively. Each team developed a project within the EiT course addressing different UN SDGs [20]. In the first cohort, every team developed a mobile app solution. In the second cohort, the MVP solution proposals were more heterogeneous.

Projects from cohort 1. **Team 1** (UN SDG 10: Reducing Inequality) developed a language app to connect pairs of people with different nationalities and native languages. Users could learn new languages, meet in person, and win prizes while participating in multi-player games. **Team 2** (UN SDG 2: Zero Hunger) tackled malnutrition in Tanzania with a mobile app that helped mill operators provide nutrients to rural populations. **Team 3** (UN SDG 8: Defining Citizens' Needs for Better Economic Growth) developed an app to administer and report a detailed survey of social services available to expats, refugees, and international students in Trondheim and give the international community a discussion forum. **Team 4** (UN SDG 13: Reducing the Carbon Footprint) developed an app to reduce Trondheim's carbon footprint by collecting, reusing, storing (in a central storeroom at NTNU), and redistributing expired food from supermarkets.

Projects from cohort 2. **Team 1 (**UN SDG 3: Good Health and Well-Being) developed an app (Agora) for younger, more tech-savvy volunteers and a phone line and email service for the older population to improve relationships in Trondheim Commune by bringing diverging generations closer in both digital and physical space. **Team 2 (**UN SDG 13: Climate Action) developed a website, Fin for Wood (FFW), to facilitate wood waste recycling in Norway by connecting sellers and buyers. **Team 3 (**UN SDG 8: Decent Work and Economic Growth) developed a mobile app to tackle real-time communication on construction sites by reducing delays between field workers and project managers. **Team 4 (**UN SDG 11: Sustainable Cities and Communities) developed freely moveable walls relying on mechanical parts controlled by smart sensors and the Internet of Things (IoT). We collected the data according to the phases described above:

Phase 1 – Questionnaires. In both academic years, we presented the students with the questionnaire before the first Bootcamp day and asked them to anonymously complete the questions online, focusing on the dimensions in Table II. At the end of Bootcamp Day 2, we asked them to complete the same questionnaire, this time reflecting on skill challenge outcomes and startup formation.

TABLE II. QUESTIONNAIRE INSTRUMENT

Question asked	Dimension analysis	Value (1–5)
To what extent are soft skills (teamwork, communication, presentation, negotiation, and innovation) a challenge in developing the final product?	Soft Skill Challenge	
To what extent are technical skills a challenge in developing the final product?	Technical Skill Challenge	
To what extent are project-management skills a challenge in delivering the final product?	Project-Management Challenge	
I am highly motivated in startup formation	Startup-Formation Motivation	
I am highly motivated to involve my team members in startup formation	Involving Team Members in Startup Formation	

Phase 1—BII. In the second academic year, we presented the students with the BII questionnaire during interim 2. The BII instrument quantitatively measures an individual's innovative mindset level and power to innovate along eight dimensions: (1) *trust*, (2) *resilience*, (3) *diversity*, (4) *belief*, (5) *perfection*, (6) *collaboration*, (7) *comfort zone*, and (8) *innovation zone*. The results are composed of (1) analysis, which provides insights into the individual's innovation mindset, and (2) recommendations, which focus on the individual's trust, resilience, and diversity based on their score. BII is an open research project developed in cooperation with industry professionals. The BII instrument has a limited scope and is intended to summarize the innovation mindset and improve the innovation capabilities of individuals. In total, 12 students from cohort 2 completed the questionnaire.

Phase 2 – Student interviews. We conducted semi-structured interviews with students between Bootcamp Days 2 and 3 (interim 2) following a question template prepared by two of the authors (Table III). In the first year, we interviewed four randomly sampled students (one representative from each student team). We assumed that all team members had acquired extensive knowledge about the project and process as well as the rest of the team members during their semester-long collaboration so that each team representative could provide detailed answers to our questions.

In the second year, rather than interviews, we conducted four focus group interviews involving all student teams (23 students) to understand the various dimensions in greater depth. Not only could all student opinions be heard in focus

groups, but participants could also stimulate new thoughts from each other. The semi-structured interviews had two parts. The first primarily discussed the project, while the second examined student learning and startup formation mindset.

TABLE III. STUDENT INTERVIEW TEMPLATE

Interview part	Question
Part 1 – Background Questions	1. What is your team composition? 2. What is your project about? 3. What are your key motivations for participating in the Bootcamp? How did you benefit from interactions with the stakeholders?
Part 2 – Specific Questions	1. What technical challenges did you have? What kinds of technical skills did you learn during the Bootcamp? 2. What soft skills did you and your team acquire during the Bootcamp? 3. What project-management approaches did you learn from the Bootcamp? 4. How did you use the new project-management skills to develop your project? 5. How much did the stakeholder participate during the project? 6. What motivates you to create a startup after the Bootcamp? 7. Would you involve your team members in future startup formation?

Phase 2 – Stakeholder interviews. The semi-structured interviews with all the stakeholders active during both Bootcamps occurred after the Bootcamp and the students' interviews. The semi-structured interview guide (Table IV) was formulated ahead of time by two of the authors and was executed by the first author.

We again split the interview into two parts. In the first, we acquired information related to the stakeholders' professional backgrounds, while in the second, we asked specific questions about their motivations to participate in the Bootcamp, skills they believed students had acquired from them, and motivations to form startups with the students.

TABLE IV. STAKEHOLDERS' INTERVIEW TEMPLATE

Interview part	Question
Part 1 – Background Questions	1. What is your professional background? What is your role in your organization? 2. How long have you been working in your organization?
Part 2 – Specific Questions	1. What is your primary motivation for participating in the Bootcamp as a stakeholder? 2. What technical skills do you think students have gained while collaborating with you? 3. What project-management skills do you think students have gained while collaborating with you? 4. What soft skills do you think students have gained while collaborating with you? 5. What motivates you to create a startup after the Bootcamp with the students?

C. Data Analysis

1) Quantitative analysis. During the first data collection, we did not know what to expect. We decided to consider the same group and analyze the mean and variance of the answers obtained before and after the Bootcamp. After analyzing the data from the first academic year, we deemed it relevant to gather and analyze similar data in the second year.

In the second year, as in the first, we deepened our understanding by repeatedly aggregating the quantitative data with specific qualitative data and gathering additional data from the BII instrument.

2) Qualitative analysis. We thematically analyzed the interview data [25,26] to identify recurring patterns of soft, technical, and project-management skills, startup formation, and motivations to involve existing team members in future startups.

We systematically analyzed as follows: (1) **Reading the transcripts.** This step initially involved quick browsing and correcting the transcribed data from the audio recordings. Later, we reviewed the transcribed data more carefully by judiciously reading line by line. (2) **Coding.** During this step, we focused on choosing and labeling (i.e., coding) relevant words, phrases, and sentences. The labels revealed more about perceptions related to Bootcamp activities. (3) **Creating themes.** After gathering all the codes, we determined the most relevant ones and created different categories (i.e., themes), dropping or merging many of the initial codes from the previous step. (4) **Labeling and connecting themes.** In this step, we decided which themes were most relevant, gave them appropriate names, and attempted to identify relationships among them. (5) **Summarizing the results.** We inductively coded [27] by interpreting raw textual data to develop our concepts, codes, and themes. After determining the themes' importance and hierarchy, we diagrammed the results using NVivo 12, which served as a collaboration tool to maintain our raw data and facilitate coding. However, we manually performed the analysis and coding (e.g., Table V).

TABLE V. AN EXAMPLE OF THE CODING PROCESS FOR THE "PROJECT MANAGEMENT SKILLS CHALLENGES" ASPECT.

Example of phrase from focus group interviews	Open codes	Theme
"The use of Scrum Burndown Charts allowed us to follow the project properly even in between calendar time gaps during the Bootcamp days." ***[Team 3 – Cohort 1]***	Use of Scrum Burndown Charts	Agile/Scrum
"We have intensively used within the group Scrum and daily meetings, together with other tools, such as Smartsheets." ***[Team 4 – Cohort 2]***	Use of Scrum standup meetings	

V. RESULTS

To answer the **RQ**, we present the impacts of the Bootcamp on students' technical skills, soft skills, project-management skills, startup-formation mindsets, and motivations to involve existing stakeholders from both quantitative and qualitative perspectives.

A. Quantitative Results

1) Questionnaire Results. During the quantitative phase of the investigation, we calculated the means and variances of the chosen dimensions (Fig. 2). Per the five-point Likert

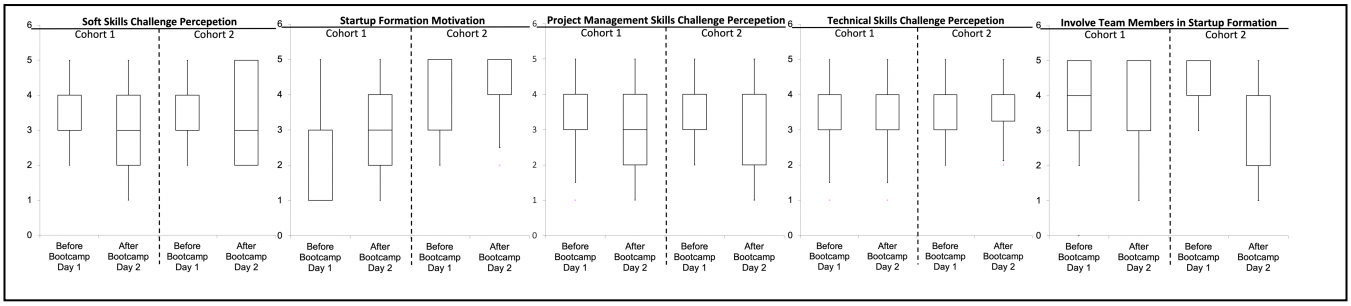

Fig. 2. Box plot representation of variations in technical, soft, and project-management skills, startup-formation motivation, and involvement of existing team members before and after Bootcamp Days 1 and 2.

scale, the values (y-axis) varied from 1–5 for each dimension (x-axis) before and after Bootcamp Days 1 and 2. There was no variation in the median (***M***), minimum (***Min***), or maximum (***Max***) of the student technical skills challenge in either cohort. In the second cohort, the median value ***M*** dropped, but there was no variation in ***Min*** or ***Max***.

Project management: The first cohort's ***M*** dropped, but its ***Min*** and ***Max*** had no variation. The second cohort had no variation in the ***M*** or ***Max***, but ***Min*** dropped. Startup-formation motivation: The first cohort's ***M*** retained its value, but its ***Min*** and ***Max*** had no variation. The second cohort's ***M*** increased, but its ***Min*** and ***Max*** retained the same values. The involvement of existing team members in startup formation: The first cohort's ***M*** and ***Min*** decreased, but its ***Max*** did not vary. The second cohort's ***M*** and ***Max*** retained their values, but its ***Min*** dropped.

2) BII Results. The BII survey results (Fig. 3) demonstrate that students had high average *trust* (70%), *resilience* (87%), *diversity* (78%), *belief* (81%), *perfection* (80%), and *collaboration* (77%).

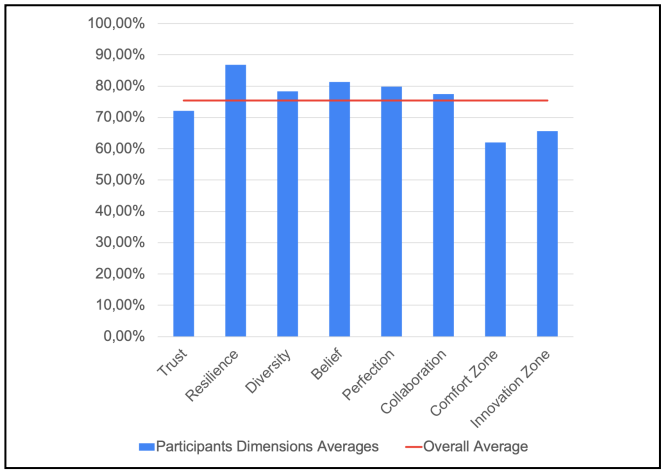

Fig. 3. BII results from cohort 2.

Similar BII scores reflect (1) a willingness to take risks, admit mistakes, and learn from them (trust), (2) an ease with accepting failure while letting go of outcomes (resilience), (3) an ease with communicating and working with people from different backgrounds (diversity), (4) an ability to overcome obstacles while not taking success for granted (belief), (5) the adaptability to shift resources when necessary (perfection), and (6) an ease with bouncing ideas off their collaborators without starting a competition (collaboration). We observed lower levels of *comfort zone* (62%) and *innovation zone* (66%) dimensions, which reflected a (1) missing "let's try it" mindset and a struggle to find self-confidence (comfort zone) and (2) difficulty understanding that innovation is likely a group effort that involves social processes (innovation zone).

The overall innovation mindset of the students in the second cohort was 75%.

B. *Qualitative Results*

Second, we thematically analyzed students' perceptions of challenges related to technical, soft, and project-management skills (Fig. 4).

1) Technical-skill challenges. The students' efforts in MVP development were among the most positively perceived technical aspects. However, students from *both cohorts* acquired little technical knowledge during the Innovation Bootcamp phases. One student reported the following:

> *Each of us brings our own previous work experiences and technical skills into use for developing the project. **[Team 3, Cohort 1]***

During a focus group interview, another team reported,

> *What stakeholders showed us was a concept…but not any implementation ideas. **[Team 2, Cohort 2]***

On interdisciplinary teams, the students expanded their knowledge and often exchanged roles. However, if a product required specific SE skills, the team had to rely on the skills of the most competent team member:

> *We developed the prototype based on X's skills in our team." **[Team 4, Cohort 1]***

Similarly, other focus group interviews revealed that

> *We [the **students**] built the system using Microsoft Teams, but they [the **stakeholders**] didn't help us with figuring out how to do it. **[Team 3, Cohort 2]***

In the same vein, one stakeholder interview said,

> *Yeah, in technical terms, they **[the stakeholders]** suggested about stability and sound proofing and other factors…I think that they have made us think about other issues that we hadn't thought about but did not provide us with any solution." **[Team 4, Cohort 2]***

Soft-skill challenges. The students learned to *communicate* with stakeholders and *exchange feedback* while acquiring relevant information to develop their projects. *Presenting and pitching* were among the most appreciated activities during the Bootcamp.

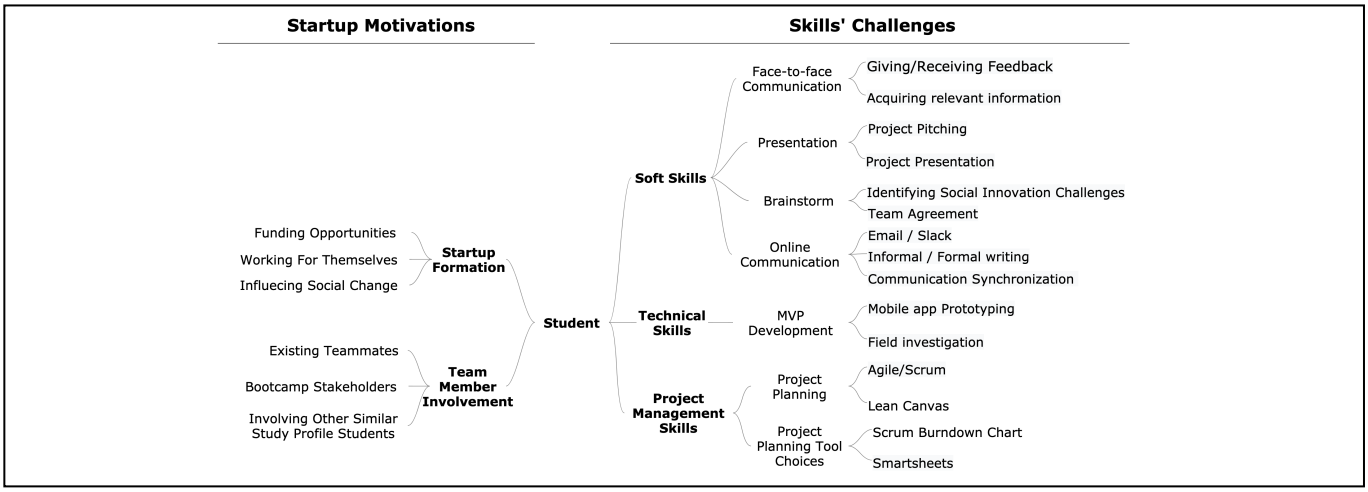

Fig. 4. Student skills challenges and startup motivation thematic analysis.

Similarly, another interview report emphasized the value of feedback while collaborating with stakeholders:

> *So, giving feedback and then taking feedback is a very good aspect of the collaboration with them [**stakeholders**]. [**Team 2, Cohort 2**]*

Moreover, one of the stakeholder interviews revealed:

> *During the presentations and pitch sessions, I [**stakeholder**] was able to provide feedback by indicating project directions quickly. [**Stakeholder for Team 2, Cohort 1**]*

Perspectives were positive regarding *online coordination and communication* via Slack and Microsoft Teams. After the Bootcamp, students felt confident collaborating online with professionals. One student mentioned,

> *They [the **stakeholders**] included us in a Slack chat where we could ask questions to them directly, which was very nice and helped us deal with frequent questions we had regarding the project. The door has always been open from their side. [**Team 1, Cohort 1**]*

Another focus group interview reported the following:

> *I think, personally, I didn't learn something completely new, but it [**online communication**] definitely helped to improve my soft skills…I think the communication was challenging at the start until we found the right channel [**Microsoft Teams**]. [**Team 4, Cohort 2**]*

Stakeholders repeatedly discussed their contributions:

> *During the presentations and pitch sessions, I [**stakeholder**] was able to provide feedback by indicating project directions quickly. [**Stakeholder for Team 2, Cohort 1**]*

> *I think the main contribution was to help students ask the right questions to the companies. First, we present the cases, and then we can see that the students really focused on being a small part of the challenge instead of seeing the whole picture…we help them think bigger. [**Stakeholder for Team 3, Cohort 1**]*

2) Project-management skill challenges. Project management was essential to developing the final MVPs. Students acknowledged the benefit of using agile and Scrum methods in project planning, reporting the following in two interviews:

> *The use of Scrum Burndown Charts allowed us to follow the project properly even in between calendar time gaps during the Bootcamp days. [**Team 3, Cohort 1**]*

> *We have intensively used within the group Scrum and daily meetings, together with other tools, such as Smartsheets. [**Team 4, Cohort 2**]*

Students managed their projects mostly on their own, although stakeholders helped them:

> *At times, I can tell I think we have done that [**project management**] ourselves, but also they [**stakeholders**] have been helpful at some level when contributing to project management. [**Team 4, Cohort 2**]*

3) Startup-formation motivations. The student interviews showed that the main startup-formation motivations were *brand establishment*, *working for themselves rather than others*, and *contributing to social change* via information and communication technologies. One student expressed,

> *If I wanted to make my effort in society, then the best option for me is to establish my own startup. And, uh, anything to help me to establish my own brand and work on the idea I have and release it to the world or give it to society. And I prefer to work for myself than [for] other companies. [**Team 2, Cohort 2**]*

Even students who wanted to work for large organizations were optimistic about the possibility of *making an impact on society* through startup formation. Other students were simply committed to their projects and wanted to pursue them further. When asked about the possibility of startup formation, students noted,

> *I prefer working for a big organization. But I think it's [**startup formation**] really inspiring to contribute to social change. That's what I like about it. [**Team 1, Cohort 1**]*

> *She [**stakeholder**] really helped to bring out the entrepreneurial side of the project. [**Team 1, Cohort 1**]*

> *Yeah, I think it's a cool project. So, at first, I didn't want to go further with it, but now that I've become committed to it, I would be motivated to go through it because I think it's very useful product for the society." [**Team 4, Cohort 2**]*

4) Involve existing team members in startup formation. The involvement of team members in startup formation took different forms. Students discussed forming startups with (1)

existing team members, (2) *other team members* not part of the course, and (3) *Bootcamp stakeholders*. One student reported,

> *Yeah. Team members are fine. Yes, I would involve the present ones, as well as others, in the future.* ***[Team 3, Cohort 1]***

Another student viewed involving existing team members as a great opportunity:

> *Certain members of our team I really, really like, and I admire a lot of the things that are the qualities that they have. So, if I were to create a new team, I think that I've gained collaborators that come from other backgrounds compared to the ones that I have from before…to start a startup again.* ***[Team 2, Cohort 1]***

We had similar reports from the focus groups:

> *I would very much like to involve all of the group members. I feel like we have every incentive to develop the startup and live up to the expectations…and they have the criteria for developing the product…I don't think we would need to involve any other people.* ***[Team 3, Cohort 2]***

> *I think the group has priority. I was thinking the same—that I would have a whole group—because we all knew the project well.* ***[Team 1, Cohort 2]***

Another student expressed that, although he learned a lot from his team members, he preferred to work with other students from his department to pursue startup formation:

> *Yes, I have thought about receiving help from some students [in] our department, but, uh, maybe not my teammates here. But I have learned from my current team members about improving my teamwork skills.* ***[Team 1, Cohort 2]***

In most cases, stakeholders were viewed as potential future customers or mentors. Two interview reports from both students and stakeholders emphasized the following:

> *For our project, we have decided to focus more on selling our product to the stakeholders.* ***[Team 2, Cohort 1]***

> *We were creating a product for ourselves, so asking them about becoming part of our team felt like a weird thing to do for me. At least, that's how I've seen them* ***[as customers]****.* ***[Team 3, Cohort 2]***

Key Findings

1. *Technical challenges.* The Bootcamp did not significantly impact the students' technical skills.
2. *Soft skill challenges*. The Bootcamp activities broadened and bolstered the students' soft skills toolset, boosted by external stakeholders' active participation.
3. *Project-management challenges*. Students learned significantly from utilizing agile and lean approaches to project management.
4. *Startup-formation motivation.* Students exhibited greater motivation to form startups following close collaboration with external stakeholders and the development of their first MVP.
5. *Involvement of existing team members in startup formation.* Students perceived the participation of existing team members as positive in most cases, but they did not exclude the possibility of collaborating with other future team members.
6. *Bootcamp startup mindset.* According to the BII results, the Bootcamp intervention provided students with qualities from startup companies' mindsets.
7. *Students' innovation mindset.* According to the BII results, the students must widen their comfort zones and personal innovation mindsets.

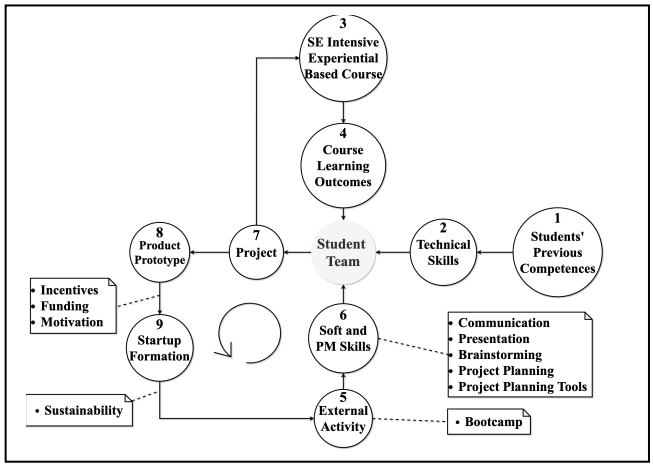

Fig. 5. EiT course model for future classes.

C. Model Facilitating Learning and Startup Formation

The data gathered from the study permitted us to answer the **RQ**. We identified the reasons for the decline in soft and project-management skill challenges and the invariance of technical skill challenges and internalized the sub-dimensions that students deemed most relevant to a project's success. These quantitative and qualitative results permitted us to conceptualize a future course model (Fig. 5) and develop a team-centered model.

Both technical and soft skills are critical to a successful student team. Students' prior competencies are the primary source of technical skills (**nodes 1** and **2**); team diversity makes teaching these unrealistic, but soft skills can be taught effectively. An experience-based course builds good team dynamics with teaching assistants' and course leaders' active participation (**node 3**), and learning outcomes are defined from the beginning, so we know more precisely what the course's team benefits are (**node 4**).

We still argue that students must endeavor to solve realistic problems based on external stakeholders' needs. Based on the results, exposure to external activity (e.g., the Innovation Bootcamp) probed variations in students' soft and project-management skills. We observed little impact on students' technical skills by the Innovation Bootcamp. Specifically, external activity is key to developing realistic soft and project-management skills (**nodes 5** and **6**). The team is supposed to deliver a worthwhile project (**node 7**) that is part of the course evaluation (**node 3**) or developed further into a functional product prototype (**node 8**).

The results demonstrate a greater interest in startup formation after the Innovation Bootcamp (**node 9**). Startup-formation motivations can be amplified by (1) incentives, (2) funding, and (3) personal motivations. The course leader should (1) incentivize startup formation within the course, such as networking with external stakeholders, (2) provide applications to local funding opportunities, and (3) address student motivation with instruments such as the BII. However, we observed little perseverance after the Bootcamp from the stakeholders to pursue projects with students. Funding the projects or enabling startup formation is an even more significant challenge. One reason for this may be a lack of initiative, motivation, and resources from both parties (students and stakeholders), such as time constraints,

budgeting, or both. Another reason may be that the course does not sufficiently incentivize stakeholders or explicitly require students to achieve such results. However, in the second iteration, we asked and challenged the students and external stakeholders to apply for funding at the research council and innovation fund of Norway.

Introducing external activities might not be enough to make the course sustainable. To build upon previous experiences, we recognize the importance of introducing the student startups of earlier years as external activities. For IP reasons, however, stakeholders are reticent to make some of their resources available (e.g., previous product implementations), hindering students from developing contiguous software solutions. One way to make the model sustainable may be having successful startup teams contribute to future external activities. Although we are thinking ahead with these proposals, the relevance of having students contribute back to the course they attended would add value. A longitudinal study is required to confirm these claims.

VI. Discussion

The quantitative results (cf. Section 5A) aligned with the reports from student interviews in Section 5B.

Indeed, students from both cohorts relied heavily on previous experiences while developing their projects. The stakeholders also seemed to agree with the students' technical choices. We confirmed our findings regarding the quantitative data's lack of variance by gathering qualitative evidence from interviews and students' project and process reports. The students reported favorable feelings about the soft skills acquired during close collaboration with the stakeholders. A plethora of activities, including giving and receiving feedback, presenting, communicating online, and brainstorming, allowed them to improve their soft skills. Thus, the observed value drop in the quantitative results reflects the students' higher confidence in coping with soft-skill challenges in more realistic settings. The students learned to manage their projects despite lacking relevant prior experience. Agile methods, such as Scrum, were also key to project management. We observed a drop in challenges relating to project-management skills (Figure 1), indicating greater project-management skills in a more realistic context. This finding was later confirmed during the interviews.

Indeed, after close collaboration with the stakeholders during the Bootcamp, the students were highly motivated to embark on startup formation. Many had entrepreneurial mindsets and viewed startup formation as an opportunity. Others were not thoroughly convinced but appreciated the long-term value of startup formation for societal change. The qualitative findings justified the increase we observed in the quantitative data. Most students also realized the importance of working in an interdisciplinary group; however, their feelings regarding existing team members in future startup initiatives varied (cf. Section 5A). Despite the overall drop in the students' desires to form startups with their teams (mostly in cohort 1), many students were open to involving existing team members in later startups (observed in cohort 2) (Section 5B). The discussion of the stakeholders' roles in future startup formation only occurred in the second phase of our investigation. However, we realized that we could not fully match stakeholders with students in future startup formations. Challenges arose when connecting those with less experience (students) with those with more experience (stakeholders), leading to team misbalances in the startup context. Students commonly considered the stakeholders to be merely customers or clients and, occasionally, mentors. The BII results show that all the listed dimensions' qualities fit the startup mindset. Startups commonly (1) learn quickly from their mistakes and pivot (*trust* and *perfection*), (2) accept failure and work with it (*resilience* and *belief*), and (3) work with multidisciplinary teams and actively exchange ideas in a constructive manner (*diversity* and *collaboration*). The teams in the second cohort certainly acquired these relevant startup-formation skills, as the surveys also showed. Regarding the comfort zone and innovation zone, the stakeholders' challenges might have frustrated the students' innovation mindsets. Perhaps some student teams should pick their challenges on their own. Personal factors may have caused other issues. We admit that, after all, many students did not have entrepreneurship backgrounds, and innovation is difficult to grasp in real-life contexts. Nevertheless, our quantitative and qualitative instruments revealed that many students had positive startup-formation motivations. The BII outcomes are strongly connected to **node 9** of our proposed model, indicating students' potential to create future startups and fit into the startup context.

Our study makes the following contributions to educators, researchers, and practitioners. Educators should (1) focus on soft skills that help SE students actively collaborate with other disciplines, (2) involve external activities early in the course with diverse stakeholder backgrounds, and (3) allow students to combine their previous technical competencies to tackle real problems. Researchers should (1) conduct further investigations following different paths of our proposed model and (2) augment the dimensions to investigate while utilizing our current findings. Finally, practitioners should (1) understand the value of participating in activities similar to ours, (2) utilize students' developed solutions to bring value to their present practices, and (3) transfer some solutions to their present practices.

A. Threats to Validity

Based on recommendations from Maxwell [28], we report how we addressed the following validity threats to our study. (1) **Content validity.** We chose to analyze dimensions (soft, technical, and project-management skills) that are widely accepted by the research community in SE literature. We also consider studies overlapping with SE practices, which rely on an experience-based learning approach. (2) **Criterion validity.** Several previous studies (cf. Section II) have achieved results like ours but relied on different methods: a survey (pre- and post-test) with a Likert scale. No previous study combined quantitative and qualitative data for a better understanding of the dimensions' variations. (3) **Descriptive validity.** To mitigate this threat to validity, we used audio to verify the descriptive data and stored the data electronically. (4) **Interpretation validity.** We have carefully kept track of the written perspectives of the individuals being researched to ensure their unique perspective is considered instead of imposing meaning from our perspective. (5) **Researcher**

bias: We were careful not to be swayed by gender, culture, or academic bias. The only possible bias was interviewing at least some SE students, but this did not undermine the study because SE was the primary focus. (6) **Construct validity:** We admit that the sample is small, so we need further experimentation to fully assess the construct validity of our quantitative data. For now, however, the results are fairly consistent with the qualitative data.

VII. Conclusion and Future Work

We designed our EiT course to allow students to interact with external stakeholders through Bootcamp activities. We sought to evaluate whether students realized the relevance of the Bootcamp and how it affected their technical, soft, and project-management skills. We also analyzed via the BII (1) students' potential to innovate and (2) the Innovation Bootcamp's qualities compared to the startup industry context. To answer our **RQ**, we conducted a design-based research study relying mainly on a mixed-methods approach. We distributed a questionnaire to both student cohorts before Bootcamp Day 1 and after Day 2 (upon developing the first project MVP). We also conducted semi-structured interviews with stakeholders and individuals from the student groups. Finally, in the second cohort, we asked students during interim 2 to complete the BII. Our findings, which are based on rigorously gathered data, support a unique course design model that fosters a startup-formation mindset through multidisciplinary student teams. We conclude that an external activity such as the Innovation Bootcamp can be effectively integrated into project-based courses (e.g., experience-based and customer-driven courses) in SE education. The benefits we list as key findings (cf. Section VI) should encourage educators to adopt our team-centered model in their courses. We intend to continue our work to propose a framework in conjunction with the model for educators and researchers to successfully orient their courses around external activities as a learning practice in SE education.

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