Towards Transferring Lean Software Startup Practices in Software Engineering Education

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ABSTRACT

In the modern economy, software drives innovation and economic growth. Studies show how software increasingly influences all industry sectors. During the last five decades, software engineering has also changed significantly to advance the development of various types and scales of software products. In this context, Software Engineering Education plays an essential role in keeping students updated with software technologies, processes, and practices popular in industries. In this Ph.D. work, I want to answer the following research questions: (1) To what extent are SE Trends presented in SEE research? (2) What do we know about the Lean Startups paradigm? (3) What is the impact of Lean Startup practices to software engineering students and curriculum? I utilize (1) literature review and (2) Mixed-methods approaches (data and methods triangulation) in gathering empirical evidence. In the first phase of the research, I pinpoint the relevance of Lean Startup within the software engineering education throughout an extensive literature review. I gather empirical evidence on Lean Startup practices and their potential transfer in software engineering education during the second research phase. I demonstrate that Lean Startup is part of the emerging software engineering trends within software engineering education research. I identify the gap of growth phase Lean Startup research in present software paradigms. I demonstrate that students can acquire soft, hard, and project management skills in a more realistic context while introducing growth phase Lean Startup practices throughout external course activities. I expect that the present software engineering curricula can benefit from a model and framework, which I intend to propose, facilitating Lean Startup practice transfer within the software engineering curriculum.

CCS CONCEPTS

• **General and reference** → **Empirical studies**; • **Social and professional topics** → **Software engineering education**.

KEYWORDS

Software Engineering, Lean Startup, Empirical Studies, Software Engineering Education

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1 INTRODUCTION

Also in the smaller scale, software startups constitute a large part of the most lucrative businesses in the last decade. Helping software startups with tailored versions of software engineering best practices has great potential to support the economy.

As in the last five decades, software engineering education (SEE) continues to evolve while focusing on preparing software engineering (SE) students for future careers [1, 21]. International organizations (such as the Institute of Electrical and Electronics Engineers [17], Computing Curricula of 2020 [14, 16], and the Association for Computing Machinery) guide SE curricula to encourage integrating industrial perspectives. Despite this support, addressing industrial demands remains an open question for SEE. Educators provide fundamental programming knowledge and skills that help students adapt to and work quickly with new technologies in industrial environments. SEE strives to meet this goal through ongoing efforts to design courses with longer durations and rely on various teaching strategies (e.g., project-based learning, capstone courses) to enable skill practicing in relatively-realistic project environments [1, 19]. Previous systematic reviews [4, 15, 21] have revealed that educators successfully convey relevant software engineering knowledge to students using these methods.

Moreover, education for software engineers should prepare students to stay current in the face of rapid change. Existing studies have reported educational challenges that exceed fundamental skillsets. For example, reports have addressed how to support students regarding communicating effectively with customers in an Agile project [20] and how to work with other developers in a geographically distributed setting. The underlying assumption of these reports is that students are already aware of the necessary state-of-the-art software engineering trends. Such topics are essential for educators when building appropriate curriculums and selecting suitable teaching methodologies [2].

Triggered by the vision of preparing students for future computing, as illustrated by the Computing Curricula 2020 project [14, 16], we recognize the necessity of reviewing SEE to yield educational outcomes relevant to the software industry in the mid-2020s and beyond. Previous studies have highlighted the importance of SEE collaborating on common education goals and remaining current

with SE trends [3, 15]. In particular, software engineering trends from previous decades within the current SE curriculum require revision. In this Ph.D., a SE trend is a commonly adopted software development approach, including a set of practices, working methods, associated toolsets, and frameworks. For example, Lean Startups is a popular industry SE trend gaining increasing interest in SEE (demonstrated in our literature review). To this end, I formulated the following Hypothesis:

H1: *"Lean Software Startup paradigms are part of SE Trends presented in SEE research."*

H2: *"There is a set of common software engineering practices among Lean Startups transferable to SEE context."*

H3: *"The adoptions of these paradigms, practices, and settings can positively affect students' skills and startup formation motivation in SEE context."*

To corroborate my Hypothesis, I have first posed three primary research questions (RQs) and corresponding sub-questions, making my study's research objectives, reported in Section 2. In turn, to answer the RQs and verify the Hypothesis, within my research scope (Section 3), I designed a detailed research methodology primarily relying on a mixed-methods approach in empirical investigations, reported in Section 4. I discuss the study expected contributions in Section 5 and results obtained so far in Section 6. I have carefully planned the timeline for evaluating my research, Section 7. I have also made a detailed plan on disseminating my research to the community, Section 8.

2 RESEARCH OBJECTIVES

This thesis aims to contribute to the ever-evolving development of industry-relevant teaching strategies, focusing on software startup. Thus, I have designated the following research objectives:

(1) Identify industry- and academia-based SE trends;
(2) Identify Lean Startup practices when transitioning from early to growth phase;
(3) Identify the extent Lean Startup is presented in SEE research;
(4) Identify primary stakeholders involved in the introduction of Lean Startup in SEE curricula;
(5) Evaluate how external activities involving internal and external stakeholders foster innovation and Lean Startups within SE curricula;
(6) Evaluate how Lean Startup paradigms, practices, and settings can affect students' skills and startup formation mindset;
(7) Propose a model and framework facilitating Lean Startup practice transfer within SEE curriculum

Concurrently, I wish to contribute to the scientific development of Lean Startup SE and SEE research. I want to demonstrate the present relevance of Lean Startup in the SEE context. My research inquiry contains the following research questions (RQs) in connection with the research objectives:

- RQ 1: To what extent are SE Trends presented in SEE research?
  - RQ1.1. Which of the industry models, processes, and methods are embraced in SEE research?
  - RQ1.2. Which are the industry-relevant teaching approaches presented in SEE research?
  - RQ1.3. Which stakeholders worked together as presented from SEE research?
- RQ 2. What do we know about the Lean Startup paradigm?
  - RQ 2.1 What are the common engineering practices in Lean Startup companies?
  - RQ 2.2 What are the discrepancies in software practices when Lean Startups transition from early to growth phase?
- RQ 3. What is the impact of Lean Startup practices to software engineering students and curriculum?
  - RQ 3.1 How do Lean Startup focused external activities impact students' learning in experience-based courses?
  - RQ 3.2 How do external activities/stakeholders affect student motivation in startup formation within the SEE curricula?
  - RQ 3.3 What model and framework can facilitate Lean Startup practice transfer within the SEE curriculum?

RQs 1, 1.1, and 1.2 relate to positioning Lean Startup in SEE while scoping the literature. I want to evaluate how startup characteristics have so far been integrated into SEE. RQ 2 and its corresponding sub-questions (RQ 2.1 and 2.2) focus on the knowledge from state of the art. I then evaluate the transferability of Software Startup practices into SEE (including multidisciplinary courses, such as Experts in Teamwork). Finally, RQ 3, RQ 3.1, RQ 3.2, and RQ 3.3 provide an evaluation of the potential impacts in the existing SE curriculum and the SE students in collaboration with other disciplines. I follow the research methodology described in Section 1 to answer each of my RQs.

3 RESEARCH SCOPE

This Ph.D. project's scope is primarily related to a student participating in NTNU SE-related master study courses (e.g., Experts in Teamwork). This project will also add to the Lean Startup research by gathering empirical data from growth phase software startups about their SE practices. The project focuses mainly on:

(1) Contributing to learning approaches for SE-related courses by adopting tech startup, Lean methodology, and minimum viable product prototyping approaches and tools;
(2) Promoting innovation and software startup models that allow students to become future Tech innovators; and
(3) Potentially adding to the present knowledge about SE practices in growth phase software startups. I will limit this study to exploring SE practices and software startup paradigm and practices transfer within the SEE context. Moreover, early-stage software startups will be outside of my research scope, as they have previously been extensively evaluated in the research community.

4 PROPOSED APPROACH

The research methodology of my Ph.D. work is primarely based on the triangulation of quantitative and qualitative methods [6] that will explore different researchable facts through various investigation types. Figure 1 outlines my research methodology steps and the connections between the research methods and the RQ summary.

The first phase of the research will acquire knowledge and insight through a literature review (RQ 1, 1.1, and 1.2). The second

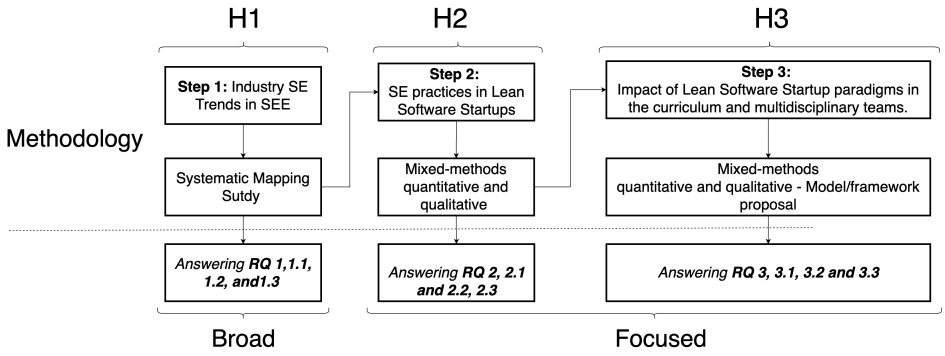

Figure 1: Methodology design.

research phase will put the focus on two directions. Firstly, I conduct investigations into SE practices in growth phase Lean Startups (RQ2, RQ 2.1, and 2.2). Secondly, I gather empirical evidence on how Lean Startup practices can affect students' skills and startup formation mindset (RQ 3.1 and 3.2) while introducing external activities to SE intensive courses with multidisciplinary teams. As a final step to my investigation, I address the transferring of Lean Startup practices within SEE curricula (RQ 3.3) while proposing a model and framework.

The data collected during these two parallel investigations will be of both quantitative and qualitative nature and analyzed in systematically- and theoretically-based ways. For instance, a grounded-theory approach will analyze the exploratory data, while other well-documented analysis methods will be employed for surveys and literature reviews [6, 18].

5 EXPECTED CONTRIBUTIONS

During the Ph.D., I expect to produce contributions inherent to adding to existing SE teaching and learning approaches, to fill the gaps between industry and academia. There is a need to expand our understanding of SE trends from the last decade. This study's first literature review will identify the software startup practice gap within SEE. Consequently, the second literature review will gauge how startup formation is used presently to provide more realistic educational practices for SE students. It may be determined that startup formation is a more pragmatic approach for future master's students to learn SE practices compared to present project-based learning and capstone courses.

Using a multidisciplinary setting and external stakeholder participation (e.g., during Bootcamp activities) should also bring real-life scenarios into the software startup formation context. I expect that some students will achieve successful results in their future careers in SE startups. I shall also contribute to the SWEBOK knowledge areas while investigating SE practices in growth phase software startups. Moreover, a sustainable model fostering startup formation in SEE context can be developed to contribute to educators, researchers, and practitioners in making educated decisions in future startup-oriented approaches for SE courses.

The results of these investigations shall be published and communicated by appropriate channels. SEE-focused journals and conferences and more general education-focused outlets will be targeted nationally and internationally (specifics about target venues have been listed in the research proposal). Compared to previous work [5, 7], my research investigation will intrinsically contribute to both SEE and Lean Startup research.

6 RESULTS ACHIEVED SO FAR

I have so far published my literature review in ICSE 2019 conference [12] and the Journal of Systems and Software [13]. Moreover, I have published in ICSOB 2019 [9] and EASE 2020 [10] conferences evidence related to growth phase startup SE practices. Furthermore, I have made several contributions in SEE context associated with students' skills and startup formation motivation in venues such as ICSOB 2019 [8], EDUCON 2020 [11], and FIE 2020 with the title "Towards Designing an Experience-based Course around Innovation Bootcamps — A Cohort Study."

7 RESEARCH EVALUATION PLAN

The research plan is divided into two phases. The phases are sequential, moving from a broad understanding of the research (phase 1) toward more specific knowledge that addresses the Lean Startup research gap in SEE. The second phase is intrinsically connected to the first phase, involving further empirical evaluation.

As stated earlier, I will perform two empirical investigations related to SE practices in growth phase software startups and SEE startup-oriented practices. I have completed Step 1 and part of the empirical investigation covering part of Steps 2 and 3, from Figure 1. Gathering of further data and evidence from growth phase startups is an imminent demand for my research study. Lastly, The research community has to accept yet my proposal of a model and framework derived from data gathered in the SEE context. The plan reported in Table 1, also follows the research methodology approaches in Figure 1.

8 DISSEMINATION PLAN

I plan several publications in high-quality journals and conferences as contributions to my Ph.D. work. Table 2 provides an overview of the sources used to disseminate the research results in relation to the methodology steps from Figure 1. Most of the publications involve close collaboration between academia and industry partners.

Table 1: Research Plan

Year	Semester	Tasks
1	Fall 2018	Systematic Literature Mapping – Conference Paper – **Step 1**
	Spring 2019	Systematic Literature Review – Journal Paper – **Step 1** Investigate software startup in growth phase practices in USA (cont.) Survey Experts in Teamwork students (first iteration)
2	Fall 2019	Investigate software startup practices in USA, Norway and Scandinavia (cont.) – **Step 2** Prepare for Spring Bootcamp activity and Network with External Stakeholders Disseminate research from Data gathered during Spring semester – **Step 3**
	Spring 2020	Survey Experts in Teamwork students (second iteration) – **Step 3** *Other Courses e.g., Advanced SE* – **Step 3** *Gather relevant data about Growth Phase Startups. (IPIT project support)* – **Step 2**
3	Fall 2020	*Disseminate research, model and framework proposal in Journals* – **Step 3**
	Spring 2021	*Disseminate research from Data gathered during Spring semester.*
4	Fall 2021	Evaluate, analyze and finalize
	Spring 2022	Thesis writing

Table 2: Selected papers sources

Journal/Conference	Step	Research reference
Journal of Systems and Software	1	Literature review
International Conference on Software Business	2	Qualitative research
Evaluation and Assessment in Software Engineering	2	Qualitative research
International Conference on Product-Focused Software Process Improvement	2	Mixed-method approach
Information and Software Technology	2	Mixed-method approach
Global Engineering Education Conference	3	Mixed-method approach
Frontiers in Education	3	Mixed-method approach
International Conference on Software Engineering	3	Qualitative approach
Journal of Engineering Education	3	Mixed-method approach

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REFERENCES

[1] Nurul Ezza Asyikin Mohamed Almi, Najwa Abdul Rahman, Durkadavi Purusothaman, and Shahida Sulaiman. 2011. Software engineering education: The gap between industry's requirements and graduates' readiness. In *2011 IEEE Symposium on Computers & Informatics*. IEEE, 542–547.

[2] Matthew Bass. 2016. Software Engineering Education in the New World: What Needs to Change?. In *2016 IEEE 29th International Conference on Software Engineering Education and Training (CSEET)*. IEEE, 213–221.

[3] K. Beckman, N. Coulter, S. Khajenoori, and N. R. Mead. 1997. Collaborations: closing the industry-academia gap. *IEEE Software* 14, 6 (Nov 1997), 49–57.

[4] Sarah Beecham, Tony Clear, and John Noll. 2017. Do we teach the right thing?: A comparison of global software engineering education and practice. In *Proceedings of the 12th International Conference on Global Software Engineering*. IEEE Press, 11–20.

[5] Vebjørn Berg, Jørgen Birkeland, Anh Nguyen-Duc, Ilias O Pappas, and Letizia Jaccheri. 2018. Software startup engineering: A systematic mapping study. *Journal of Systems and Software* 144 (2018), 255–274.

[6] Maura Borrego, Elliot P Douglas, and Catherine T Amelink. 2009. Quantitative, qualitative, and mixed research methods in engineering education. *Journal of Engineering education* 98, 1 (2009), 53–66.

[7] Kevin Buffardi. 2018. Tech Startup Learning Activities: A Formative Evaluation. In *Proceedings of the 2Nd International Workshop on Software Engineering Education for Millennials (SEEM '18)*. ACM, New York, NY, USA, 24–31.

[8] Orges Cico. 2019. The Impact of IT Bootcamp on Student Learning-Experience from ICT Enabled Experiential-Based Course. In *International Conference on Software Business*. Springer, 430–435.

[9] Orges Cico. 2019. Technical Debt Trade-off-Experiences from Software Startups becoming Grownups. In *International Conference on Software Business*. Springer, 413–418.

[10] Orges Cico, Anh Nguyen Duc, and Letizia Jaccheri. 2020. An Empirical Investigation on Software Practices in Growth Phase Startups. In *Proceedings of the Evaluation and Assessment in Software Engineering*. 282–287.

[11] Orges Cico, Anh Nguyen Duc, and Letizia Jaccheri. 2020. Software Startup Formation in an Experiential-Based Course-An Empirical Investigation of Students' Motivations. In *2020 IEEE Global Engineering Education Conference (EDUCON)*. IEEE, 1278–1285.

[12] Orges Cico and Letizia Jaccheri. 2019. Industry trends in software engineering education: a systematic mapping study. In *2019 IEEE/ACM 41st International Conference on Software Engineering: Companion Proceedings (ICSE-Companion)*. IEEE, 292–293.

[13] Orges Cico, Letizia Jaccheri, Anh Nguyen-Duc, and He Zhang. 2020. Exploring the intersection between software industry and Software Engineering education-A systematic mapping of Software Engineering Trends. *Journal of Systems and Software* (2020), 110736.

[14] Alison Clear, Allen S Parrish, John Impagliazzo, and Ming Zhang. 2019. Computing Curricula 2020: Introduction and Community Engagement. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*. ACM, 653–654.

[15] Vahid Garousi, Kai Petersen, and Baris Ozkan. 2016. Challenges and best practices in industry-academia collaborations in software engineering: A systematic literature review. *Information and Software Technology* 79 (2016), 106–127.

[16] John Impagliazzo, Alison Clear, and Hala Alrumaih. 2018. Developing an Overview of Computing/Engineering Curricula via the CC2020 Project. In *2018 IEEE World Engineering Education Conference (EDUNINE)*. IEEE, 1–4.

[17] Association for Computing Machinery (ACM) Joint Task Force on Computing Curricula and IEEE Computer Society. 2013. *Computer Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science*. ACM, New York, NY, USA.

[18] Barbara Kitchenham, O Pearl Brereton, David Budgen, Mark Turner, John Bailey, and Stephen Linkman. 2009. Systematic literature reviews in software engineering–a systematic literature review. *Information and software technology* 51, 1 (2009), 7–15.

[19] Li-Qun Kuang and Xie Han. 2012. The research of software engineering curriculum reform. *Physics Procedia* 33 (2012), 1762–1767.

[20] T. C. Lethbridge, J. Diaz-Herrera, R. J. J. LeBlanc, and J. B. Thompson. 2007. Improving software practice through education: Challenges and future trends. In *Future of Software Engineering (FOSE '07)*. 12–28.

[21] Maíra R Marques, Alcides Quispe, and Sergio F Ochoa. 2014. A systematic mapping study on practical approaches to teaching software engineering. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*. IEEE, 1–8.