2019 8th MEDITERRANEAN CONFERENCE ON EMBEDDED COMPUTING (MECO), 10-14 JUNE 2019, BUDVA, MONTENEGRO

# The Design of a Survey on Bridging the Gap between Software Industry Expectations and Academia

Deniz Akdur
ASELSAN Inc.,
Ankara, Turkey
denizakdur@aselsan.com.tr

***Abstract*—Software practitioners have a variety of different roles, whose academic backgrounds are not only based on "Computing Disciplines" but also non-computing ones such as Electrical and Electronics Engineering. Many engineering graduates in the software industry often face difficulties after beginning their professional careers due to misalignment of the skills learnt in the university education with what is needed in the job. It is also reported that software practitioners in the embedded industry, who were graduated from any non-computing disciplines are lacking knowledge in key software engineering (SE) topics and knowledge areas (KAs), which they learn or improve themselves during the job (e.g., after university education). Companies spend crucial resources to train these personnel, who are not "ready" for the industry. Hence, academia must know what skills are needed to adapt the educational programs via an effective curriculum. Although SE is shaped and used by both practitioners and academicians, these two separate worlds have different objectives and concerns. In order to increase Industry-Academia Collaboration (IAC) in SE, it is necessary to understand different perceptions of practitioners about academia. After inspiring different curriculum guidelines and related studies and then identifying the expectations and opinions of practitioners about the academic world (as expert opinions via semi-structured interviews), a survey, which explores the gap between the industry expectations and academic activities, was designed. In this article, the design phase activities of this survey, whose results will shed light on software development education and more IACs, are presented.**

***Keywords-software industry; software engineering education; embedded; non-computing curriculum; practitioner survey; industry academia collaborations (IAC)***

## I. INTRODUCTION

Software Engineering (SE), which is one of the newest engineering disciplines, is defined as "*the application of the systematic, disciplined and quantifiable approach to the development, operation and maintenance of software*" [1]. This definition affects how or to whom SE topics are taught in the university education; hence, most research focuses to improve the curriculum for "Computing Disciplines" (e.g., Computer Science (CS), Computer Engineering (CENG), Information Technology (IT) and Information Systems (IS)). However, the practitioners have a variety of different SE roles (e.g., from software developers to testers and from systems engineers to project managers), whose academic backgrounds are not only based on these computing disciplines but also non-computing ones such as Electrical and Electronics Engineering (EEE). In our previous survey, which investigated software modeling practices in different embedded sectors (e.g., consumer electronics, defense & aerospace, etc.), ~40% of respondents were graduated from non-computing disciplines, which shows that there is a huge number of such practitioners in the industry [2]. This fact, which is one of the main motivations of this study, was also revealed in our cross-factor analysis interviews that non-computing graduates in embedded software industry are lacking knowledge in key SE topics [3, 4]. Therefore, the need for an effective curriculum for different SE roles should not focus on only computing disciplines but also a wider perspective, especially in the embedded software industry. In a specific industrial context, the increasing amount of components in the software-intensive embedded systems, which require seamless integration of many hardware and software systems, force various SE roles (from software developers to systems engineers) to know different key SE topics while working across multiple disciplines.

We have already investigated how the educational skill-set of the practitioner (e.g., whether or not they took any courses related to some SE topics) affect corresponding practices and challenges [4]. Therefore, it is crucial to analyze the gap between the software industry needs and the academic curriculum for two reasons: (1) for companies, it is important to hire properly trained (e.g., "ready") graduates, which allows them to spend less time while incorporating these personnel more efficiently into the workplace; (2) for universities, understanding the required skill set is critical for curriculum maintenance and development. However, given the critical nature of understanding which skills are important, there is no established consensus regarding core skills required for various SE roles, which might be graduated from different disciplines.

SE, which is the application of engineering to software [1], is shaped and used by both academicians and practitioners. However, these two different worlds have totally different objectives, contributions and concerns; hence many researchers and practitioners are not collaborating with each other to solve industrial problems. Since academicians and practitioners have different mindsets (e.g., motivation, goal, focus, etc.), the level of Industry-Academia Collaboration (IAC) in SE is low. Depending on demographic factors such as educational-skill set, SE role or previous poor experience on IACs, there are mismatches in perceptions of various practitioners. Therefore, it is also very necessary to investigate different perceptions of practitioners about academicians in order to increase IACs in SE by improving mutual understanding of each side.

After inspiring different curriculum guidelines and related studies, and then identifying the current expectations and opinions of various industry partners (as expert opinions via semi-structured interviews) about academia, a survey, which explores the gap between the industry expectations and curriculum (e.g., the skills learnt in the university) and research activities, was designed. This survey not only addresses the

978-1-7281-1740-9/19/$31.00 ©2019 IEEE

need to align different SE roles' education with software industry needs but also the opinions of the practitioners about the academic world. In this article, the design phase activities of this survey, (e.g., the selection of critical SE topics and identifying the practitioners' opinions about how they see academics), which took over six months, are presented. Note that besides its overall results, which closes the gap between industry and academia, this study will also shed light on embedded software development education and possible IACs in specific industrial contexts.

The remainder of this paper is structured as follows. Section 2 gives the related studies. Section 3 presents the research methodology by giving the aim and design phase activities of this study, which is the main goal of this paper. Finally, Section 4 concludes this study by giving future directions.

## II. Related Studies

A number of studies have been conducted to determine the critical knowledge and skill set that graduates need to perform in the software industry. The knowledge gap between the industry needs and educational programmes was highlighted by several studies (e.g., [5-8]).

When analysing necessary SE skills, there are two primary concepts: "*hard skills*" and "*soft skills*". Hard skills can be seen as "technical" skills that are gained in the academic curriculum. On the other hand, although soft skills (e.g., personal attributes) can also be gained and improved in these curricula, there is almost no dedicated course on these topics. Rather, students are expected to get these skills through in-class activities or during team projects. Many studies focused on these skills (e.g., [9, 10]) and their results show that both hard and soft skills are needed in order to understand the needs of the software industry. However, these studies also showed that there is no agreement as to what are the most important. While some SE skills stay the same over the years, there are differences based on changes in time and technology. Moreover, these required skills – both hard and soft - depend on the characteristics of the practitioner (e.g., demographics), the type of application (e.g., embedded or desktop) or the target sector of the products.

To highlight the need for more IAC and how to bridge the gap, various conferences & events are regularly organized such as at the International Conference on SE (ICSE). Moreover, the challenges in IAC besides the practitioners' perception of the relevance of SE research have been reported by several reports and systematic reviews (e.g.,[11, 12]).

This study builds on previous studies and significant extensions: it is not limited to neither the educational background (e.g., computing disciplines' graduates), nor a subset of SE roles (e.g., not only developers or IT personnel), nor just a specific region (e.g., not only USA, UK or Finland), or nor too general results to address specific needs (e.g., focuses on application type (e.g., embedded vs desktop) or industrial sector (Consumer Electronics, Defense & Aerospace, IT & Telecommunications)). In this perspective, this survey, by including practitioners' opinions about academia, bridges the gap between software industry expectations and academia with a wider coverage. Moreover, for "embedded software development", this study will have significant results since the survey was designed with the collaboration of various embedded professionals, which will be presented next.

## III. Research Methodology

In this study, the online survey method was chosen to obtain information from various practitioners in a quick manner to analyze these data easily [13]. In this method, there might be some drawbacks due to possible ambiguous and poorly-worded questions [14]. In order to cope with this challenge, pilot studies were applied before the execution of the survey.

### *A. Goal and Research Questions*

The main goal of this survey is to bridge the gap between software industry expectations and academic activities. This main goal is decomposed into three sub-goals: (1) Identifying the usage and importance of SE knowledge areas (KAs) and topics by measuring knowledge gaps with the industry needs and academic curriculum (e.g. "hard skills" analysis); (2) Understanding the most important soft skills; (3) Analysing the opinions of practitioners about IAC on both educational and research activity sides. Based on these goals, by creating corresponding survey sections, the following research questions (RQs) are raised:

- ***RQ1****: What are the most used KAs and SE topics in the software industry? What are the knowledge gaps and coverage of the industry expectations after university education?*
- ***RQ2****: How does educational skill set of the practitioner affect software modeling approach and practices?*
- ***RQ3:*** *What are the most important soft skills in the industry?*
- ***RQ4:*** *What are the opinions of software practitioners for more IAC as part of the education?*
- ***RQ5:*** *How do practitioners see academicians? What are their perceptions about academicians and academic outputs?*

### *B. Survey Design and Execution*

In designing the survey, we made sure that the questions are relevant to the industry and capture the most useful information as relevant to the goal and RQ's of the survey. During this stage, survey guidelines (e.g., [13]) and also previous experience in designing & executing industrial surveys (e.g.,[2]) were utilized and benefitted.

The identified target audience is anyone working in the software industry, with different SE roles from software developer to tester and from systems engineer to manager. This study established a sampling frame composed by a large set of practitioners from different countries with different application type and sectors. The 'accidental non-probabilistic' sampling was used [13] and subjects were targeted via various industry contacts, professional social network sites such as LinkedIn, industry events and forums. The survey was also promoted through SE mailing lists besides encouraging recipients to distribute the survey to their colleagues and partners.

#### *1) Designing survey questions*

In order to develop a survey that would adequately cover the goal of this study, the organization of survey was carefully designed by considering survey guidelines [13].

The survey began with an informed consent, which contained the topic of the study, a confidentiality statement, the expected time to complete the survey and a thank you statement (See [15]).

It is necessary to get a detailed demographics in such a study since practitioners' and projects' characteristics directly affect the results. SE practices used in the industry and opinions of practitioners about IAC do not only depend on their university education (e.g., not only based on the courses taken in BSc or postgraduate) but also depend on the experiences and training undertaken during the job. In other words, we cannot isolate the gained skill set and perceptions of the practitioner from the workplace, which might also affect the results of such a study. Therefore, besides university degree(s) (e.g., computing vs non-computing) and SE role(s) (e.g., developer, tester, systems engineer, etc.), it is also very necessary to know the countries, where the practitioner has worked and the country, where this practitioner completed his university education (e.g., BSc and postgraduate, if any). Note that a practitioner, who completed his/her BSc degree in one country, might go abroad for postgraduate education or their professional career; hence knowing the –possible- differences between these countries might be crucial to compare the results. Apart from this information, knowing the work experience (e.g., the perceptions of experienced professionals vs fresh graduates), the type of applications (e.g., embedded vs desktop) and industrial sector (e.g., consumer electronics, defense & aerospace, automotive, etc.) are also important to better understand and characterize the cross-factor analysis.

In order to align different SE roles' education with industry expectations, Section 1 of the survey aims at identifying the most important hard skills in the industry by shedding light on usage/importance and knowledge gaps of different SE topics. After identifying the necessary KAs and SE topics based on curriculum guidelines such as SWEBOK and ACM Computing Curricula ([1, 16]) and by reviewing similar surveys (See Section II) and the improvement with personal industrial experience, Section 1 mainly asks whether the participant took a specific course related to this item. Then, by asking the usage of this item (i.e., as Likert scale from *Never(0)* to *Always(5))*, it is aimed to analyze the knowledge gaps to address RQ1.

To cope with software complexity, modeling helps engineers to achieve different objectives for different SE roles. We have already shown that the modeling approaches in the embedded software industry (from informal sketches on a paper to formalized models using sophisticated modeling tools) vary since the modeling characteristics depend on a variety of properties such as purposes, SDLC phases, and SE roles [17]. Since the educational skill-set of the practitioner affects the modeling approach and related practices, as RQ2, we wanted to analyze the relation between academic background and the state-of-practices of modeling in Section 2.

After asking about hard skills (e.g., domain knowledge and technical skills), Section 3 tries to understand the importance of soft skills in the workplace (RQ3) and whether the practitioner did take any courses, which improve these skills during university education. The selection of these soft skills is based on related studies (See Section II) and reports (e.g., [18]).

Section 4 and Section 5 are mainly related to perceptions of practitioners about IAC on education and how they see academics. There are various arguments, which reflect the opinions of software practitioners in the scale of *Strongly Disagree* to *Strongly Agree*. These arguments were identified by not only related studies (see Section II) but also by consulting with several practitioners and using personal industrial experiences. In Section 4, it was also intended to verify what were asked about SE topics in previous sections (e.g., the weight of some KAs or soft skills in the curriculum or non-computing graduates' challenges). In Section 5, by applying a similar design to [2]'s "*paired questions*" to explore the balance between various perceptions, participants were asked about IACs. (Notice that these arguments were finalized after expert opinions, which is presented next).

The organization of the survey is depicted in Figure 1. After gathering the demographics of the participants, the survey questionnaire consisted of five main sections [15].

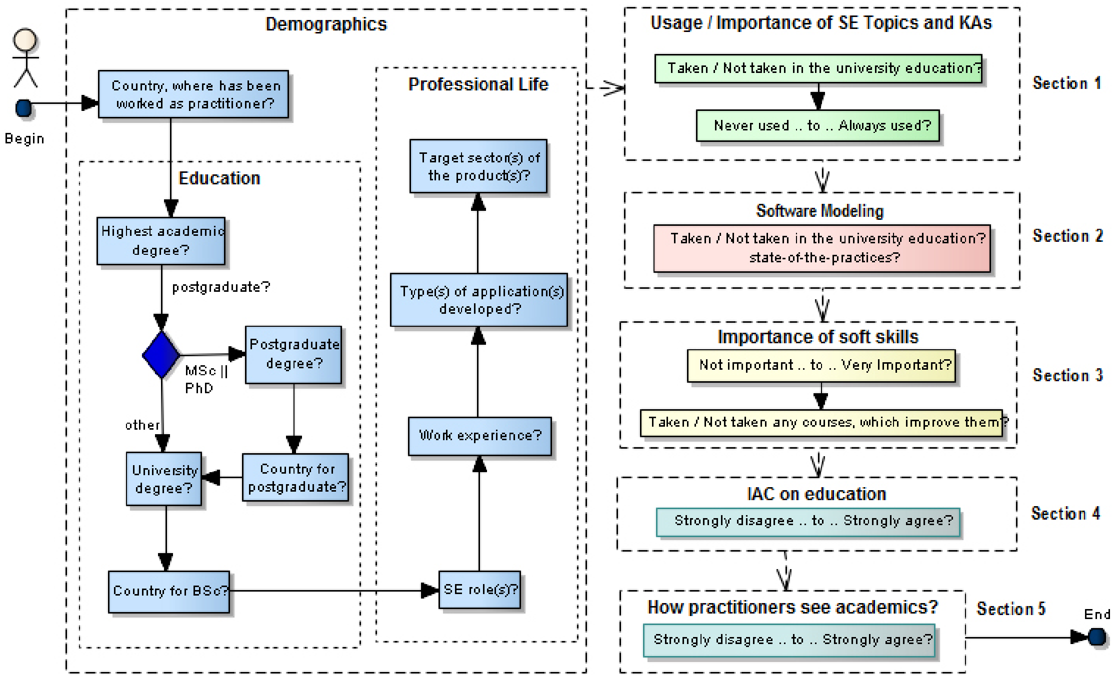


Figure 1. *Organization of Survey Questions*

After preparing this set of questions, to take feedback and suggestions about this draft, as a qualitative approach, semi-structured interviews (e.g., peer reviews as expert opinion) were conducted over two months with 16 experienced practitioners from different SE roles and academic backgrounds in different application types and sectors (Table 1).The interviews were conducted mostly in face-to-face meetings, but if it was inconvenient, on Skype (i.e., five practitioners' interviews (i.e, three from USA and two from UK) were conducted via Skype; all others were face-to-face). The day before the interview, the questionnaire was sent to give him/her chance to think about and criticize these selected SE topics and KAs besides the arguments given in Section 4 and Section 5 of the survey.

TABLE 1. INTERVIEWERS' DEMOGRAPHICS (FOR EXPERT OPINION)

| SE Role | Application Type | Target Sector | Experience* | Degree(s)** |
|---|---|---|---|---|
| High/Middle level manager | Embedded & Desktop | Defense & Aerospace | 28 | CENG |
| Software Architect | Embedded | | 21 | EEE |
| Software Architect | Desktop | | 19 | CENG |
| Software Tester | Embedded & Desktop | | 14 | CENG |
| Systems Engineer | Embedded | | 16 | EEE |
| High/Middle level manager | Embedded | Consumer Electronics | 29 | EE, CENG |
| Software Architect | Embedded | | 15 | CS |
| Software Architect | Embedded | | 14 | CENG |
| Software Developer | Embedded | | 12 | EEE, CENG |
| Software Architect | Embedded | IT & Telecommunications | 17 | EEE |
| Software Architect | Desktop | | 19 | CENG |
| Software Architect | Embedded | Healthcare & Biomedical | 18 | EEE |
| Software Architect | Embedded | Finance & Banking | 16 | CS |
| Software Architect | Desktop | | 14 | CENG |
| Software Architect | Embedded | Automotive | 15 | CENG |
| Software Architect | Desktop | Government | 17 | CENG |
| **Total:** 16 software practitioners, 284 years of work experience | | | | |

* Software development experience in years
** Computer Science (CS), Computer Engineering (CENG), Software Engineering (SE), Electrical/Electronics Engineering (EEE)

Given their feedback and suggestions, the survey was refined in each section by getting a consensus. The organization and contents of Section 1 and Section 2 were modified (e.g., including/removing new SE topics and KAs) according to common concerns. Section 3 was refined by combining some similar skills into one item to achieve common understanding of the same attribute (e.g., *"Analytical/Critical/Creative thinking"* or *"Presentation /Documentation skills"*). The most challenging parts were the modifications in Section 4 and Section 5 since they included more personal experiences and different perceptions about the academic world. Almost all arguments were refined according to each feedback.

*2) Survey piloting and execution*

The survey was firstly piloted by seven colleagues from different industries working in different SE roles and different nations (five Turkish, two English). This was done to ensure that the wording and terminology used in the survey is easily understandable and well-formulated to get high quality data. Given their feedback and the time needed to fill out the survey, the organization of Section 1 was refined by modifying subsections for some specific KAs. Two arguments in Section 4 and one argument in Section 5 were modified to increase its understandability. The revised survey was reviewed a second time by four other colleagues and two colleagues, who had participated in the first pilot study. Therefore, the final version of this survey was reviewed by 11 professionals.

To design and execute the survey, the Google Forms tool was used. The ethics approval for the survey was issued by the Human Subjects Ethics Committee of Middle East Technical University (METU) in March 2019. The survey was then executed in the period of March-May 2019.

## IV. CONCLUSION AND FUTURE DIRECTIONS

In this article, the design activities of a survey, which bridges the gap between the software industry expectations and academic activities, was presented. During this process, as a qualitative approach, various expert opinions from the field were taken (Table 1) to reflect different industrial needs and perceptions about academic activities.

With the help of the results of this study, whose cross-factor analysis for different demographics have been already started, academia can adapt their programs with an effective curriculum for different SE roles and sectors (e.g., especially for non-computing disciplines in embedded software) so that various graduates will be more efficiently incorporated into the industry. Moreover, revealing practitioners' perceptions about academia with demographic differences (e.g., regional, application type, sector, etc.) will increase IACs. Collected data are planned to be published as research articles.

## ACKNOWLEDGMENT

The author would like to thank all software professionals, who contributed to the design of this survey study.

## REFERENCES

[1] P. Bourque and R. E. Fairley, *Guide to the Software Engineering Body of Knowledge (SWEBOK(R)): Version 3.0*: IEEE Computer Society, 2014.

[2] D. Akdur, V. Garousi, and O. Demirörs, "A survey on modeling and model-driven engineering practices in the embedded software industry," *Journal of Systems Architecture* vol. 91, pp. 62-82, 2018.

[3] D. Akdur, V. Garousi, and O. Demirörs, "Cross-factor analysis of software modeling practices versus practitioner demographics in the embedded software industry," in *6th Mediterranean Conference on Embedded Computing (MECO)*, Montenegro, 2017.

[4] D. Akdur, O. Demirörs, and B. Say, "Towards Modeling Patterns for Embedded Software Industry: Feedback from the Field," in *44th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*, Prag, Czech Republic, 2018.

[5] T. C. Lethbridge, "What Knowledge Is Important to a Software Professional?," *Computer,* vol. 33, pp. 44-50, 2000.

[6] B. Kitchenham, D. Budgen, P. Brereton, and P. Woodall, "An investigation of software engineering curricula," *Journal of Systems and Software,* vol. 74, pp. 325-335, 2005.

[7] S. Surakka, "What subjects and skills are important for software developers?," *Commun. ACM,* vol. 50, pp. 73-78, 2007.

[8] A. M. Moreno, M.-I. Sanchez-Segura, F. Medina-Dominguez, and L. Carvajal, "Balancing software engineering education and industrial needs," *J. Syst. Softw.,* vol. 85, pp. 1607-1620, 2012.

[9] C. L. Aasheim, S. Williams, and E. S. Butler, "Knowledge and Skill Requirements for it Graduates," *Journal of Computer Information Systems,* vol. 49, pp. 48-53, 2009.

[10] A. Radermacher, G. Walia, and D. Knudson, "Investigating the skill gap between graduating students and industry expectations," presented at the 36th International Conference on Software Engineering, India, 2014.

[11] D. Lo, N. Nagappan, and T. Zimmermann, "How practitioners perceive the relevance of software engineering research," presented at the Foundations of Software Engineering, Italy, 2015.

[12] V. Garousi, K. Petersen, and B. Ozkan, "Challenges and best practices in industry-academia collaborations in software engineering," *Inf. Softw. Technol.,* vol. 79, pp. 106-127, 2016.

[13] J. Linaker, S. M. Sulaman, R. Maiani de Mello, M. Höst, and P. Runeson, "Guidelines for Conducting Surveys in Software Engineering," 2015.

[14] F. Shull, J. Singer, and D. I. K. Sjoberg, *Guide to Advanced Empirical Software Engineering*: Springer-Verlag New York, Inc., 2007.

[15] D. Akdur, "Survey Form: Bridging the Gap between Software Industry Expectations and Academic Activities," *https://drive.google.com/file/d/1TvYUHScDojZPC6nLSWGpewKUbS0ewgrP/view,* 2019, Last accessed: Mar. 15, 2019.

[16] ACM, AIS, and IEEE-CS, "Computing Curricula," 2005.

[17] D. Akdur, O. Demirörs, and V. Garousi, "Characterizing the development and usage of diagrams in embedded software systems," in *43rd Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*, Vienna, Austria, 2017.

[18] "Future Work Skills 2020," The Institute for the Future, 2011.