

Are Requirements Engineering Courses Covering what Industry Needs? A Preliminary Analysis of the United States Situation

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Abstract—In the United States, only few undergraduate curricula for computing-related field majors have an entire course dedicated to requirements engineering (RE). Usually, these are the bachelors of science in software engineering (BS SWE), while bachelors of science in computer science (BS CS) cover the topic during an overview course on software engineering, and dedicate only a couple of weeks to RE. Recent studies have shown that companies have specific demands for the competences that requirements engineers should have, and often such competences, such as analytical thinking and communication skills, are not sufficiently covered by RE textbooks and courses. However, no systematic analysis has been performed on the actual content of RE-related courses. In this paper, we survey what is taught in academia in RE-related courses. Our analysis is based on the data collected from more than 40 universities in the United States that offer a BS SWE. We show potential misalignments between what is offered by courses and industry needs, and we propose a research plan to further investigate this situation and to develop possible remedies for it.

Index Terms—Requirements engineering, industry needs, curriculum.

I. INTRODUCTION

Requirements engineering (RE), in particular requirements analysis and specification, is one of the 10 knowledge areas considered fundamental for software engineers by software engineering IEEE/ACM guidelines [13], which recommend 30 hours of lectures on RE-related topics (6 on fundamentals, 10 on elicitation, 10 on specification and documentation, and 4 on validation).

Many of the competencies taught during RE courses are very important for many computing-related positions. Moreover, industry requires many of the soft skills (e.g., communication skills) that are characteristics of good requirements engineers. Recent studies, conducted in Europe and South and Central America, have shown that even if the title “requirements engineers” might not exist on the job market [7], requirements engineer’s and business analyst’s expertise are highly needed and there are specific knowledge and skills the industries looks for [4], [2]. Given the fundamental role of RE in the preparation of software engineers and computer scientists, the RE community have dedicated a lot of energy to develop courses, lectures, and experiences to effectively teach this challenging and important discipline and the needed soft skills to succeed in it [10].

However, at the first impression, it does not seem that majority of computing-related field majors dedicate many hours to requirements engineering. For example, in the United States, only few undergraduate curricula for computing-related field majors have an entire course dedicated to RE. Typically, these are the bachelors of science in software engineering (BS SWE), while bachelors of science in computer science (BS CS) usually cover the topic during an overview course on software engineering and dedicate only a couple of weeks to RE, and sometimes offer an elective for the students who are interested in deepening their knowledge of RE. This represents a misalignment between the market needs [7], [4], [2] and how we prepare students to succeed in their careers and is also in contrast with the guidelines given in [13].

To confirm this initial impression and better understand the situation, we have analyzed more than 40 BS SWE programs in the United States to see how many of them have a course dedicated to RE and, for those, we have looked at how the time is distributed over the different topics and if any interesting active learning activity is included in the course schedule. For the programs without RE courses, we looked at where RE notions are introduced and how much time is dedicated to them in total. The preliminary collected data allow us to have a clearer idea of the situation in the United States and are an encouragement to plan a more rigorous analysis to be able to correct the current trend and avoid misalignment between industry and education. Notice that the focus of this paper is the analysis of the current status of education and not of the industry needs, for which at the moment we rely on existing studies [7], [4], [2].

The remainder of the paper is structured as follows. Section II presents the data collected in our analysis of BS SWE programs in the United States and the reflections that these data generated. Section III outlines our research plan to better understand the United States situation on RE education (REE) and discusses possible outcomes and risk of the proposed research. Finally, Section IV concludes the paper.

II. PRELIMINARY ANALYSIS OF THE UNITED STATES UNDERGRADUATE CURRICULA

To have a preliminary overview of the status of REE in the United States, we searched for BS SWE programs in the

different states of the country. Even if the need of analysts with higher education [2] has been recognized, at least in some countries, as one of the industry demands, in our work, we focused on undergraduate programs. Indeed, as reported in the 2014 study of the United States Department of Education [9] that analyzed the employment or enrollment status in 2012 of bachelors degree recipients in 2007–2008, the majority of students in engineering and computing-related majors in the United States does not pursue a graduate degree after graduating from a BS. More precisely, 85.3% of the students who completed a bachelor degree with a STEM major in engineering and engineering technology stopped studying after the BS. The percentage increases to 91.2% in the case of students who completed a bachelors degree with a STEM major in computer and information sciences.

The following data collection and analysis do not have the ambition to give any answer to the United States status on REE, but aim at motivating the research proposed in Section III, raising the interest in conducting similar studies also in other geographical areas, and starting a discussion on possible solutions to this misalignment between industry and education.

Data collection procedure. To evaluate the situation of the REE in the United States, we first identified the BS SWE programs in the country. We decided to focus only of SWE programs and neglect any other computing-related field major in this phase, since only the software engineering IEEE/ACM guidelines [13] includes a considerable numbers of “core” hours dedicated to RE topics. This choice has caused the exclusion of some institutions with strong software engineering groups, since they do not offer a BS SWE.

As a first step we considered the BS SWE listed as the 20 best program in software engineering in 2018 [3]. After that, we looked for all the BS SWE programs that had ABET¹ accreditation in 2017. This allowed the addition of 15 more programs. Then, with a further (non-systematic) online search, we found 6 other BS SWE for a total of 41 BS SWE programs.

For each of the identified programs, we searched for the program description and the curriculum sheet to identify which of them include a class explicitly dedicated to RE. For the programs which have an RE course, we searched for the description and the syllabus of this course to identify its detailed content and the distribution of the lectures over the covered topics. For the programs without a course dedicated to RE, we looked for the course(s) which include some RE notions and we searched for their description, schedule, and syllabus, to identify how many lectures in the course are dedicated to RE. Moreover, since active learning is recognized as an important tool to help students’ success [5], [14], we also looked in the syllabi for innovative teaching methods, active learning, role-playing activities, and on-the-field experiences.

The data were collected by the first author and checked by sampling and partially integrated by the second author.

¹ABET [1] is the non-prof organization that accredits college and university programs in the disciplines of applied and natural science, computing, engineering and engineering technology.

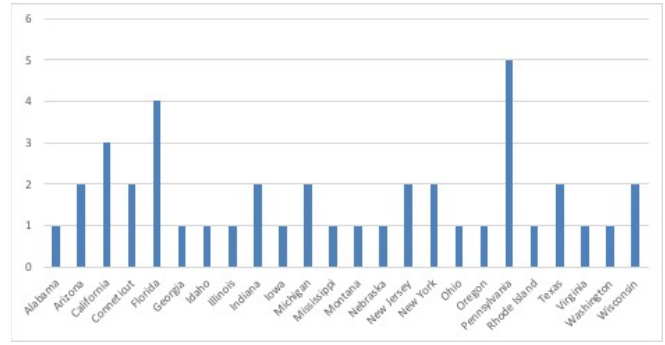


Fig. 1. Geographical distribution in the United States of the considered BS SWE.

Collected data. The identified programs are distributed over 24 states (see Figure 1 for more details on the distribution) and more than 65% of them held the ABET accreditation in 2017². Only 17 of 41 (41.5%) have a course explicitly dedicated to RE (or related) topics, but among them 6 (more than a third) are not fully dedicated to RE and also introduce some other major software engineering topic (e.g., software architecture). For the majority remaining programs (51.3%), we were able to identify the course(s) in which notions of RE are taught and, in 71.4% of these cases (36.6% of the total number of considered programs) these notions are included in introductory courses on software engineering. For a small portion of the considered programs (7.3%), it was not possible to identify where RE notions are introduced. Notice that we were able to find online the syllabi of only half of the programs and, in the remaining cases, we mainly relied on the course descriptions from the university catalogue, which were not always accurate enough to deduce relevant information. The absence of many syllabi is a threat to the validity of our analysis, but this limitation can be considered acceptable for a preliminary study.

For 26 programs, using the syllabi and the online descriptions, we were able to estimate the number of hours dedicated to RE topics. In these programs, on average 20 hours and 30 minutes are dedicated to RE. In particular, the average number of hours dedicated to RE topics in institutions with a course explicitly dedicated to RE is 27 hours and 30 minutes, while for the other institutions the average is 6 hours. Among these programs, the minimum number of hours dedicated to RE topics is 1 hour and 30 minutes.

Finally, in those cases where the syllabus was present, we noticed that the distribution of the topics is not consistent to what recommended in [13], and also did not take into consideration industry needs, which require students to be able to perform typical requirements engineering tasks, such as elicitation of requirements, analysis of processes, documentation, coordination of requirements with customers, management of requirements changes, consulting of customers with modeling,

²The most of the non-accredited BS SWE programs belongs to institutions with other STEM programs which are accredited. This suggests that their BS SWE program might be “too young” to be accredited, but will be accredited soon.

and development of RE guidelines [7], [4], [2]. For example, regardless the importance of elicitation, that as been recognized as one of the main causes of software failures [6], in the majority of the cases only one or two lectures are dedicated to the topic. There were only 2 exceptions to this allocation of time: in two courses 6 hours were assigned to requirements elicitation. The assignment and lecture descriptions in the available syllabi do not suggest any particular active learning activity worth to be reported.

Reflections. Even if our data collection does not have any ambition of being a rigorous study and does not provide a complete picture of the situation in the United States, the glimpse of the global picture it gives both suggests a few reflections on the current REE situation in the United States and raises some questions on the impact of this situations on BS SWE students' success.

The picture that the data draw starts unveiling a misalignment between what the industry looks for when hiring and how many programs distribute their hours and credits to prepare software engineers. Indeed, as also reflected in the time allocation of the ACM/IEEE guidelines [13], industry looks for graduates able to well perform typical requirements engineering tasks [7], [4], [2]. It is very surprising that so many programs do not respect the ACM/IEEE guidelines [13] in terms of hours dedicated to RE topics. It is also surprising that the existing courses do not rely on many active learning activities that are fundamental in teaching the soft skills needed to succeed as a requirements analyst. For example, in the case of elicitation, many techniques rely on soft skills and talent of the analysts, and the needed skills should be taught and practiced in RE courses. As already shown in many studies [15], [12], [11], role playing and active learning, in general, is an effective pedagogical approach to enable students to learn from experience, so it should be included in RE courses, since the students' success in the field might depend on those skills.

This glimpse of the United States situation raises also a few questions on the impact of the curriculum on students, both in terms of success and perception, and on companies. In particular, it would be interesting to investigate the following topics:

- 1) **Students' perception of RE topics:** Do they recognize the importance and difficulty of the RE phases? Do they underestimate most of it? Does their perception change after they graduate and start working in the field? If so, how?
- 2) **Students' success rate in Industry:** Are BS SWE graduates hired for positions with RE-related responsibilities? If so, do they succeed in these positions? Does the success require additional training?
- 3) **Companies' perception on RE education:** How do companies perceive the way in which different United States institutions teach RE topics? Do they consider the effort enough? Would they be interested in the design of a different educational solution or in being involved in active learning activities?

Before answering to the above questions, it is important to first understand which is the detailed REE situation in the United States and if the glimpse given by this preliminary study is confirmed.

III. RESEARCH PLAN

Our preliminary study shows that the current BS SWE programs in the United States do not dedicate much time to teach RE-related topics. Given the importance of RE for the software development process, this could be harmful for the quality of software, so it is essential to deepen in the data and better understand the situation and, if confirmed, react to it. To this end, we plan to collect a new set of data with a more complete and systematic procedure, and to analyze and correlate them using the appropriate statistical indices.

Data collection. As a first step we need to systematically search for BS SWE programs to try to include all the available ones. To do so, we will rely on the following sources:

- ABET accredited program search engine (to add the program accredited in 2018)
- Additional university rankings
- Professional mailing lists and colleagues from different states

During this search, we will also include online programs, but we will keep the data of on campus and online program separated, and we will analyze them as separate sets since online education presents a different set of challenges [8].

Once the BS SWE programs are identified, for each of them, we will look online for the following data:

- Program description
- Curriculum sheet
- Description of all the SWE courses in the program
- Syllabus of all the SWE courses in the program
- Tentative schedule of all the SWE courses in the program
- List of special activities related to RE courses

These data will allow a global view on the program and the SWE courses in it.

Since, as happened in the search we did for our preliminary analysis, we will not be able to find all this information online, for each program, we will contact both the Department Chair of the department hosting it and the Program Coordinator to ask them to both validate and complement the identified data. We will also develop and distribute to them a questionnaire to gather their perception on the preparation of their students on RE-related topics.

In this phase, we will also develop three additional questionnaires, one for the students, one for the alumni, and one for the companies that participate in the Industry Advisory Board of each program to collect the data needed for answering to some of the questions raised at the end of Section II.

To make our data collection procedure more rigorous, the team working on the data collection will be composed by 4 researchers and the search of programs will be performed by 2 researchers independently. Once a common complete list is created, for each of the identified programs, they will also

independently search for the needed material. Their work will be merged and reviewed by all the members of the team, and, after this revision, the Department Chair and coordinator of the program will be contacted.

Data analysis. Once the data are available, it will be first analyzed using classic basic statistical indices. This will help to have a high level view on the hours dedicated to RE topics, the distribution of the hours on the topic, the kind of active learning activities executed. This information will be then separated and aggregated using different criteria, such as size of the program, geographical location, and type of institution.

The data from the questionnaires distributed to students, Industry Advisory Board (IAB), and faculty will be correlated with the program the participant is affiliated with, so that we can evaluate the relationship between the perception of the importance and difficulty of the topic and the time dedicated to it in the program, and misalignment between the provided REE and industry expectations.

The data collected from the alumni will help to measure the success of the students in RE-related activities and to correlate it with the received education. In this analysis we will also consider the students' career data, such as GPA, years needed to complete the program, and other demographic information.

Risks. There are many risks related to the proposed study, some caused by the size of the study and the potential variables to consider. First of all, since the considered programs are distributed in different states of the United States, very different results can be found because of the characteristics of geographical area in which the programs are offered. Geographical location might not be considered to decide the number of hours to allocate to RE topics and the time distribution among them, but might impact on the IAB needs (and, hence perception) and on the alumni success. In order to avoid meaningless results obtained by aggregating data in the wrong way, we need to separate data geographically when relevant and add geographical characteristics as part of the analysis. Another main risk is not being able to find all the needed data because of a low response rate from any of the involved sources. This is not avoidable. Sending reminders to the chairs and coordinators and highly advertising the questionnaires can mitigate this risk, but cannot give any assurance. If not enough data will be collected for a particular program, the program will be neglected in the indices computation.

IV. CONCLUSION

In this position paper, we have presented the results obtained through a preliminary analysis of the REE situation in the United States. Our study does not claim any rigor, but gives a glimpse of the current status, in which more than half of the 41 identified BS SWE programs do not have a course dedicated to RE topics and dedicate to RE-related topics only a few hours in an introductory courses on software engineering. These initial results suggest that we need to run a more rigorous study to have reliable data to analyze. If the new data will confirm that most of the programs do not dedicate much time to RE topics, we will need to evaluate the consequences of this and react to

them. To this end, we will also collect additional information about the perception that students, faculty and IAB members have of RE and the REE offered in the program they attended to and the current status of alumni and their experience with RE-related jobs. After the analysis of the BS SWE against the industry needs identified in existing studies, we will expand our analysis to also focus on the requirements engineering skills that United States companies are looking for in order to have a more accurate view of the misalignments between industry and education.

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