Assessment and improvement of a Software Engineering curriculum using the SWEBOK[1]

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Abstract. The paper reports an assessment and improvement of the Software Engineering (SE) curriculum in the context of a SE university program in Turkey, taking the latest version 3.0 of the Software Engineering Body of Knowledge (SWEBOK) as the baseline. Using the systematic case-study approach and quantitative analysis of hourly topics covered in each SE course, we conducted cross checking of the hourly topics with the 15 knowledge areas of the SWEBOK version 3.0. According to our empirical findings topics that are not covered were identified and a set of recommendations are proposed to improve the curriculum under study.

Keywords: Software engineering education, software engineering curriculum, assessment of curriculum, SWEBOK

1 Introduction

Software Engineering (SE) is one of the fastest-evolving engineering disciplines and most of the tasks of software development organizations are diverse in nature. Various studies, e.g., [1-4], have shown that there is a wide gap between software industry needs and education for prospective software engineers. SE curriculum should correspond to the industry needs, and only then can universities train highly-skilled professionals, who can meet the needs of software industry [5]. It is quite common to hear the complaints of

software companies about the inadequate practical knowledge of the students who start working after the completion of their academic programs [6].

Various reference models are being used for continuous improvement of SE curriculum, e.g., the Software Engineering Body of Knowledge (SWEBOK) [7-9] and "Software Engineering (SE) 2004" [10].

The study reported in this article was motivated by a need in Atilim University's SE program to analyze potential overlap among SE courses and provide recommendation for an adequate coverage of various SE topics in lieu of the knowledge areas in the latest version of the SWEBOK. While a number of previous studies, e.g., [11-15], have conducted assessment and improvement of SE curriculum using the SWEBOK, our approach uses the SWEBOK's latest 2014 version and offering a more in-depth and quantitative assessment compared to existing work.

The remainder of study is organized as follows. Section 2 presents background about the related work. Section 3 presents our assessment and improvement approach for the SE curriculum using the SWEBOK. Finally, Section 4 concludes this study and points out the future work directions.

2 Background and related work

We briefly present next a review of the SWEBOK and its history. Related work and an overview of SE education in Turkey are discussed afterwards.

As of this writing, the most recent version of the SWEBOK is its version 3.0 [9] which was released in 2014, and had 15 knowledge areas (KA's). SWEBOK knowledge areas for all its three versions 2001, 2004 and 2014 are shown in Table 1.

Table 1. Evolution and the knowledge areas (KA's) of the SWEBOK

Trial version (#1), 2001 [7]	**2. ver., 2004 [8]**	**Version 3.0, 2014 [9]**
1. Software requirements 2. Software design 3. Software construction 4. Software testing 5. Software maintenance 6. Software configuration management (CM) 7. SE management 8. SE process 9. Software quality 10. SE tools and methods	Same KA's as the trial version, with improvements and revisions	1-8 as in Trial version (#1], 2001 9. SE models and methods (replaced SE tools and methods) 10. Software quality 11. SE professional practice (professionalism) (new) 12. SE economics (new) 13. Computing foundations (new) 14. Mathematical foundations (new) 15. Engineering foundations (new)

The SWEBOK has been utilized for a variety of purposes in the literature, e.g., designing questionnaire-based surveys in various areas of SE (e.g., [16]), proper training of professionals (e.g., [17]), SE education (e.g., [11-15]), etc.

Most of the Turkish universities, including Atilim University, have adapted the well-known European Bologna process [18], while is a joint Europe-wide effort for standardization and quality assurance of higher education qualifications across Europe.

3 Assessment and improvement of SE curriculum using the SWEBOK

We first present an overview of the case under study (Atilim University's SE curriculum). Then, we discuss the assessment methodology, how we have applied it on the case under study and the results.

3.1 Case under study: Atilim University's SE curriculum

Atilim University's SE program was established in 2005. The SE program's curriculum has been carefully improved in several iterations in years 2012 and 2014 according to earlier version of the SWEBOK.

The program already has courses in various SE topics, e.g., "Software Requirements Engineering, "Software Quality Assurance", "Software Project Management", Software Architecture, and Systems Software Validation and Testing.

In addition to the above, over the last few years, the department has received feedback from students about some redundancy among the SE courses. Based on all the above reasons, the authors decided to conduct a comprehensive analysis and come up with certain recommendations with regards to potentially redundant topics across courses and also coverage adequacy of various SE topics in courses in lieu of SWEBOK knowledge areas, to be later passed on to the course instructors for improvement of the courses.

3.2 Assessment methodology

As for the methodology, to ensure that we would conduct a systematic analysis, we adopted the well-known 'case-study' approach [18] used frequently in the SE research literature, and namely, 'exploratory' and 'improving' case studies

In the exploratory phase, our approach was to take the 15 KA's of the SWEBOK and assess quantitatively how each of the SE courses of the program under study cover each of the KA's. After the exploratory phase, we

wanted to assess and pinpoint the inadequate coverage of SE topics (if any) among the program courses and also to quantitatively measure the redundancy among SE courses.

3.3 Exploratory phase: assessment w.r.t. the knowledge areas

As discussed in Section 2.3, all the courses have standard Bologna-based course outlines, from which we extracted the weekly materials and mapped them to the 15 KA's of the SWEBOK. Fig. 1 depicts our process for assessing the SE curriculum w.r.t. the KA's. As an example, the weekly contents of the course SE 112 have been shown. Numbers in this matrix represent the number of weeks (total 14) spent on each KA in each course.

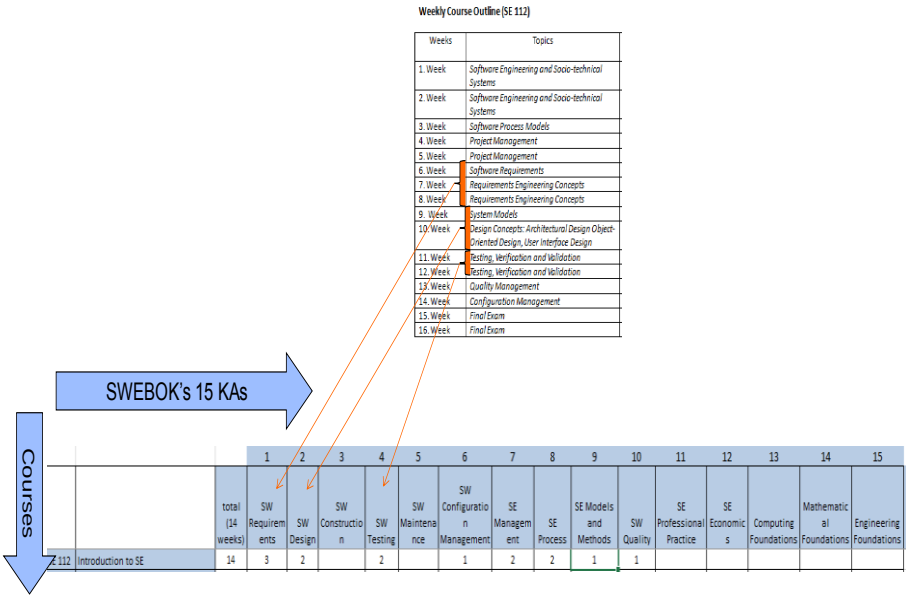

Fig. 1. Process for assessing the SE curriculum w.r.t. the 15 knowledge areas of the SWEBOK

Fig. 1 shows the final result which provides an overview picture of the curriculum w.r.t. the KA's. As we can see in the table, there are 13 core SE courses in the program.

Table 2. Assessment of the Atilim SE curriculum w.r.t. the 15 KA's.

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		total (14 weeks)	SW Requirements	SW Design	SW Construction	SW Testing	SW Maintenance	SW Configuration Management	SE Management	SE Process	SE Models and Methods	SW Quality	SE Professional Practice	SE Economics	Computing Foundations	Mathematical Foundations	Engineering Foundations
SE 100	Fundamentals of SE	14			2					1					9		2
SE 112	Introduction to SE	14	3	2		2		1	2	2	1	1					
SE 212	Human Computer Interaction	14	1	1		1									11		
SE 221	SW Requirements Engineering	14	13			0,5			0,5								
SE 222	SW Quality Assurance	14				2		1				11					
SE 320	SW Project Management	14							12			1		1			
SE 321	Object-Oriented Analysis and Design	14	2	11							1						
SE 322	SW Architecture	13		12								1					
SE 344	Systems SW Validation and Testing	14				12	0,5	0,5			1						
SE 394	Project Orientation	14							3						1		10
SE 399	Summer Practice I	14											14				
SE 494	Senior Project	14	1	2	4	1			2	1	1	1		1			
SE 499	Summer Practice II	14											14				
		Totals	20	28	6	18,5	0,5	2,5	19,5	4	4	15	28	2	21	0	12

We summarize and discuss in the following the exploratory assessments and observations based on Table 2.:

- We found that there is generally a good coverage of requirements, design, construction, testing, SE management, SE process, SE models and methods, SW quality, and SE professional practice.
- The coverage of SW maintenance, SW CM and SE economics is low.
- We noticed that SW maintenance and SW CM were not required from students in the "Senior project" course.
- For the KA of SE economics, students are only taking the course Engineering Economy Analysis, offered by another department. However, we need more coverage in SE-specific economics. Improving phase: recommendations for SE curriculum improvement.

Based on the findings in the exploratory phase, we prepared a set of recommendations to be delivered to the curriculum committee as follows:

- For the SW maintenance: We reported that just mentioning the phrase "SW maintenance", and that it is important in SE, is not enough. We need to have more practical exercises in the courses focusing on SW maintenance. It is apparent that, in the real-world projects (e.g., [20]), a large ratio of developer's time is spent on SW maintenance.
- For the SW CM: We recommended that we need to require from students in their senior SE courses (3rd and 4th year) to use code-versioning system.
- For the SE economics: We are aware that economics is a major driver of SW projects in the industry. We thus recommended that there is a need to talk more about SE economics in various courses, e.g., cost-benefit analysis of use-cases, ROI of software quality activities and also the need for more practical exercises about SE economics.

- There is need of more applied content on software process improvement and software process models.
- SE professional practice should be included and this may be part of summer practice and field trip of software companies and software technology parks.

A departmental committee has now been tasked to use the information in this analysis to make revisions to the courses and improve delivery of the SE material in the program.

4 Discussions and Conclusion

The paper reported an assessment and improvement of the Software Engineering (SE) curriculum in the context of a SE university program in Turkey. Using the systematic case-study approach and quantitative analysis of hourly topics covered in each SE course, we conducted cross checking of the hourly topics with the 15 knowledge areas of the SWEBOK version 3.0. Among our empirical findings in the context of the case SE program under study were the followings: (1) We noticed that the concept of software maintenance has barely only mentioned in the SE courses, and there is a need for practical exercises on this very important SE topic; (2) Based on our analysis, we recommended that there is a need to require from students in their senior SE courses (3rd and 4th year) to use code-versioning system; and (3) There is need to introduce SE-specific economics course; (4) Software engineering tools and methods adoption in courses; (5) Industry based senior projects so students can appreciate real-life software development environment

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