

The skills needed for employing new software engineering graduates

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Abstract

It's been widely reported in the literature that new software engineering graduates are facing difficulties in transitioning from the educational environment to the work environment. The difficulties are mostly attributed to the lack of the required skills for entering the labor market. It's also believed that software engineering students are not aware of these required skills during their educational period. To this reason, this research aims to review the related literature and uncover the necessary skills that employers desire when hiring new software engineering graduates. The research used a qualitative methodology to address the research objectives. The reviewed literature categorized skills to technical skills and non-technical skills. The findings show that employers desire software engineering professional practice and non-technical skills in general. They also give importance to certain activities and skills especially requirements engineering, design and testing. Specific areas of SE such as configuration management, SE models and methods as well as SE process need more attention by educational institutions, as well as, the importance of real-world examples in SE courses.

Key words: Software engineering, skills, required skills.

المخلص

يتم التعاطي على نطاق واسع أن خريجي هندسة البرمجيات الجدد يواجهون صعوبات في الانتقال من بيئة التعليم إلى بيئة العمل. وتعزى الصعوبات في الغالب إلى نقص المهارات المطلوبة لدخول سوق العمل. من المعتقد أيضًا أن طلاب هندسة البرمجيات ليسوا على

دراية بهذه المهارات المطلوبة خلال فترة تعليمهم. لهذا السبب ، يهدف هذا البحث إلى مراجعة الدراسات السابقة ذات الصلة والكشف عن المهارات اللازمة التي يرغب فيها أصحاب العمل عند تعيين خريجي هندسة برمجيات جدد. استخدم البحث منهجاً نوعياً لمعالجة أهداف البحث. صنفت الدراسات المهارات إلى المهارات الفنية ، والمهارات غير الفنية. تظهر النتائج أن أصحاب العمل يرغبون مهارة الممارسة المهنية لهندسة البرمجيات والمهارات غير الفنية بشكل عام. كما أنهم يعطون أهمية لأنشطة ومهارات معينة خاصة هندسة المتطلبات والتصميم والاختبار. كما تحتاج مجالات معينة من هندسة البرمجيات مثل إدارة التكوين ونماذج هندسة البرمجيات وأساليبها بالإضافة إلى عملية هندسة البرمجيات إلى مزيد من الاهتمام من قبل المؤسسات التعليمية ، فضلاً عن أهمية الأمثلة الواقعية في مقررات هندسة البرمجيات.

1. Introduction

According to [1] it's predicted that the demand for software engineer's employment will grow worldwide. SlashData [2], a leading software development analyst firm, reported an estimated 19 million software developers at the start of the year 2019. The firm also expects that by the end of the decade, the number will more than double, to reach around 45 million software developers globally. To fill those roles, experts anticipate the job market for software development will continue to soar [1]. This increasing demand for hiring software engineers gives more importance to conducting this research.

Students seeking a degree in software engineering have the perception that after graduation they will be ready to pursue a career in their field of study. According to the literature, students have the perception that the software engineering curricula that they study prepares them for work. Also, many new software engineering graduates face difficulty in transitioning from the educational environment to the work environment due to lack of certain skills. As many studies [9][10][11][12][13][14][15][16][17][18] have indicated, the difficulties students face after graduation are mostly attributed to lack of certain skills that employers see as essential for hiring new graduates.

In order to help in best preparing students for the work environment, this study aims to review the related literature to uncover the skills that employers' desire in new graduates, and highlight them so that they work toward obtaining these skills before graduation. We believe that these skills are universal for all new graduates of software engineering.

The rest of the paper is structured as follows; section 2 points out the research methodology, section 3 gives the necessary background and the review of related research, a discussion of the findings is given in section 4, and finally concluding remarks are given in section 5.

2. Research methodology

The data collected in this research was based on the qualitative research methodology. Qualitative research is a type of research that enables researchers to gather data about past experiences, behaviors, and peoples' perceptions and meanings they attach to the topic. The methodology assists researchers to gain better knowledge and understanding of specific issues or problem, they are trying to study [3]. The source of the data was a literature review of previous related studies about the topic under investigation in this research.

2.1 Research question

The data collected because of the review of previously related literature is purposely meant to answer the following research question:

- What skills are most valued by employers when hiring new software engineering graduates?

The next section presents the background and the literature reviewed in trying to find answers to the above research question.

3. Background and related literature research

3.1 Software engineering

Software Engineering (SE) is the branch of computer science that deals with the design, development, testing, and maintenance of software applications. Software engineers apply engineering principles and knowledge of programming languages to build software solutions for end users [4].

IEEE, in its standard 610.12-1990, defines software engineering as “the application of a systematic, disciplined, which is a computable approach for the development, operation, and maintenance of software.” [5].

3.2 Software engineer

IEEE, in its standard 610.12-1990, defines a software engineer as “the person who applies the principles of software engineering to design, develop, maintain, test, and evaluate computer software.” [5]

3.3 Skills

The Webster dictionary, defines skills as “the ability to use one's knowledge effectively and readily in execution or performance of a particular job.” [6].

In the literature skills are classified to technical skills and soft skills or non-technical skills.

3.3.1 Technical skills

Technical skills, also known as hard skills, are the specialized knowledge and expertise required to perform specific tasks and use specific tools and programs in real world situations [4]. The Software Engineering Body of Knowledge (SWEBOK Guide V3) defines 15 knowledge areas; These are: requirements, design, development, testing, maintenance, configuration management, project management, SE process, SE models and methods, quality, SE professional practice, SE economics, computing foundations, engineering foundations, and mathematical foundations [7].

3.3.2 Non-technical skills

Non-technical skills, also known as soft skills, represent a range of different abilities, personality traits and attributes that are often necessary for success in a particular role. They can be best described as personal traits that shape the way you work and interact with others. Soft Skills play a key role in demonstrating how an individual interacts with colleagues, performs work related tasks, communicates and builds relationships. More specifically, they include Communication skills, Problem-solving skills, Learning Agility, Team-building skills, Adaptability, Time management skills, Leadership skills, Ability to Work independently, Interpersonal skills and Negotiation skills [8].

3.4 Literature review of related studies

Many studies have been conducted worldwide to determine the skills that a new IT graduate needs to possess to meet employers desires for employment[9][10][11][12][13][14][15][16][17][18]. These studies have explored the skills from the perceptions of students, IT professionals, and corporates. These studies used various methods of data collection, including questionnaires, interviews, case studies, and focus groups among others. The results showed differences in the perceptions of these skills among the study participants. The most commonly mentioned skills were related to coding skills, relational databases, requirements, design, testing, configuration management tools, project management, networking, security, web applications, mobile commerce applications and protocols, problem solving skills, communication and presentation skills, team work, and other personal qualities.

Lee and Han [19]found that application development, social and business skills were highly valued. They recommended that general problem solving skills and knowledge of business functions be taken into account when future IT educational programs are designed.

Lee,Koh, and Tang [20] found that soft skills were more important in new hires than core IT skills.

Surakka [21], found that the level of importance of continuous mathematics and basic science has decreased, and that skills, such as web-related skills, are getting more emphasis.

In their examination of skills listed in advertised jobs, Gallivan, et al. [22] found that the skills listed, mostly technical ones, were inconsistent with the non-technical skills organizations claimed were more important in new hires.

In their study, Kim et al. [23] found that project management was ranked the highest skill, and that end-user computing, security, and soft skills should be given more emphasis in IT educational programs.

Another study that used data collected from job ads on the internet is [24].The study found that web programming, UNIX, C++, Java, SQL, and Oracle DB were the top skills at the time of the study.

In another study [25], the authors examined job advertisements, conducted interviews and focus groups research and found that industry representatives are less concerned about technical skills than soft skills needed for team based, customer focused, and business environments. The authors believe that the industry tends to seek base-level technical skills and make recruitment decisions on more personal qualities, leaving detailed training to on-the-job. In their research, Garousi et al. [26] extracted data from 33 studies related to the skill gap between software engineering and industry. By harmonizing the importance of data from the studies and normalizing and mapping of the ranking of topics in the papers with SWEBOK that they selected as a model, they found that hard skills alone are not enough and soft skills are equally important. They mentioned that 24 of the 33 studies recognized non-technical skills importance. They categorized non-technical skills as follows: Teamwork and communication (discussed in 19 studies), Leadership (13 studies), Critical thinking (11 studies) and others (17 studies). They also stated that other non-technical skills were mentioned in the studies, such as: understanding business drives, cultural fit, attitude, learning and curiosity, coping with ambiguity, passion/drive to innovate.

In his study [27], Scaffidi interviewed 11 IT employers who highlighted the importance of skills related to web development, relational databases, and testing. In addition to non-technical skills like collaboration and communication, the study also uncovered the importance of skills tied to personal attributes such as innovation, coping with ambiguity and learning quickly.

An observational study methodology [28], observed 8 recent graduates who joined Microsoft Corporation as software developers. The study revealed numerous on-the-job challenges in the transition from the educational environment to the work environment. The challenges included problems with coordinating work with colleagues and knowing when to ask for help. Moreover, these new employees often struggled with using source code control and related tools.

Another study [29], involved interviewing 9 software developers about what skills they had to gain through on-the-job training, due

to inadequacies in their preparation upon graduation. The most mentioned skills they needed to gain were in the areas of working with source code control, maintaining code, and testing. The study strongly emphasized on the importance of workers being capable of teaching one's self from examples and of using peers as a resource, specifically in the context of team projects.

4. Findings and discussion

The literature reviewed in this research showed diversity in the importance of technical skills among the participants in these studies. On the other hand, there seems to be a general agreement on non-technical skills. While both technical and non-technical skills are important, the skills most critical for employers are non-technical skills as found by almost all the reviewed literature in this study. By comparing the times of conducting the studies that were reviewed in this research, it is clear that with the rapid development of technologies, the technical skills that employers pay attention to are also related to the advances in technology, especially web technologies as found in recent studies like [12][26] and [27] for example. It's also noticed that non-technical skills have increased in importance with the advent of new methodologies and technologies of developing software, for example, peer programming in agile development technique, as stated in studies like [25][27][29]. So, to answer the research question, "What skills are most valued by employers when hiring new software engineering graduates?" which was raised in this research, we cannot neglect the time factor in which these skills are valued in the labour market.

So, to put things in perspective, Table 1 below highlights and categorizes the most critical skills resulting from the reviewed literature.

Table 1. Most critical skills for software engineers

| Non-technical skills | Technical Skills | | |
|----------------------|------------------|---------------------------|--------------------------|
| | SE Practices | Computer Science concepts | Software Tools |
| Communications | Requirements | Data structures | Configuration management |
| Problem solving | Design | Programming | Development tools |

| | | | |
|-------------------|---------------------|------------|-----------|
| Presentation | Testing | Networking | Debuggers |
| Team work | Software life-cycle | Security | |
| Critical thinking | Project management | Databases | |

Our findings from the reviewed literature in this study show the importance of SE professional practice and non-technical skills in general; The importance of certain SE activities and skills in SE education especially requirements engineering, design and testing which were the most commonly mentioned skills in the reviewed literature. Also, specific areas of SE such as configuration management, SE models and methods as well as SE process need more attention by educational institutions, as well as, the importance of real-world examples in SE courses.

Employers expect graduates to have technical and discipline competences gained during their education, but require graduates also to demonstrate a range of broader skills and attributes that include team-working, communication, presentation, critical thinking, problem solving and managerial abilities. It is necessary for a software engineer to communicate well, both orally and in reading and writing. The successful attainment of software requirements and of meeting deadlines depends on developing clear understanding between the software engineer and customers, coworkers, managers, and other stakeholders. And hence, the software engineer's own career success is affected by the ability to consistently provide oral and written communication effectively and on time. Problems are common with any software project. An engineer without problem solving skill will encounter difficulties with problems which never occurred before. A problem solving skill makes it possible for a software engineer to investigate, comprehend, and summarize information. Software engineers must present their work to others, being their managers, coworkers, or customers. They need presentation skills to be able to convey what they present. Software engineers must work with others. On one hand, they work internally in engineering teams; on the other hand, they work with customers, members of the public, and other stakeholders. Software engineers need to be able to analyze

information objectively and make a reasoned judgment. The need critical thinking to draw reasonable conclusions from a set of information, and discriminate between useful and less useful details to solve problems or make decisions. Employers prioritize the ability to think critically.

Therefore, higher education institutes' curricula must incorporate occasions to develop such skills in conjunction with subject specific skills and knowledge.

5. Conclusion

In this study, the diversity of skills both technical and non-technical that are required of software engineers for a seamless transition from the educational environment to the work environment was highlighted. Technically, software engineers should realize the importance of certain SE activities and skills in SE education especially requirements engineering, design and testing. Furthermore, specific areas of SE such as configuration management, SE models and methods as well as SE process need more attention by educational institutions, as well as, the importance of real-world examples in SE courses. Software engineers also need to possess certain non-technical skills like communication, problem-solving, presentation, team-work, and critical thinking.

Therefore, higher education institutes' curricula must incorporate occasions to develop such skills in conjunction with subject specific skills and knowledge. This ought to enhance the potential of new software engineering graduates for success in the recruitment process by making them work-ready. Software engineering graduates should be able to hone their capabilities to rapidly adapt to changing environments.

The methodology employed in this study was not aimed at generating definitive conclusions with respect to the study question, but rather meant to open up the opportunity for future work to further analysis of the study subject.

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