

Software Engineering Education: The Gap Between Industry's Requirements and Graduates' Readiness

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Abstract— Software engineering is one of the most demanding jobs in software industry nowadays and its demand keeps on increasing. However, there are several issues arise with regard to readiness of Information Technology (IT) or Computer Science (CS) graduates from the point of views of software industry. This perspective causes the supply of graduates mainly in software engineering field seems to be insufficient. The industry claims that the software engineering graduates are not able to meet their requirements in software industry. This is really surprising to the academia that offers software engineering specialisation or related programmes in IT or CS field. This phenomenon creates the gap between industry's requirements and graduates' readiness which indirectly reflects the gap between software engineering education and industry. A number of studies and frameworks are available to ponder the issues on software engineering education and industry. This paper reports the gap between industry's requirements and graduates' readiness in software engineering perspectives to face the real world. From the findings, we conclude that there is a gap due to high demands from the industry in highly skilled fresh graduates. In contrast, future graduates are still lack of confidence and readiness though they specialise in software engineering field that has more job opportunities in IT or CS field.

Keywords—Software Engineering Education; Software Engineering Industry; Industry's Requirement; Graduates' Readiness

I. INTRODUCTION

Unemployment among Information Technology (IT) and Computer Science (CS) graduates has been a concern either locally or globally. The unemployment rate keeps on increasing as if IT or software industry gets tougher for the graduates to enter and survive. Is the IT or software industry getting more competitive or is it the graduates are not marketable and not ready to meet the industry's requirements? This phenomenon also exists in software engineering industry though it is one of the most demanding jobs that require human capital resources. Besides, software is present everywhere in today's world and one of the most prominent, the most challenging and the toughest technology in the new area [1]. This reflects the reason why

software industry requires high skilled fresh graduates mainly among software engineering specialisation.

In general, IEEE Std 610.12-1990 defines *software engineering* as “the application of systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software” [2]. As the software engineering industry strives for skilful employers due to the gap between industry's requirements and graduates' readiness, there are several factors that cause this gap. One of the reasons why the gap keeps on increasing is the lack of preparation among graduates especially in software engineering field [3]. Karunasekera and Bedse [3] report that the least preparation for the professional career is one the common complaints utter by the industry. In addition, a rapid advancement of software engineering and an increase of software business demands are among the factors that create the gap [4]. Another factor is because software engineering curriculum does not align with what software engineering industry's needs [4] [5][6]. This shows that what the Software Engineering Education (SEE) provides does not fully satisfy the requirements of Software Engineering Industry (SEI).

In order to succeed in SEI, graduates' potential is based on some factors such as skills, attitude and knowledge [7]. Ledgard and Tauer [8] remind the graduates about the attitude and the team work issues that are described as egotistical individuals which may arise during working in team projects during their tertiary education. This is because the individual with such characteristic will ignore other team members and only focus on personal goals causing graduates to fail in the middle of their career [8][9].

Our study focuses on the gap between industry's requirements and graduates' readiness when facing the real world. The main objective is to propose a possible balance between SEE and SEI requirements in order to reduce the gap. This study is indeed an important effort and timely as it can provide the guidelines to graduates to prepare for the industry and provide them an exposure or knowledge about the industry's requirements before entering the industry especially in software engineering perspectives.

The following section will digest some related work, before we discuss the survey, its analysis and findings and finally conclude the work.

II. RELATED WORK

A. Software Engineering

According to Roy and Veraat [10], software engineering discipline has been discussed over the last decade in term of SEE that has influences with regard to the problem in the gap between industry's requirements and graduates' readiness. The curriculum in SEE requires continuous enhancement and maintenance to produce software engineering graduates that fulfil the industry's requirements. In order to overcome this issue, current works propose some frameworks for SEE that could be guidelines to SEE [1] [3] [4] [5] [11] [12] [13].

Hamau-Lhadj et al. [11] propose a model-driven approach in SEE. This approach can help the graduates in SEI as it is the most current technique in software engineering. However, the work does not state whether graduates who study using this approach is highly demanded in the industry or not because it only discusses on how to prepare the graduates to meet the SEI's requirements. Another work proposes the use of learner-centred web-based approach model [12]. This approach is based on three ideas that are: (i) SEE must become more realistic; (ii) SEE has to move closer to the learner and (iii) it must take advantage of the Web. In this approach, the students learn better if they construct knowledge by themselves and make use the Web in their studies because the Web is a unique tool to change the education. The third example of a new framework is Group Projects approach [13]. This approach suggests that students should work independently as suggested by Hadjerrouit [12] and also work in team to achieve effective SEE programs. Mahmood [13] also describes on how undergraduates should perform and understand the real software engineering requirements, implements and references. In short, there are a number of frameworks that are available in order to enhance the curriculum in SEE and to ensure the graduates are equipped with what SEI requires. Most of the frameworks suggest some changes in SEE in order to reduce the gap between industry's requirements and graduates' readiness.

Besides, another way to reduce the gap is through collaboration between SEE and SEI [1] [4] [5] [14]. According to O'Leary et al. [5], the collaboration can help students to achieve what the industry requires or expects and ease them during the transition from education to industry. This will help them to get ready before facing the real world. According to Mahanti and Mahanti [1], collaboration between SEE and SEI can help students to keep abreast with the latest development and an example of collaboration programme is faculty from industry can visit and give lectures on emerging technologies in software industries and software engineering to the students. Furthermore, using collaboration to reduce the gap can also bring benefit to both parties [14]. Table I summarises the benefits to SEE and SEI by having collaboration according to Beckman et al. [14]. Therefore, by doing the collaboration between the SEE and SEI, all the parties can gain some benefits including the fresh graduates, who will be more ready to face the real working environment.

TABLE I
BENEFITS OF COLLABORATION TO SEE AND SEI [14]

SEE benefits	SEI benefits
<ul style="list-style-type: none"> • Have easy placement of students. • Get special funding from corporate partners. • Have insight on corporate issues at the applied, practical level. 	<ul style="list-style-type: none"> • Have influence on academic programs. • Have access to university researches. • Get new revenue sources. • Have cost-effective, customized education and training.

B. Industry's Requirements and Graduates' Readiness

There are huge demands on software development with large requirements of highly professional skilled individuals [1]. As the technology today are rapidly progressive in various fields including software engineering field, the employment demand also increases waiting for job seekers. However, there are several complaints from the industry sector about software engineering graduates who do not prepare well for their professional careers [3] [15] [16]. This issue arises because SEE environment differs from SEI environment. This is due to the nature in SEE that focuses more in theoretical concepts where more abstract and less practical in learning [1] [3] [6]. As a result, the SE graduates hardly understand the practical scale in the industry due to insufficient exposure in practical experience [3]. For this problem, Rayford et al. [17] suggest a few requirements that are needed by the industry from the graduates. Among the requirements are the ability to work under stress, good communication skills, and ability to follow processes, a solid work ethic and project management skills. These requirements are what most of the graduates lack of. They do not possess the skills needed by the industry which cause them to be not ready to enter the real work environment.

The main reason why the graduates could not gain the skills is because they choose the skills that they are already strong in and refuse to learn the area that they are weak or need to improve more while doing the project [3]. This choosy attitude causes them to focus in their interested area and discard other areas. However in reality, the industry requires graduates that are capable in various skills. To overcome the problem, that is lack of skills by the graduates, some of the companies need to provide training centres (both local in-house and external) to the graduates [18]. In a survey done by Taran and Rosso-Llopart [18], one of the respondents stated that, it was difficult to find engineers with all skills required by the industry, therefore in-house training need to be done for the newcomers and training is about the technical, people, management and company induction training. This shows that SEI confronts with some problems in recruiting new employees as fresh graduates are still not ready to face the real work environment. Hence, SEE must take action to equip the graduates with the requirements needed by the SEI and this can be done by enhancing the curriculum in SEE and create collaboration between SEE and SEI. Hence, our study will further justify the gap between software industry's requirements and graduates' readiness.

III. THE SURVEY STUDY

This section reports the survey we conducted to study the industry's requirements via interviews and graduates' readiness using questionnaire.

A. Objective

The main goal of the study has twofold: to examine the expectation of industry and employers and to survey the readiness of the final year students specialising in software engineering for the industry. The respondents were in their final year of School of Computer Sciences, specialised in software engineering and had just completed a five-month industrial training between May to September 2010. The objective was to survey on the aspects of: (1) what they had learned during studies especially in software engineering subjects, (2) what courses they learned that they had applied during the industrial training and (3) to know their opinions whether what they had learned under software engineering specialisation could make them feel ready to face the industry and also whether they are applicable during the industrial training. As for the industry, the purpose of study was to know the expectation of the software industry from the employer's perspectives with regard to the graduates marketable and the readiness.

B. Methods

We used cluster sampling method which involved twenty final year students specialising in software engineering and two companies involved in software development in Malaysia where the two main authors had their industrial trainings. The survey for the students was conducted by giving a set of questionnaire that requires the respondents' demographic background, their opinion about readiness to face the real world after undergoing the industrial training and mapping the software engineering subject they learned with the experience they had while undergoing industrial training. It consists of eleven questions of two parts (see Table II): Part A: Demographic background (A1-A4) and Part B: Information about the graduates' readiness (B1-B7). Some answers require reasons in order to justify respondents' opinion.

TABLE II
INFORMATION SOUGHT FROM THE QUESTIONNAIRE

Description	Question Number
Characteristic	
Specialisation in study	A1
The age of the respondents	A2
The generalization of the biological studies	A3, A4
The company type that respondents join	B1
Opinion	
Are SE subjects enough to apply in SE related jobs later?	B2
Are you ready to face the real working environment upon graduation?	B3
Did you apply SE subjects and how they were related during industrial training?	B4
Did you learn new things during industrial training?	B5
Does SE specialisation give an advantage in job market?	B6
Expectation	
What do you want to be upon graduation?	B7

As for the industry, we interviewed top level personnel. The interview aimed to investigate the expectations of employers towards the graduates specialised in software engineering, their opinion whether most graduates fulfil the industry's requirements, their evaluation on what graduates do not possess and their recommendation for the universities with regard to fresh graduates. The information sought is summarised in Table III.

TABLE III
INFORMATION SOUGHT FROM THE INTERVIEW

Question Number: Description
Opinion
I1: What are the expectations of the employer towards software engineering graduates?
I2: Do most graduates fulfil the expectations of the employer?
I3: What are the aspects that graduates do not have?
Expectation
I4: What are the recommendations to the universities to produce quality software engineering graduates?

IV. THE ANALYSIS

The analysis is based on 3 categories of data that are characteristic, opinion and expectation as in Table II and Table III. The questions that do not have any response were considered missing.

A. Characteristic

In characteristic element, the survey identified the properties of the final year students which include graduates' specialisation background, ages, personals (gender and race) and types of company they joined for the industrial training. As mentioned, all the respondents were major in software engineering specialisation. Their age was between 21 to 22 years old, all Chinese, consisted of 7 males and 13 females.

The types of company the respondents joined during their industrial training are shown in Fig. 1: 10% of the respondents joined Government Agencies (GA), 5% joined Public Higher Learning Education (PHLE), 30% joined Small/Medium Companies (SMC) and the highest rate that is 40% of the respondents joined Multi-national Companies (MNC) and finally 3 respondents (30%) did research training at USM instead of industrial training (OTH).

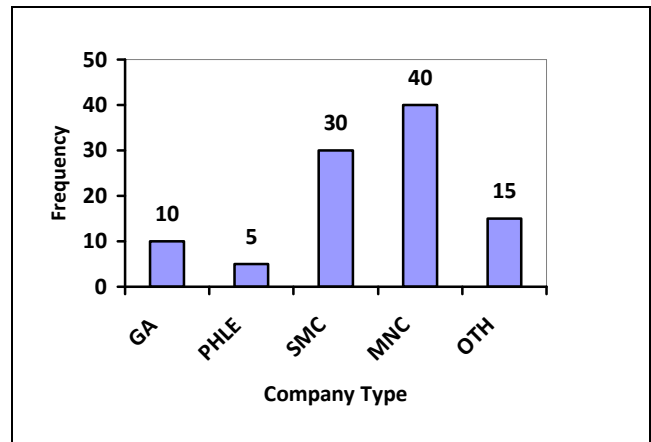


Fig.1. Type of companies chosen for industrial training

For the interview with practitioners, the two companies involved were a private software house and a government department. We interviewed five persons from the private company and one person from the government department. The four persons from the private software industry were the Chief Executive Officer (CEO), two Senior Software Engineers and one System Engineer, while from the government department the person interviewed was the higher officer in charge of IT department.

B. Opinion

Opinion element studied “What the final year students of software engineering thinks about the field” in term of subjects they had learned and their readiness to face the industry. Referring to Table IV, most of the respondents stated “Yes” and said what they had learned during their study were enough for them to apply to software engineering related jobs later (60%). On the hand, eight respondents said “No” that the subjects they already learned were not enough for them to apply in their jobs later.

TABLE IV
OPINION OF GRADUATES

Question Number: Description	Response Item	F	%
B2: Are SE subjects enough to apply in SE related jobs later?	Yes	12	60
	No	8	40
B3: Are you ready to face the real working environment upon graduation?	Yes	12	60
	No	8	40
B5: Did you learn new things during industrial trainings?	Yes	16	80
	No	4	20
B6: Does SE specialisation give an advantage in the job market?	Yes	17	85
	No	3	15

Note: F: Frequency, %: Percentage.

For element B3, twelve respondents (60%) said they were ready to face the real working environment once they graduated. For those said “Yes”, they gave a reason that they understood better on what the working environment need and they experienced the real task during their industrial training. They also stated that they wanted to earn money upon graduation and could adapt to working environment. On the other hand, eight respondents stated “No” (40%) with the reasons that they were not ready to face the real working environment and they needed to improve themselves in term of required skills required by the industry. Some of the reasons included that they were too stressed and not ready.

The next element B5 shows that sixteen respondents said they had learned new things during industrial training (80%) while 20% of the respondents did not learn anything new during the industrial training. The new things the respondents had learned include Visual Basic, PHP, MySQL, PERL, Testing Life Cycle, Automated Testing Life Cycle, ColdFusion, ASP.NET, Oracle, Joomla, Wordpress and KAIZEN.

The last element that we surveyed was B6. There were seventeen respondents stated “Yes” that software engineering specialisation would give them an advantage in the job market. The respondents said that the market industry demand in IT were software engineering. They also stated

that the job market was huge for SE specialisation. However, three respondents said “No”. They gave the reasons that things in the job market rarely reflects what they have learned and they gave the reason that the actual skill they had was more important when getting jobs.

Regarding the related course they had learned (B4), there were eighteen respondents (90%) said “Yes” and chose the related course that they applied during their industrial training (See Table V). The subjects that the students applied during industrial training are depicted in Fig. 2. It shows that most of the students applied Programming Language Concepts & Paradigm (PLCP); and Software Project Management, Process and Evolution (SPMPE). On average, the students applied Software Requirements Analysis & Modelling (SRAM); Software Design & Architecture (SDA); and System Analysis & Design (SAD). While Design & Analysis of Algorithm (DAA) is the least related course that students applied during their industrial training.

TABLE V
OPINION OF GRADUATES ON SOFTWARE ENGINEERING COURSES

Question Number: Description	Response Item	F	%
B4: Did you apply SE subjects and how they were related during industrial trainings?	Yes	18	90
	No	2	10

Note: F: Frequency, %: Percentage

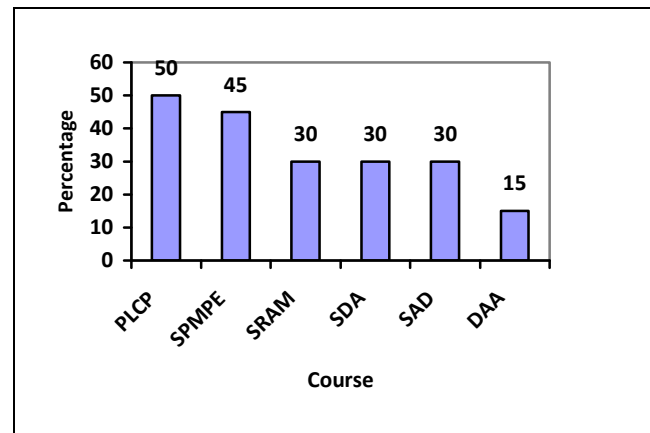


Fig. 2. Subjects in software engineering specialisation that students found being applied during industrial training

The opinion element for the interview (see Table VI) identifies “What are the expectations from the industry towards graduates”. In I1 element, employers expect the fresh graduates to be confident in giving opinions and broaden their knowledge especially in computer skills. As for I2 element, employers stated that the graduates partially fulfil their requirements and were not creative in generating new ideas. Element I3 studied the aspects that employers could not find in graduates. They stated that among the aspects that they did not obtain from the graduates include communication skills, lack of team work, not good at sharing ideas and not independent in self improvements.

TABLE VI
OPINIONS DERIVED FROM THE INTERVIEW

Question Number: Description	Response Item
I1: What are the expectations of the employer towards software engineering graduates?	Confident in giving opinions, need to broaden the knowledge of the area (computer skills), think out of the box, creative, good analytical thinking, able to identify problems in existing systems and suggest the best solution.
I2: Do most graduates fulfil the expectations of the employer?	Fulfilled if graduates are able to finish the tasks on time. The tasks given to fresh graduates are partially easy like doing homework of what they have studied. However, this is not fulfilled if graduates are not creative in generating new ideas.
I3: What are the aspects that graduates do not have?	Communication skill, lack of team work, not good in expressing and sharing ideas among other team members, no creativity, not independent in knowing industries skills and future ideas.

C. Expectation

For the expectation among the respondents, we surveyed on the future career that they choose upon graduation and the suggestion for the university from industry's practitioners.

Regarding element B7 (see Fig. 3), seven respondents wanted to be a Software Engineer (SE) upon graduation. While four respondents wanted to be a Software Analyst (SA) and two wanted to be a programmer (PG). On the hand, one respondent chose to be a Software Tester (ST) as their career and six respondents chose to do non-IT related jobs (OTH) such as a teacher, a professor, a businessman, a salesman and a computer gamer.

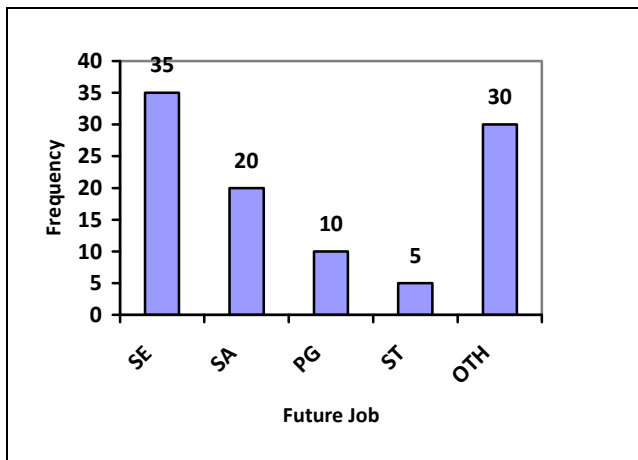


Fig. 3. Future careers chosen by SE graduates

As for I4 (see Table VII), the employers recommended some suggestions for universities to produce better performance graduates in future. The employers stated that the universities should expose the students with more technical skills. Moreover, employers also recommended

that the universities should hire lecturers that have several years of working experience.

TABLE VII
EXPECTATIONS: EMPLOYEES

Question: Description	Response Item
I4: What are the recommendations to the universities to produce quality software engineering graduates?	<ul style="list-style-type: none"> - Keep up the industrial training exposure; it can develop students' confidence. Expose more to the real live working environment. - Expose the students with more technical skills. - Guide the students for preparation on how to become the employee and tell the employers' expectations. - Expose the students with the new technologies, languages and software.

V. THE FINDINGS

We anticipate that IT or CS graduates specialise in software engineering are not ready to face the real working environment as what always perceived by the stakeholders in software industries. However from our survey, 60% of final year students who were the respondents stated that they were ready to face the real working environment and claimed that what they had learned were enough for them to apply the job later. As the respondents had just completed their industrial training, this perspective could be due to least tasks they had during the industrial training and the time period of each given task was not so pressured. For example, one of the respondents who were not ready to face the real working environment said that the task during their industrial training was lighter than the real task working environment.

Even though, most of them claimed that they were ready to face the real work environment, 80% of them stated that they learned new technology or skills during their industrial training despite the fact that they learned the basic technologies in programming languages and databases before going out for industrial trainings. This reflects the fact that what the industry needs from the students are not enough as they still have to learn diverse technologies once they join a company upon graduation. This fact was also supported by the industry's claim through the interview we conducted that expect universities to expose more technical skills, new technologies, languages, and software.

The skills that industries expect from the graduates could not be educated during the studies [1]. This shows that the employers' expectations from the interview could not be completely fulfilled such as 'think out of the box'. Another example, if students have the skill on C++ language but they need to develop a system using another language such as Java, they should be able to adapt to both languages as the methodologies of the languages and the skill required to solve the problems using the logical thinking are the same across all programming languages. This shows that industries should provide training to fresh graduates in the technology that their company adopts. This is due to the fact that software industry grows rapidly and its technologies are extremely diverse which are not possible for academia to expose all to their students mainly commercial technologies which are very costly for universities to purchase them.

The employers claimed that graduates are lack in creativity and the potential in creating new ideas, therefore students are advised to be more adventurous in trying new things and broaden their knowledge of new technologies in the industry instead of focusing their academic requirements only. Besides, the employers also highlighted that the low performance of graduates in terms of communication skill, lack of team work, not independent in knowing industry skill and other contributing factors might interrupt the growth of software industries.

VI. CONCLUSION

We conducted a survey among twenty final year students specialising in software engineering and interviewed five software related personnel in two companies. The study aims to investigate the gap between industry's requirements and graduates' readiness. We believe by addressing this issue to both SEE and SEI, they could get some insights on this issue to reduce the gap. The findings of the study also provide the guidelines to future CS or IT graduates and mainly software engineering graduates to prepare themselves before facing the real working environment later.

In short, industry has its own demands on hiring well trained and highly skilled graduates who comply with their requirements. However, students are still lack of required skills such as soft skills, managerial skills and technical skills. Our study deduces that both SEE and SEI should play their part and collaborate to ensure the SEE produces high skilled graduates that give benefit to the SEI. In addition, most graduates are still not ready to face the real working environment unless they attend some extra courses to enhance their soft skills, managerial and technical skills before they seek their first job once they graduate.

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