

Reducing the Gap between Software Engineering Curricula and Software Industry in Jordan

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Received 6 April 2014; revised 3 May 2014; accepted 1 June 2014

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Abstract

Nowadays software is taking a very important role in almost all aspects of our daily lives which gave great importance to the study field of Software Engineering. However, most of the current Software Engineering graduates in Jordan lack the required knowledge and skills to join software industry because of many reasons. This research investigates these reasons by firstly analyzing more than 1000 software job listings in Jordanian and Gulf area e-recruitment services in order to discover the skills and knowledge areas that are mostly required by software industry in Jordan and the Gulf area, and secondly comparing these knowledge areas and skills with those provided by the Software Engineering curricula at the Jordanian Universities. The awareness of the Software Engineering students and academic staff of the concluded mostly required knowledge areas and skills is measured using two questionnaires. Recommendations to decrease the gap between Software Engineering academia and industry had also been taken from a sample of software companies' manager using a third questionnaire. The results of this research revealed that many important skills such as Web applications development are very poorly covered by Software engineering curricula and that many Software engineering students and academic staffs are not aware about many of the mostly needed skills to join industry.

Keywords

Software Engineering, Software Industry, Knowledge Areas, Knowledge Gap, Required Skills to Join Industry

1. Introduction

Software Engineering (SE) is the discipline providing methods and tools for the construction of quality software with a limited budget and a given deadline, in the context of constant requirements change.

SE education in Jordan is currently facing a major problem. Namely, the current SE graduates lack the needed skills and experience to join industry because these graduates had gone through poor preparations during their university study [1].

Because of this problem and other related problems, the enrollment in most of the SE departments at the Jordanian universities is decreasing. For example, the number of students of the SE department at the faculty of IT at Philadelphia University in Jordan had decline from more than 1600 students in 2004 to about 400 students in 2014 which means about that the number has decreased to almost the quarter of the students.

The SE education literature has revealed that the decline in the SE enrollment is not only in Jordan but rather in all over the world.

So shortly, the problem is that, there is an increased demand for the SE professionals by the software industry but at the same time there is an incline in the SE enrollment and moreover, lack of the needed knowledge and skills to join the industry even for the small number of those who do actually enrol in the SE departments.

To attract more students and to solve the problem of enrolment incline, the SE departments must search for the suitable means to reduce the gap with industry in order to encourage students to enrol in these colleges that guarantee suitable jobs for them when finishing their study.

The main contributions of this research are:

- Determining the mostly required knowledge areas and skills by the software industry in Jordan and the Gulf area.
- Measuring the coverage of the mostly required knowledge areas and skills by SE curricula at the Jordanian Universities.
- Determining the weakness of the current SE curricula in Jordan.
- Assessing the awareness of the SE students as well as academic staff of the mostly needed knowledge areas and skills to join software industry.
- Determining the opinions of the software company managers of the required skills to join software industry.
- Suggesting means to reduce the gap between student and industry based on the previous analysis.

This research considers only Jordan as a case study, however, similar research can be conducted for SE curricula in other countries.

Gulf area software companies are also considered in this research because a large portion of Jordanian graduates do transfer to work at these companies in order to get much high salaries than Jordan.

Both academia and software industry will benefit from this research because academia will know the knowledge areas that must be added to the SE curricula to help students to join software industry faster, and the industry will know the skills that it must enhance in the new SE workers.

The novelty of this research is that it tackles the gap problem between students and industry by combining and comparing the data obtained from four different sources of data, namely, SE curricula, SE students, SE academic staffs and software companies' manager. Also it is the first research, as far as the authors' knowledge, to measure the SE students-industry gap based on the Jordanian Universities case study.

2. Background

The related work to the research in this paper can be divided into 6 categories:

- 1) The research that analyzes job listings in order to conclude the mostly needed skills by software industry;
- 2) The research that surveys SE student to assess their awareness of the SE curriculum courses of the greatest importance to join industry;
- 3) The research that surveys software companies managers in order to conclude the needed skills to join software industry;
- 4) The research that analyzes SE curricula in order to assess its conformance with the suggested knowledge areas in the Software Engineering Body of Knowledge (SWEBOK);
- 5) The research that is related to proposing means to reduce the gap between education and industry;
- 6) The research that is related to reducing the gap between the curricula and industry in other scientific disciplines such as Engineering and Medicine.

It must be mentioned that these categories are not mutually exclusive since a single research can belong to more than one category.

Among the mostly related research in the first category of analyzing job listings is:

In 2002, Koong and colleagues [2] analyzed the job listings in two jobs databases and found that over half of the job opportunities are in the area of programming languages and Web development. They also found that great majority of the jobs required the ideal candidate to have multiple classes of skills or multiple categories of skills.

In 2006, Kim and colleagues [3] examined the kinds of skills that are needed in the IT marketplace and whether the IS curricula are meeting these needs. They found that project management and security should be given greater emphasis in IS curricula.

In 2008, Lee and Han [4] conducted an empirical study on programmer/analyst skill requirements by collecting and analyzing 837 job ads posted on a certain corporate websites for three years. It was concluded that skills related to development, software, social skills, and business were highly required for programmer/analysts by these large corporations. Relatively less attention was given to skills under the categories of architecture/network, hardware, management, and problem solving.

In 2008, Kovacs and Davis [5] analyze keywords from internet job posting to determine the skills and knowledge requirements of IT and then show the top ten IT keywords which have the highest count in these posting.

In 2008, Li and colleagues [6] electronic business curricula from many universities and job announcements from career Web sites in both the US and Taiwan were collected. Remedial actions for narrowing the gap between industry and academia were proposed such as 1) enhancing training in information and communication technologies, 2) increasing e-marketing training, 3) increasing e-business programmer training, and 4) increasing networking specialist training.

Among the mostly related research in the second category of surveying SE students is:

Lethbridge research [7] in 2000 is one of the most cited and well known researches in the SE education field, Lethbridge questioned 186 respondents from different educational backgrounds about 75 educational topics. According to his results, the five most important topics were data structures, specific programming languages, software design and patterns, requirement gathering and analysis, and software architecture.

In 2005, Kitchenham and colleagues [8] adapted a survey instrument developed by Lethbridge to assess the extent to which the education delivered by four UK universities matches the requirements of the software industry.

Among the mostly related research in the third category of surveying company managers is:

In 2011, Amiri and colleagues [9] stated that the SE curricula must be revised by the managers of software industry. In this research, SE curricula in Iran were presented to the software managers, and they were asked to choose it as essential or elective course, or it must be removed from the curriculum.

In 2009, Aasheim and colleagues [10] analyzed the required knowledge and skills to join the software industry and compared between the academia versus company managers perspectives of this knowledge.

They found out that at the individual skill level, faculty and IT managers perceive some differences in the relative importance of that skill for entry-level workers.

Among the mostly related research in the fourth category of comparing SE curricula with SWEBOK are:

In 2014, Hanna and colleagues [11] analyzed the SE curricula of 13 Jordanian Universities and compared it with the knowledge areas suggested by SWEBOK and it was found that many of the knowledge areas are not covered by the SE curricula.

In 2012, Moreno and colleagues [12] examined whether the SE2004 [13] and GSWE2009 [14] cores provide knowledge that is useful for performing each career space task related to each of the three software development-related profiles: Software and Applications Development, Software Architecture and Design and IT Business Consultancy.

In 2007, Surakka [15] updated [7] results, this research emphasized the importance of Web-based subjects, compilers and distributed systems as well as SE topics.

They have found that none of the three industry profiles is completely covered by either SE2004 or GSWE2009. The biggest gap found concerns tasks associated with the IT Business Consultancy profile. Knowledge required by such tasks is beyond the classical technical knowledge that we are accustomed to in most undergraduate and graduate SE programmes.

In 2012, Aashiem and colleagues [16] stated that the top 5 technical skills have not changed considerably in the past five years. They are operating systems, security, hardware, networking, and database.

Among the mostly related research in the fifth category of suggested means to reduce the gap between education and industry is:

In 2007, Lethbridge and colleagues [17] had suggested many methods that should be followed in order to improve the education in SE, namely, 1) making programs attractive to students, 2) focusing education appropriately, 3) communicating industrial reality more effectively, 4) defining curricula that are forward-looking, 5) providing education for existing practitioners, 6) making SE education more evidence based, 7) ensuring that SE educators have the necessary background, and 8) raising the prestige and quality of SE educational research. Lethbridge mentioned that improving education may be the single best investment SE profession can currently make.

In 1999, Saiedian [18] stated that proper software engineering education can significantly improve the state of software development and help alleviate many of the traditional problems and crisis associated with industrial software practices.

In 2013, Lavrisheva and Ostrovski [19] discussed approaches for teaching students the aspects of software industry at Ukrainian universities. A new approach to e-learning students some aspects of SE, oriented on assembling heterogeneous components using product lines and e-learning SE disciplines, has been introduced.

In 2007, Karunasekera and Bedse [20] developed a learning framework which aims to provide the undergraduate students with the technical and non technical skills that help the students to engaged in the SE industrial market.

In 2011, Almi and colleagues [21] 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.

In 2010, Kulkarni and colleagues [22] suggest a collaboration between the industry and academia in order to bridge the gap between the students knowledge and the industrial needs, these including faculty training and curriculum development, where undergraduates students are exposed to tools that are standard in the software industry (e.g., Eclipse and version control systems), and acquiring more practical experience and work on real-life projects that will permit them to acquire technical, soft and IT offshore outsourcing skills.

Among the mostly related research in the sixth category of other science disciplines is:

In 2012, Dalveren [23] aimed at demonstrating the gap between the content of elective courses, in the Radio Frequency and Communications field, and industry expectations.

In 2012, Souza and colleagues [24] discussed the challenges of changing the curricula of Medicine Schools in Brazil.

In 2010, Cai [25] discussed the curriculum design of the English language for non-English postgraduates in the Chinese Universities.

So it can be concluded that the problems of curriculum design and the gap between industry and curricula is not limited to SE but rather in other sciences such as Engineering, Medicine and Languages.

As mentioned before this research is different because it handles that gap problem by collecting and comparing the data from four different related sources to this problem.

3. Methodology

The objectives of this study are:

- 1) Assessing whether the SE curriculum at the SE departments at Jordanian Universities do cover the mostly needed knowledge areas by software industry;
- 2) Assessing the awareness of the students and academic staffs at the SE departments at Jordanian Universities of the mostly needed knowledge areas by software industry;
- 3) Assessing the weaknesses of the newly hired SE graduates according to the opinions of software companies manages;
- 4) Determining the mostly needed skills to join software industry in Jordan and the Gulf area.

To achieve these objectives, this research has gone through the following phases:

Phase 1: 1054 software related job listings disclosed in the databases of many famous Jordanian and Gulf area e-recruitment services had been analyzed in order to find out the mostly needed job skills by software industry in Jordan and Gulf area.

Phase 2: In order to measure the gap between SE curriculum and software industry, the mostly needed skills that were concluded in phase 1 had been compared with the SE curricula of 3 different SE departments at the Jordanian Universities.

In Jordan, there are 18 universities, however, only 13 of them do have a SE department at their Information Technologies Faculties. In a previous research [25] the knowledge areas that are covered by the SE curricula of the Jordanian Universities were compared with knowledge areas suggested by the SWEBOK [6], based on the result of that research, this study has chosen only 3 of the SE curricula depending on the covered SWEBOK knowledge areas, where the boundary value analysis were used in the selection process, which means that the curriculum that mostly cover the SWEBOK was chosen first and that curriculum was for the SE department at Philadelphia University in Jordan, then the curriculum of the least percentage of the covered areas was chosen and that curriculum was for the SE department at Petra University in Jordan, and finally the curriculum with nominal percentage of covered SWEBOK knowledge areas was chosen and that curriculum was for the SE department at the Hashemite University in Jordan.

The previous 3 curricula were then compared with the most required skills obtained in Phase 1 in order to investigate whether these curricula do cover the mostly required skills by software industry, the results of this comparison is in Section 4.2.

Phase 3: In order to measure the awareness of the SE students at the Jordanian Universities of the mostly needed skills by industry, a questionnaire has been design and distributed electronically [26] to a sample of 200 SE students in all the SE departments at the Jordanian Universities. The students were selected among the final year students who are currently working on their graduation project.

The number of responses we get for this questionnaire was 72 responses from students from different Jordanian Universities.

This questionnaire contained two questions:

The first question (Q1) is: How much do you think this course will help (or has helped) you to join software industry?

The question used also the past tense (or has helped) because very few portion of the fourth year students are already working in software industry.

The answer to Q1 is a measure in the range [1..6] (where 0 means that the student did not gain any benefit from a course and 5 means that the student gained the maximum benefit from a course, while 6 means that this specific course is not in the student's curriculum.

The aim of this question was to assess the awareness of the SE students about the mostly important courses in their curricula relating to the software industry.

To compute the importance of each course, according to the student's opinions represented by the answer to Q1, the following equation has been used:

$$\begin{aligned} & \text{importance of course } i \text{ (students view)} \\ & = \frac{\text{proportion of students scoring 4 or 5 for course } i}{(\text{total number of students} - \text{proportion of students scoring 6 for course } i)} \end{aligned} \quad (1)$$

where score 4 is the percentage of the students who selected 4 as an importance measure for a specific course and 5 is the percentage of the students who selected 5 as an importance measure for a specific course, response 6 is the percentage of the students that the course is not in their curriculum.

This equations mean that: for each course i in a student's curriculum the importance of this course is calculated by dividing the number of students who answered 4 or 5 to this question (and this represents the students who think that this specific course is very important to their career), to the whole number of students (72) minus the students with a response of 6 to this specific course because that answer will indicate that these students have not attend this course because it is not in their curriculum and hence they must be excluded from the total number of students.

The second question (Q2) was an open question that asked the students to give their opinions about the skills, courses or knowledge areas that should be added to their curricula to help them in the process of joining the software industry faster.

To compute the importance of each skill or knowledge area that is not included in the SE curricula, the following equation has been used:

$$\text{importance of skills } i \text{ (students view)} = \frac{\text{proportion of students mentioned skill } i \text{ in Q2 response}}{\text{total number of students}} \quad (2)$$

Phase 4: Similar to the questionnaire in Phase 3, a new questionnaire were designed and distributed but this time for the SE academic staffs of the 13 SE departments at the Jordanian Universities [27].

The number of responses received for this questionnaire was 33 from different universities.

The questionnaire contained also two questions:

The first question asked a SE academic staff to give a measure of importance [1..6] about his/her opinion of each of the courses in the SE curricula regarding the usefulness each specific course in the process of helping students to join the software industry.

The second question was open, similarly to the student's questionnaire, where academic staffs are asked to give their opinions of the courses or knowledge areas that should be added to the SE curricula to help SE students in the process of joining the software industry faster.

To compute the importance of each course, according to the academic staff's opinions, the following equation has been used:

$$\text{importance of course } i \text{ (staff view)} = \frac{\text{proportion of staffs scoring 4 or 5 for course } i}{\text{total number of academic staffs}} \quad (3)$$

To compute the importance of each skill or knowledge area that is not included in the SE curricula according to the academic staff's perspective, the following equation has been used:

$$\text{importance of skills } i \text{ (staff view)} = \frac{\text{proportion of staffs mentioned skill } i \text{ in Q2 response}}{\text{total number of staffs}} \quad (4)$$

Although the authors of this research concluded the mostly required skills by industry after analyzing 1054 job listings, these skills were not included in students or academic staffs' questionnaire because the aim of the questionnaires were to find out whether SE students and academic staffs aware of these skills even without mentioning these skills in the questionnaires.

Phase 5: A third questionnaire had been design a distributed for software companies managers, the objective of that questionnaire was to:

- Determine the weaknesses of the newly hired SE graduates according to the software companies' managers.
- Gather more information about the methods that should be followed to reduce the gap between SE graduate and industry.

The questionnaire included the following questions to companies' managers:

Q1) What are the weaknesses of the newly hired Software Engineering Employees?

Q2) What skills (Knowledge areas) do you think must be possessed in a SE graduate so that you can hire him/her?

Q3) How do you think SE curriculum at Jordan University can be improved?

31 responses had been received from company managers of software companies in Jordan and the results are discussed in Section 4.4.

4. Results

This section will discuss the results obtained in each of the 4 phases described in Section 3.

4.1. Mostly Needed Skills by Software Industry

Table 1 specifies the importance of each skill required by software industry based on the analysis of 1054 software related job listings disclosed in the databases of many famous Jordanian and Gulf area e-recruitment services.

The importance column were simply computed by dividing the number of times each skill was mentioned in the job listings to the whole number of job listing analyzed which is 1054.

The skills that have less than 1% of importance were excluded because the research considers only the significantly required skills.

It must be mentioned that the term skill is used in **Table 1** and in the whole research to mean a knowledge area, programming language, development framework, SE development phase etc., however, the word skill is used instead to decrease the repetitions and to group all the needed knowledge to join software industry in a single term.

The following results can be concluded from **Table 1**:

- ASP.NET has the highest importance among other skills and after that comes Oracle, SQL, and software testing respectively.
- Web development related jobs gained the highest ratio of the job listings with an accumulated importance of 45%.
- Among programming languages, Java gained the highest importance of 9% and after that C# with 6% importance.
- Among the mobile development technologies and operating systems, iOS and Android gained the highest importance of 8% and 7% respectively.
- Among the core SE core courses, software testing gained the highest importance with 10% of the job listings.

Table 1. The importance of the different required skills by software industry based on job listings analysis.

Knowledge Area	Specific Skill	Appearance in Job Listings	Importance (%)
Web Development	ASP.NET	264	25
	PHP	55	5
	HTML + CSS	38	4
	Share point	15	1
	JQuery + JavaScript + AJAX + JSON	38	4
	Web service + SOAP +XML	68	6
Database	Oracle	115	11
	SQL	106	10
Programming Language	C#	60	6
	Visual basic	28	3
	Python	9	1
	C++	40	4
	Delphi	13	1
	Java	93	9
Mobile Development	iOS	72	7
	Android	87	8
	BlackBerry	5	1
	Windows Phone	6	1
Software Engineering Core SE Courses	Software testing	104	10
	Project management	55	5
	Software design	60	6
	Software requirements	51	5
	Object oriented programming	41	4
	Documentation	11	1
	Software architecture	6	1
	Software quality	22	2
	Software modeling	11	1
	Software analysis	23	2
	Software process	31	3
Software maintenance	13	1	
Others	Network management	22	2
	Operating systems	22	2
	ERP	12	1
	Technical support	11	1

4.2. Comparison between Mostly Needed Skills by Software Industry and SE Curricula

In this section, each of the curricula of the 3 SE departments mentioned in Section 3 will be compared with the mostly required skills by industry concluded in **Table 1**.

Based on **Table 1** results, the importance of the different skills were divided into 4 different categories according to the descending importance, namely, $\geq 12\%$, 8% - 11%, 4% - 7% and 1% - 3% importance ratios. This categorizing is useful in estimating the relative importance of each skill in the job listings. After that the count of skills that belong to each category were then computed as specified in **Table 2** below. For example, in **Table 2**, one skill only has an importance of $\geq 12\%$ and this skill in **Table 1** is ASP.NET Web development, 5 skills have importance in the range 8% - 11% and these skills in **Table 1** are Oracle, SQL, Java, Android, and Software Testing, 11 of the skills have importance in the range from 4% - 7% and finally 17 of the skills have importance in the range from 1% - 3%.

The skills that belong to each importance category obtained based on **Table 1**, were then compared with the courses in the curricula of the 3 SE departments mentioned earlier. The target of this comparison is to know the number of courses (if any), in the SE curricula, that cover the skills with different importance categories according to industry.

The comparison with the Philadelphia University SE curriculum will be specified in **Table 2**, similarly, the comparison with the Hashemite and Petra SE curricula will be specified by **Table 3** and **Table 4** respectively.

The most significant results that can be concluded from **Table 2** are:

- The only skill that has importance of $\geq 12\%$, which is ASP.NET, is not covered by any of the courses of the SE curriculum at Philadelphia.
- For the 5 skills with the very high importance of 8% - 11%, 2 of these skills (40%) are not covered by the SE curriculum at Philadelphia.
- For the 11 skills with the importance of 4% - 7%, 3 of these skills only (27.3%) are not covered by the SE curriculum at Philadelphia.

Table 2. Comparison of the mostly required skills by industry with Philadelphia University SE curriculum.

Importance	Number of skills	0 Course	1 Course	2 Courses	3 Courses or more
$\geq 12\%$	1	1	0	0	0
8% - 11%	5	2	3	0	0
4% - 7%	11	3	5	3	0
1% - 3%	17	9	7	1	0
Total	34	15	15	4	0

Table 3. Comparison of the mostly required skills by industry with Hashemite SE curriculum.

Importance	Number of skills	0 Course	1 Course	2 Courses	3 Courses or more
$\geq 12\%$	1	1	0	0	0
8% - 11%	5	2	2	1	0
4% - 7%	11	4	5	1	1
1% - 3%	17	12	5	0	0
Total	34	19	12	2	1

Table 4. Comparison of the mostly required skills by industry with Petra SE curriculum.

Importance	Number of skills	0 course	1 course	2 courses	3 courses or more
$\geq 12\%$	1	0	1	0	0
8% - 11%	5	1	2	1	1
4% - 7%	11	6	5	0	0
1% - 3%	17	11	6	0	0
Total	34	18	14	1	1

- Philadelphia University should consider adding 6 courses to the SE curriculum corresponding to the skills with an importance of $\geq 4\%$ with no curriculum coverage.
- The overall percentage of uncovered skills is (15 of 34) which is 44.1%.

Similar analysis has been conducted to the SE curriculum of the Hashemite University and the results are described by **Table 3**.

The most significant results that can be concluded from **Table 3** are:

- ASP.NET, is not covered by any of the courses of the SE curriculum at Hashemite University.
- For the 5 skills with the very high importance of 8% - 11%, 2 of these skills (40%) are not covered by the SE curriculum at Hashemite.
- For the 11 skills with the importance of 4% - 7%, 4 of these skills (36.4%) are not covered by the SE curriculum at Hashemite.
- Hashemite University should consider adding 7 courses to the SE curriculum corresponding to the skills with an importance of $\geq 4\%$ with no curriculum coverage.
- The overall percentage of uncovered skills is (19 of 34) which is 55.9%.

Also, similar analysis has been conducted to the SE curriculum of the Petra University and the results are described by **Table 4**.

The most significant results that can be concluded from **Table 4** are:

- ASP.NET, is covered by only one course of the SE curriculum at Petra University.
- For the 5 skills with the very high importance of 8% - 11%, only 1 of these skills (20%) is not covered by the SE curriculum at Petra.
- For the 11 skills with the importance of 4% - 7%, 6 of these skills (54.4%) are not covered by the SE curriculum at Petra.
- Petra University should consider adding 7 courses to the SE curriculum corresponding to the skills with an importance of $\geq 4\%$ with no curriculum coverage.
- The overall percentage of uncovered skills is (18 of 34) which is 52.9%.

Figure 1 below will summarize the number of uncovered skills, with important of $\geq 4\%$, by each of the 3 SE curricula at Philadelphia, Hashemite and Petra universities.

Obviously, the three universities must consider adding courses to the SE curricula corresponding to the uncovered skills that are mostly needed by industry.

Table 5 will compare the three universities according to the overall uncovered skills by their curricula. Where the percent of uncovered skills had been computed using the results in **Table 2** to **Table 3**. For example, in Philadelphia, there are 15 skills that have 0 course coverage by the SE curriculum so the percent is 44.1%.

The results in **Table 5** will be shown in **Figure 2**.

From **Table 5** and **Figure 2**, it is concluded that:

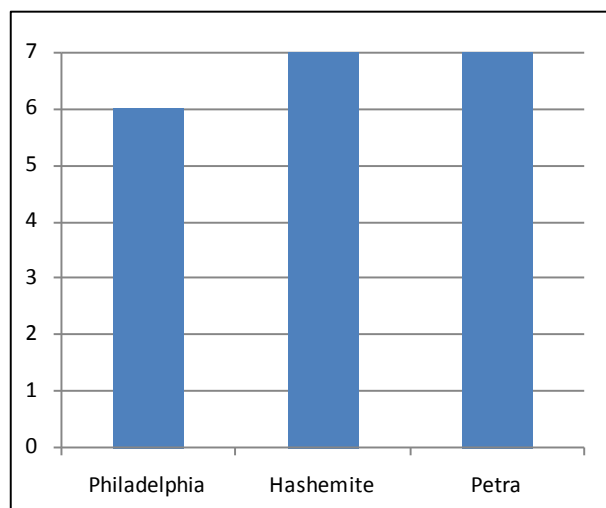


Figure 1. The number of uncovered industry skills by 3 SE curricula.

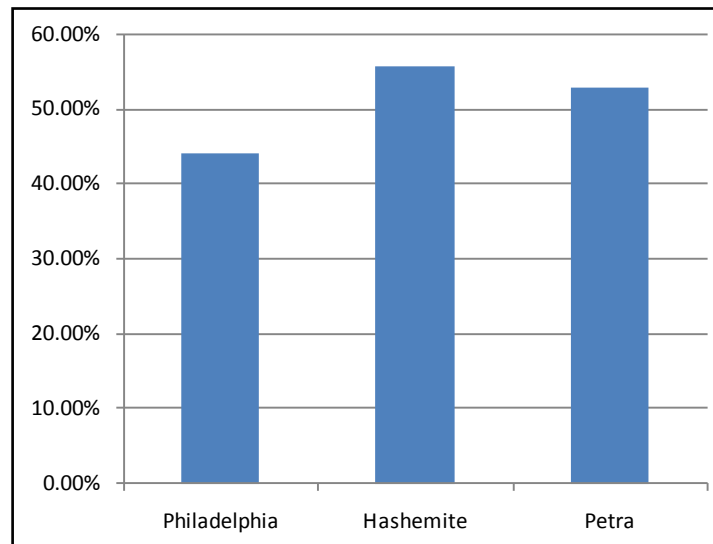


Figure 2. The percentages of uncovered industry skills by 3 SE curricula.

Table 5. The percentages of uncovered industry skills by 3 SE curricula.

University	Percent of uncovered skills
Philadelphia	44.1%
Hashemite	55.9%
Petra	52.9%

1) Two of the 3 SE curricula investigated do not cover more than 50% of the mostly required industrial skills according to the analysis of 1054 job listings.

2) Philadelphia has the best ration of coverage which is 44.1% but it is still a very high ratio of uncovered skills by industry.

Similar analysis can be conducted for the SE curricula at the other Jordanian Universities.

4.3. Students and Academic Staffs Awareness

As mentioned in Section 3, to assess the awareness of the SE students and academic staffs of the mostly required skills by industry, two questionnaires were designed and distributed one for the SE students and the other for the SE academic staffs.

The number of responses that was received from the SE students was 72 responses while the number of responses that was received from the SE academic staffs was 33 responses.

Question 2 of both questionnaires was used to assess the awareness of the SE student and academic staffs of the mostly required skills by industry.

In **Table 6**, for each of the required skills by software industry that has a significant importance of $\geq 4\%$ and no coverage by the SE curricula, the percent of students and academic staffs who mention this specific skill in the open question of the questionnaire (Q2) is computed. For example, for ASP.NET 42% of the students responses mentioned ASP.NET as a required skill to join industry while 18% mentioned the same skill in the academic staff's responses.

It can be concluded from **Table 6** that:

1) Although ASP.NET has the highest importance among the required skills by industry, only 18% of the academics staffs mentioned this skill as an important skill to join software industry. This indicates that academic staffs are unaware of the importance of this skill by industry.

2) Although Oracle have a high importance by industry 8% - 11%, none of the academic staffs mentioned this skills as an important skills to join software industry.

3) Although the Web development related skills such as: JQuery, JavaScript, AJAX, JSON, Web Services,

SOAP and XML have an important in the range 4% - 7% in industry, neither the SE academic staffs nor SE students mentioned these skills as an important skills to join software industry.

4) Students gave 29% importance to iOS and only 12% to Oracle while according to industry Oracle have higher importance than iOS.

In **Table 7**, for each required skill by industry that is covered by only one course in the SE curricula, the importance of this skill will be compared with the importance given by students and academic staffs to the course that cover this skill based on Equation (1) (for the students) and Equation (3) (for the academic staffs).

For example SQL, has only one equivalent course in the SE curriculum of the 3 universities mentioned before, and it has importance in the range 8% - 11%, The importance given by students is 56% and by the academic staffs is 61%.

It can be concluded from **Table 7** that:

1) Although PHP, (HTML + CSS) and C++ have a significant importance of 4% - 7%, SE students and academic staffs gave these skills the least importance among the other skills in **Table 7** which means that students and academics staff are unaware of the importance of these skills to join software industry.

2) Both SE students and academics staffs are aware of the importance of the other skills in **Table 7**.

The previous conclusions from **Table 6** and **Table 7** reveal the fact that both SE academic staffs and students are not fully aware of the important skills needed by software industry.

4.4. Companies' Managers Perspectives of the Needed Skills

This section will discuss the results obtained after distributing the company manager's questionnaire discussed in Section 3.2.

For Q1 about the weaknesses of the newly hired SE employees, the highest proportion of managers mentioned the following weaknesses:

- 1) Lack of practical experience in software development skills and programming skills.
- 2) Lack of knowledge about applying SE lifecycle phases such as requirement, architecture, design, etc.

Table 6. Skills with no curriculum coverage that with the SE students and academic staffs opinions.

Skills	Importance	Importance by SE Student	Importance by SE Academic Staffs
ASP.NET	≥12 %	42%	18%
Oracle	8% - 11%	12%	0%
Android		41%	43%
JQuery + JavaScript + AJAX + JSON		0%	0%
Web service + SOAP +XML	4% - 7%	0%	0%
iOS		29%	12%

Table 7. Skills with only one equivalent SE course with the SE students and academic staffs opinions.

Skills	Importance	Importance Given by Students	Importance Given by Academic Staffs
SQL		56%	61%
Java	8% - 11%	81%	84%
Software Testing		73%	92%
PHP		32%	23%
HTML + CSS		32%	23%
C++	4% - 7%	41%	30%
Project Management		83%	85%
Software Design		67%	93%
Software Requirements		68%	89%

For Q2 about the knowledge areas that should be possessed by a SE graduate to get hired, managers had responded to this question by mentioning the following skills in descending order of importance:

- 1) Web development tools and technologies such as HTML, JavaScript, CSS and ASP.NET;
- 2) Programming languages such as C# and Java;
- 3) Object oriented programming;
- 4) Operating systems and networks.

For Q3 about the managers' opinions of the methods that should be followed to enhance SE curricula at the Jordanian universities, the following main answers have been received:

- 1) Graduation projects can be supervised by IT companies where students can work on real projects, adding standards, business plans, and marketing plans;
- 2) Adding more subjects such as game programming, mobile development, e-commerce development, and design patterns;
- 3) Improving the practical part of the curriculum.

5. Discussion

In this section the result obtained in Section 4 will be discussed in details, besides comparisons will be made for the responses received from different recourses: SE students, SE academic staffs, and software companies' managers.

For ASP.NET which was the mostly needed skill by industry by gaining 25% of the job listings:

- Among the 3 SE curricula of Jordanian Universities, only one curriculum contained a course related to ASP.NET and this is a very huge gap between the needed skills by industry and SE curricula. SE departments must add at least 2 courses about ASP.NET in order to help its students to join software industry.
- SE students seem to be aware of the importance of ASP.NET because 42% of the students mentioned this skill when answering Q2 of their questionnaire.
- SE academic staffs seem not to be aware of this skill because only 18% mentioned it as being important skill to join industry.
- Software managers also seem to be aware of the importance of ASP.NET according to their responses.

For second most important skills, namely, Oracle, SQL, Android Java and Software Testing that gained an importance in the range 8% - 11% according to the job listings:

- SE curricula do cover only part of these skills, namely, SQL, Java and Software Testing, however, Oracle and Android are not covered by the investigated SE curricula. SE departments should add at least one course about Oracle and Android.
- Neither SE students nor SE academic staffs seem to be aware of the importance of the Oracle skill because only 12% of the students mentioned this skill as being important and non of the academic staffs mentioned it in their responses, however, both SE students and academic staffs seem to be aware of the other skills in this category, namely, SQL, Android, Java and Software testing.
- Software companies' managers seem to be aware of the previous skills except as important skills to join industry.

For the skills that gained an importance between 4% - 7%, we will only consider here the skills with no SE curricula coverage, namely, JQuery, JavaScript, AJAX, JASON, Web Services, XML, SOAP, and iOS.

- None of these skills are covered by SE curricula and hence SE departments should add at least one course about these skills.
- None of the SE students or academic staffs mentioned these skills as important skills to join industry except for iOS that gained a 29% importance by students and 12% only by academic staffs.
- Software companies' managers seem to be aware of the importance of these skills except for Web services that did not gain any response from managers.

It must be mentioned that for the skills with 4% - 7% only the skills with no curriculum coverage were considered here because giving these courses importance, only one course in the SE curriculum is considered enough to cover each of these skills.

6. Conclusions and Future Work

The main objective of this research was to determine the causes of the Gap between SE graduates and software

industry. To achieve this objective, data have been collected from five different resources:

- 1) Job listings in a famous Jordanian and Gulf area e-recruitment services;
- 2) SE curriculum of 3 Jordanian Universities;
- 3) SE students at Jordanian Universities;
- 4) SE academic staffs at Jordanian Universities;
- 5) Software companies managers.

In the background section, it was mentioned that the related work to this research can be divided into 6 categories; a comparison will be conducted below between the research in this paper and the research in each of these categories.

For the research that analyzes software job listings, this research is different because it also compared these listings with the SE curricula in 3 Jordanian Universities and connected the mostly needed skills in the job listings with the SE students and academic staffs opinions.

For the research that surveys SE students, this research is similar to the research in this category however considering the Jordanian Universities case study which has not been considered before as far as the author's knowledge.

For the research that surveys software companies managers, this research is different in that it did not specify specific skills or SE courses to managers in order to give them the freedom to specify the mostly needed skills to join industry without affecting their opinions.

For the research that assesses the conformance of SE curricula with SWEBOK, this research did not consider comparing with SWEBOK because it was done in a previous research by the authors [11] and the results of that research was used in this research.

For the research aims at proposing means to reduce the gap between SE curricula and industry, this research has also proposed means to reduce this gap such as adding courses to the curricula related to the uncovered skills specified by the research based on the industry needs.

For the research in the education of other science disciplines, this research is obviously different because it considered only SE education however some ideas of the research in other disciplines has been also adapted to be used in this research.

The main result in this research was that, in the average about 50% of the skills required by software industry are not covered by the SE curricula of the investigated Jordanian Universities.

It was concluded that the biggest gap between SE curricula and industry is the ASP.NET web development Framework because although this skill has a very high importance in industry, it is not covered by the investigated 3 SE curriculum at Jordanian universities except for one curriculum that cover this skill by only one course. Jordanian SE department at Jordanian Universities must add 2 or more courses related to this skill.

The other skills that SE department must add according to this research analysis are Oracle, Android, JQuery, JavaScript, AJAX, Web service, XML, SOAP, and iOS.

SE student and academic staffs seem to be aware of many skills that are not included in the curricula such as, SQL, Android, Java, and Software Testing, however, SE students and academic staffs seems to be not aware of some other skills such as, Oracle, JQuery, JavaScript, Web service, XML, and SOAP.

Because they have experience in software industry software manager seems to be aware of the mostly needed skills expect for very few skills such as Web services.

This research recommends the following to reduce the Gap between academia and software industry:

- Adding the skills with no SE curriculum coverage mentioned before such as ASP.NET, Android, Oracle, and Web services.
- Improving the practical part of the curriculum.
- Increasing the awareness of students and academic staffs by allowing SW company managers to give lectures about the mostly needed skills.

In this research only SE curricula were considered, however, future work will consider other IS related curricula such as CS curricula in order to investigate which of these curricula covers more of the skills that are required by software industry.

Also, this research had only considered the Jordanian Universities case study, however, future research will compare the gap in Jordan with the same gap in other countries such as the United States in order to investigate whether similar causes of this gap exists also in other countries.

Acknowledgements

This research was fully supported by the research deanship at Philadelphia University in Jordan.

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